ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL

RELATIONSHIP BETWEEN WATERSHED MANAGEMENT AND SPATIAL PLANNING IN TERMS OF SUSTAINABLE DEVELOPMENT

Ph.D. THESIS

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JANUARY 2021

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ISTANBUL TEKNİK ÜNİVERSİTESİ ★ İTÜ LISANSÜSTÜ EĞITIM ENSTİTÜSÜ

SÜRDÜRÜLEBİLİR KALKINMADA SU HAVZASI YÖNETİMİ VE MEKANSAL PLANLAMA İLİŞKİSİ

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OCAK 2021

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Date of Submission : 30. 11. 2020
Date of Defense : 15. 01. 2021

FOREWORD

Throughout the writing of this dissertation, I have received a great deal of assistance.
I would first like to thank my supervisor, Professor Handan Turkoglu, whose guidance and expertise was invaluable in formulating the research questions and analyses. Her insightful feedback pushed me to sharpen my thinking and brought my work to a higher level.
I would also like to extend my gratitude to my thesis committee members, especially dear Associate Professor Umit Arpacioglu from Mimar Sinan Fine Arts University, who assisted me with his suggestions during the methodology and development of this research work. His willingness to give his time so generously has been appreciated. I also thank Dr. Betül Uygur Erdoğan from Istanbul University, Faculty of Forestry, for providing me with valuable information.
I would also like to thank the staff of the institutions of State Hydraulic Works (Devlet Su İşleri Genel Müdürlüğü), Istanbul Water and Sewerage Administration (İstanbul Su ve Kanalizasyon İdaresi), and Ministry of Agriculture and Forestry (Tarım ve Orman Bakanlığı) for enabling me to visit their offices and discussing over research questions and the existent issues over Turkey water resources.
I also wish to thank all of the Urban and Regional Planning Department's academicians at Istanbul Technical University. They participate in answering the questionnaires and participating in the final meeting to discuss over obtained results.
Without whose cooperation, I would not have been able to conduct this analysis.
I would especially like to thank my amazing sister Sima for her wise counsel, constant encouragement, and sympathetic ear that I have gotten over the years. Finally, I could not have completed this dissertation without the love, support, and assistance of my husband Ferit; You are always there for me.

January 2021

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ABBREVIATION

AHP **:** Analytical Hierarchy Process
EPA **:** US Environmental Protection Agency
EU **:** The European Union
CAN **:** The National Water Commission
DSI **:** Devlet Su İşleri (The State Hydraulic Works)
GWP **:** Global Water Partnership
IWRM **:** Integrated Watershed Resource Management
ISKI **:** Istanbul Su ve Kanalizasyon Idaresi (Istanbul Water and Sewerage Administration)
ICPR **:** The International Commission for Protection of the Rhine
LCA **:** Life Cycle Assessment
NUTS **:** Nomenclature of Territorial Units for Statistics
PES **:** Payment for Ecosystem Services
RDA **:** Regional Development Agencies
SWAT **:** Soil and Water Assessment Tool
SWRM **:** Sustainable Water Resource Management
SWRP **:** Sustainable Water Resource Planning
SWOT **:** Strengths, Weaknesses, Opportunities, and Threats
TOB **:** Tarım ve Orman Bakanlığı (Ministry of Agriculture and Forestry)
TSI **:** Turkish Statistical Institute
UN **:** The United States
WF **:** Water Footprint
WFD **:** Water Framework Directive

SYMBOLS

Mm	**:** Millimeter
m^3	**:** Cubic meters
km	**:** Kilometer
km^2	**:** Square kilometer
km^3	**:** Cubic kilometer
hm^3	**:** Cubic hectometre
CR	**:** Consistency Rate
RI	**:** Random Index
∑	**:** Summation

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RELATIONSHIP BETWEEN WATERSHED MANAGEMENT AND SPATIAL PLANNING IN TERMS OF SUSTAINABLE DEVELOPMENT

SUMMARY

With the growing population and economic development, water basins and water resources have faced environmental pollution, ecological deterioration, and other issues. Thus, the subjects of water basin protection and planning have been much more critical. Sustainable watershed management and planning approach has appeared to address the problems related to the water basins and water resources. However, sustainable water resources management and planning are not straightforward, involving various social, economic, and ecological dimensions. "Integrated Water Resource Management" (IWRM), as an approach toward water sustainability, has achieved several common goals in watershed management for world countries. Even though there are some noticeable achievements of IWRM in real cases, the concept is still unclear and complicated in terms of implementation. This research aims to define a planning structure and model for evaluating the plans suggested for water resource protection. The work emphasizes providing connectivity between water basin management as a sector with the land use planning and socio-economic sectors.

Turkey has 25 water basins that suffer from problems posed by fertilizer usage in agriculture, incorrect land uses, sedimentation, wrong water policies, industrial water pollution, illegal settlement, and so on. Turkey has initiated fundamental changes and modifications in the watershed management process and planning approach following the international agreements on watershed protection. This research aims to provide an evaluation model of the water basin plans based on sustainability principles. First, it evaluates the Turkey water resource management and planning modifications based on the sustainable development criteria. The evaluation of two related plans (including the Environment Plan and Protection Plan) could show that the plans' regulations have addressed the water and environmental pollution, stream health, economic restrictions, administrative cooperation, sustainable agriculture, organic farming, and the protected zones. However, some other aspects of sustainability such as the land use assessment, finance allocation, social rights, user participation, life pattern, and public attitudes have been underestimated in the action plans proposed for water resource protection in Turkey.

Following the goal, this study ranks the sustainability dimensions in terms of their importance in water resource resilience. The Analytic Hierarchy Process (AHP) was utilized for weighing the sustainability criteria in planning water basins and watersheds. According to the AHP structure, a questionnaire was prepared in which the management and planning elements of water basins are asked for pair-comparison. Experts who have knowledge or experience on the subject through a questionnaire evaluated the water resource planning factors and sub-factors. As water resource management planning is a specific field of study, a limited number of experts has been chosen for answering the questionnaire. The questionnaire form was sent to the selected individuals, including 20 persons of academicians (university teachers)

and 17 persons of professionals who are working in one of the State Hydraulic Works (DSI), Istanbul Water and Sewerage Administration (ISKI), or Ministry of Agriculture and Forestry in Turkey. Experts could rate the comparison as equal, slightly strong, strong, very strong, and extremely strong. Finally, the questionnaire data were obtained from the experts' judgments on the importance of the planning factors in sustainable water resource management. Considering different perspectives and opinions that might emerge between academicians and professionals in water resource planning, the various groups' achieved answers are evaluated separately.

The evaluations of the experts' judgments show that there are critical differences among two groups of the academics and professionals' choices, especially in ranking sub-factors of the ecology and built-environment. The professionals considered ecosystem functions, infrastructure planning, land-use impacts, and other natural sources as less critical for sustainable water resource planning and management. In general, the academicians having more holistic views based on their knowledge, have considered global issues for the water basin planning. They know more about climate change, ecosystem and biodiversity, and land uses effects than the professionals. The professionals and executors attempting to solve the existing issues like water pollution and institutional principles in the water bodies have been affected by the institutional perspectives. However, in most areas, with small differences, the correlation is understandable among two groups prioritization in evaluating the economy, society, and land-use sub-factors. The research shows that the various experts' conflicting views should be identified, understood, or harmonized to make decisions through the water basin planning and management.

After analyzing the questionnaires, a focus group meeting was designed to discuss the achieved results. In this online discussion, 12 professors from Urban and Regional Planning, Landscape Architecture, Forestry Engineering, and Environmental Engineering were invited. They have been chosen based on their educations and researches on the country's water resources. The professors were asked to analyze the reasons for emerging different viewpoints on prioritizing the factors among the experts. The professors who participated in the meeting have also expressed some solutions and recommendations regarding Turkey's water basin protection through another questionnaire, following the meeting.

According to the experts' opinions, the wrong and inappropriate land uses, water and environmental pollution, and insufficient water infrastructure has been recognized as the main problems of the water basins in Turkey. The participants also put comments on the leading causes of the mentioned issues. Considering their words the land use planning and water resources management is not integrated, the management system in existing water resources is inappropriate, and there is no institutional coordination and national laws related to the water basins in Turkey. Finally, as a consequence, this research provides practical suggestions and solutions to mitigate the issues and improve Turkey's water resource resilience. Suggested strategies are about the water amount increase, water demand management, environmental protection, ecological problems, water resources improvement, stakeholder and community involvement, economic problems, land use plan and water basin management integration, implementation problems, and the basin social life.

This study shows that water basin planning and management as an interdisciplinary process needs to be integrated with different disciplines and sectors. It provides a good example of using the AHP for evaluating the sustainability indicators and discovering the conflicting perspectives on the water basin management and planning. The results proved that there might be critically different views on the importance of the

sustainability dimensions among the experts. The evaluation model for the water basin plans, proposed in this research has a flexible structure that considers the diverse perspectives and the future changes in the basin situations.

SÜRDÜRÜLEBİLİR KALKINMADA SU HAVZASI YÖNETİMİ VE MEKANSAL PLANLAMA İLİŞKİSİ

ÖZET

İnsan yaşamının her alanında örneğin doğal sistemlerin ve hayatın sürdürülmesinde, tarımsal üretimde, ekonomik ve sosyal kalkınmada suyun önemi inkar edilemez. Hızlı kentleşme ve artan nüfusla birlikte, su kaynakları tahrip olmakta ve dünyanın pek çok bölgesinde su kıtlığı yaşanmaktadır. Bunun sonucu olarak su konusu, sürdürülebilir kalkınmanın merkezine yerleştirilmektedir. Su kaynaklarının korunması ve sürdürülebilirliği için, su dağıtımından, su kullanımına ve atık su deşarjına kadar, bütüncül bir planlama yaklaşımına ihtiyaç duyulmaktadır.

Su kaynaklarının doğası gereği su yönetim planları, mekansal ve kendine özgü olmalıdır. Bu planlarda mevcut ekolojik sorunlar ele alınmalı, ekonomik kaynakların sürdürülebilirliği sağlanmalı, sosyal gereksinimlere cevap verilmeli ve havzadaki yerleşmenin özellikleri dikkate alınmalıdır. Öte yandan su kaynaklarının planlanmasında dikkate alınması gereken ortak faktörler söz konusudur. Bu araştırma, su kaynaklarının planlama ve yönetim sürecinde ekolojik, sosyo-ekonomik ve yapısal çevre kapsamında ortak faktörlerin değerlendirilmesine odaklanmaktadır.

Türkiye'de su havzalarında, tarım alanlarında gübre kullanımından kaynaklanan sorunlar, yanlış arazi kullanımı, sedimantasyon, yanlış su politikaları, endüstriyel su kirliliği, kaçak su kullanımları vb. sorunlar yaşanmaktadır. Türkiye su havzalarının korumasına ilişkin uluslararası anlaşmaları kabul ederken havza yönetimi ve planlama sürecinde bir dizi değişiklik gündeme gelmiştir.

Bu araştırmanın temel amacı su havzalarının korunması çerçevesinde, ilgili parametrelerin oluşturulması ve önceliklerinin belirlenmesi, Türkiye için su havza planlaması ve yönetiminde sürdürülebilirlik parametrelerine dayalı, koruma stratejilerin ve ilkelerinin belirlenmesi ve mekânsal planlama sürecine entegre edilebilecek kapsamlı bir modelin oluşturulmasıdır.

Sürdürülebilirlik çerçevesinde içme suyu havzaların planlaması ve yönetimi için geliştirilen parametrelerin önceliklendirmesinde akademisyenler ve uzmanlar arasında farklı bakış açıların oluşabileceği gibi farklı disiplinlerden akademisyen ve uzmanlarda da farklı bakış açılarının varlığı tezin hipotezini oluşturulmuştur.

İlk aşamada sürdürülebilir kalkınma ilkelerine göre Türkiye'deki su kaynaklarına ilişkin planlama yaklaşımı ve yönetim süreci değerlendirilmiştir. Bu amaç doğrultusunda seçilen 5 içme su havzası ile ilgili mevcut Çevre Düzeni Planı ve Havza Koruma Planı stratejileri sürdürülebilirlik faktörlerine göre değerlendirilmiştir. Her iki planda çevre kirliliği ve akarsu sağlığı konusu, idari işbirliği, ekonomik kısıtlamalar ve koruma bölgelerindeki faaliyetlerin belirlenmesi ve sürdürülebilir tarım konuları, planların stratejileri ve gereksinimleri ele alınmıştır. Değerlendirme sonuçlarına göre planlarda sürdürülebilir arazi kullanımı öngörüleri, finansman tahsisi, sosyal haklar,

kullanıcı ve akademisyenlerin katılımı ve yaşam kalitesi gibi bazı konuların gözardı edildiği saptanmıştır.

Bu çalışmanın ikinci aşamasında sürdürülebilirlik boyutları, su havzalarının korunması açısından değerlendirilmiştir. Literatüre bağlı detaylı bir incelemeye dayalı olarak oluşturulan model çerçevesinde su kaynakları ve su havzalarının planlanmasında sürdürülebilirlik faktörlerini ve alt faktörleri ağırlıklandırmak için analitik hiyerarşi süreci kullanılmıştır. Süreçte faktörler konu hakkında bilgi veya deneyime sahip uzmanlar tarafından anket yoluyla değerlendirilmiştir.

Üçüncü aşamada Analıtıcal Hırachy Süreci yapısına göre hazırlanan ve su havzalarının planlama ve yönetimi ile ilgili karşılıklı karşılaştırmanın istendiği anket seçilen kişilere gönderilerek akademisyenler ve uzmanlar arasında ortaya çıkabilecek farklı bakış açıları ve görüşler de dikkate alınarak cevaplar ayrı ayrı değerlendirilmiştir. Çevrimiçi olarak hazırlanan form 20 akademisyen ve Devlet Su İşleri (DSİ), İstanbul Su Kanalizasyon (İSKİ) ve TC Tarım ve Orman Bakanlığı'nda çalışan toplam 17 uzmana gönderilmiştir. Karşılaştırma düzeyi uzmanlarca eşit, biraz güçlü, güçlü, çok güçlü ve son derece güçlü olarak değerlendirilmiştir. AHP sürecinin sonunda uzmanlardan sürdürülebilir su havzaları yönetiminde ele alınan planlama faktörlerinin önem sıralaması talep edilmiştir.

Akademisyenler ve uzmanlardan oluşan iki grubun tercihleri, özellikle ekolojik çevrenin değerlendirilmesi ve arazi kullanımının ağırlıklandırılmasında kritik farklılıklar ortaya koymuştur. Uzmanlar, ekosistem fonksiyonları, altyapı planlaması, arazi kullanım etkileri ve diğer doğal kaynaklar gibi faktörleri, sürdürülebilir su havza planlaması ve yönetimi için daha az önemli olarak değerlendirirken, akademisyenler su havzası ile ilgili genel ve küresel konulara örneğin iklim değişikliğini, ekosistemi, biyolojik çeşitliliği ve arazi kullanımlarının etkisi gibi konulara daha fazla önem vermektedirler. Su kirliliği ve kurumsal ilkeleri gibi mevcut sorunların çözümlerini düşünen uzmanlar ve uygulayıcılar kurumsal perspektiften de etkilenmektedirler. Genel olarak, akademisyen ve uzmanların tercihleri sosyal ve ekonomik faktörleri önceliklendirmede benzer düşüncede iken, arazi kullanımı ve ekolojik faktörleri değerlendirmede farklılıklar ortaya çıkmaktadır.

Dördüncü aşamada anketlerden elde edilen analiz sonuçlarını tartışmak için Şehir ve Bölge Planlama, Peyzaj Mimarlığı, Orman Mühendisliği, Çevre Mühendisliği bölümlerinden; su kaynakları konusundaki araştırmaları ile tanınan 12 öğretim üyesi ile çevrimiçi bir odak grup toplantısı gerçekleştirilmiştir. Toplantıda akademisyenler ve uzmanlar arasında önceliklendirmeye ilişkin sonuçlar ve farklı bakış açıları tartışılmış ve daha sonra toplantıya katılan akademisyenlere çevrimiçi bir anket yöneltilerek sorun ve sorunlara yönelik çözüm önerileri talep edilmiştir.

Toplantı sonucunda akademisyenler ve uzmanlar arasında ortaya çıkan sonuçlarda farklılıkları en aza indirmek ve ortak akıl geliştirmek üzere öneriler geliştirilmiştir; Bunlar;

• Su havzaları ile ilgili projelerde iki grup akademisyen ve uzman arasında işbirliği konusunun yasa ve yönetmeliklerde yer alması ve su kaynakları ile ilgili yapılan projelerde, su tüketicileri, yöneticileri ve uzmanlar dahil paydaş katılımının düzenli hale gelmesi ve su kaynaklarının korunması ve planlanmasıyla ilgili kararlarda yer almaları sağlanmalıdır. Planlama sürecinin ilk aşamasından itibaren ilgili devlet kurumları, yerel kurumlar ve diğer kamu kuruluşların aralarındaki işbirliği tanımlanmalı ve oluşturulmalıdır.

• Bu kapsamda çeşitli karar verici gruplar, bilgi sahipleri ve kamu kullanıcıları bir araya getirilerek toplantılar, tanıtım programları ve eğitim atölyelerin organize edilmesine ihtiyaç duyulmaktadır. Bu programlar, kapsam belirleme ve önceliklendirme, sorunların açıklığa kavuşturulması, yönetim stratejilerinin belirlenmesi, çözüm önerileri, kaynak tahsisi vb. konuları ele alarak, su kaynakların planlamasının her aşamasında değerlendirilmelidir. Toplantılarının sonunda, katılımcıların görüşleri ortaklaştırılarak kapsamlı çözümlerin önerilmesi sağlanacaktır.

• Akademisyenlerin ve uygulayıcıların katılım programlarında ve projelerinde ortak bir dile sahip olmaları önemlidir. Akademisyenler, toplantılarda pratik stratejiler sunması profesyonellerin daha başarılı sonuçlara yol açacak ve ilişkiyi güçlendirecek yaklaşımları basit bir dil ve teknikle anlamasını sağlayacaktır.

• Türkiye'de su havzalarının yönetim sisteminin ve planlamanın farklı kapsam, yaklaşım ve süreçlere yol açan karmaşık bir yapıya sahip olmaları nedeni ile su havzalarıyla ilgili bakanlıklar, kurumlar ve diğer ilgili sektörlerin politikalar, düzenlemeler ve yaklaşımlar açısından bir koordinasyonun oluşturmasına ihtiyaç duyulmaktadır.

Türkiye'deki su havzalarının temel sorunları yanlış ve uygunsuz arazi kullanımı, su ve çevre kirliliği ve yetersiz su altyapısı olarak rapor edilmiş, sorunların ana nedenleri ise arazi kullanım planlaması ve su kaynakları yönetiminin birbirine entegre olmaması, mevcut su kaynaklarındaki yönetim sisteminin uygun olmaması, kurumsal koordinasyonun yetersizliği, Türkiye'deki su kaynaklarına ilişkin ulusal politika ve kanunların yeterli ve destekleyici olmaması olarak belirtilmiştir.

Bu araştırma; su kaynaklarının miktarını ve dayanıklılığını artırmak, su talebini yönetmek, havzaların çevresini korunmak, ekolojik sorunları gidermek, su kaynaklarını iyileştirilmek, su ve çevre kirliliğini azaltmak, paydaş ve toplum katılımını sağlamak, su havzalarındaki ekonomik ve bütçe sorunlarını iyileştirmek, arazi kullanımı ve su kaynakları arasındaki ilişkiyi güçlendirmek, yönetim ve uygulama sorunlarını çözmek ve su havzalarında sosyal yaşamı iyileştirilmek için pratik öneriler ve çözümler sunmakta, sürdürülebilirlik göstergelerinin değerlendirilmesinde havza yönetimi ve planlamasındaki zorlukların belirlenmesi sürecinde AHP metodunun kullanılmasına örnek oluşturmaktadır.

Araştırma sonuçlarına göre akademisyenler ve uzmanlar arasında göstergelerin özellikle önem sıralamasında farklı bakış açıları olması bir başka deyişle araştırmanın hipotezinin test edilmiş olması, sürecin farklı disiplinlerin ve sektörlerin katılımı ile organize edilmesinin önemini ortaya koymaktadır. Burada belirtilmesi gereken bir diğer husus da içme suyu havzası yönetimi ve korumasına ilişkin karar vericilerin konu alanları ile ilgili olarak donanımlı olmaları ve kapsamlı bilgiye sahip olmaları gereğidir. Uzmanlar, arazi kullanım etkileri, ekosistem döngüleri, ekonomik ve sosyal gereksinimler gibi konular hakkında bilgili olmalıdırlar. Farklı uzmanlık grubunda yer alan kişilerin tartışma ortamında ortak akıl üretebilmeleri ve değerlendirmede her uzman grubunun görüşünün alınması gereklidir.

Havza koruma ve planlaması sürecinin karar aşamasında paydaşlar, kullanıcılar, yöneticiler, uzmanlar ve diğer ilgili kuruluşların görüşleri ve bakış açıları arasındaki farklılıklar saptanmalıdır. Karar verme süreci, yönetim programlaması ve uygulama sırasında ortaya çıkabilecek kritik zorluklar ortak akılla aşılabilir. Paydaşlar arasında yapılan tartışma toplantıları çatışan görüşleri paralel hale getirmenin yollarından

biridir. Bununla birlikte, farklı bakış açıları, havza yönetim pkanını daha bütünsel hale getirmenin güçlü bir yönü olarak kabul edilebilir.

Araştırmanın bir diğer sonucu önerilen değerlendirme modelinin, farklı bakış açılarını dikkate alan esnek bir model olmasıdır. Zamana bağlı olarak insanların yaşamı ve bilgileri değişmekte, iklim değişikliği ve su havzaların özellikleri ve sorunları da değişmektedir. Bu anlamda önerilen değerlendirme modelinin esnek olması gereği vardır.

1. INTRODUCTION

Water resources are critical sources for water purification, water supply, flood, and erosion control (Kennedy et al., 2012). However, with the population growth and urbanization, water demand and water pollution increase, environmental pollution (both point and nonpoint pollution), droughtiness, deforestation, and the effect of climate change, the water basin protection subjects have been much more critical. Human activities and intervention in the water cycle put many river basins under stress and have changed the hydrological regime of river basins. There are various cases worldwide that illustrate the costs of environmental degradation at the basin scale. The extent of these problems has often lead to a significant rethinking of basin planning processes.

Water resources have become one of the main elements in sustainable development (United Nations, 2014). In moving towards sustainable river basin management, an integrated approach in institutional processes named Integrated Water Basin Management (initiated from 1980) suggests an integrated planning approach. Sustainable watershed management is a multidimensional process that needs the involvement of various disciplines and sectors. It considers a specific position for water sustainability in the plan's national, regional, development, and spatial strategies. It should is integrated with the urban planning process and other related processes as well. However, urban and regional planning in water basin protection seems to be underestimated, and water basin planning takes an approach that is not integrated into the urban planning process.

There is a noticeable gap between the water situation and land use patterns, and urbanization. Cities are the primary problem holders of water scarcity because of rapid development, population growth (cities are home to half of the world population), water pollution, increasing water use, and aging water infrastructure in water basins. Land use plans should be prepared following water resource protection strategies, and urban planners must protect the catchment areas and reservoirs of potable water. Water issues often remain disconnected from urban planning processes. Urban developers

and designers are not related to the water resource management and water demand-supply system. This research aims to research how various disciplines can contribute to water basin management to protect them, reduce water pollution, reduce water use effects, and improve ecosystems and environmental values. This research also aims to introduce a holistic approach regarding water resource sustainability structure the sustainability principles in water basin planning and management.

Turkey is under the pressure of water shortage and the risk of ecological degradations in the water resources. Since the second half of the twentieth century, the water uses for the growing population, agricultural activities, energy purposes, and industrial development have increased in Turkey, which has posed water basin deterioration. Furthermore, Turkey has an average rainfall of 643 mm per year and located in a semi-arid area of the globe, has a significant variation between regions in terms of precipitation (3000 mm per year in some territories, however, 250 mm per year in some other areas), (Yilmaz, 2014).

Over the last decade, Turkey, following the European Union membership has been committed to function according to international agreements like Water Framework Directive (2000). It led to several modifications and changes in Turkey's planning and management approach to preserving drinking water resources. It seems necessary to provide a valuation model for the water resource plans that can contribute to providing a sustainable management and planning approach.

This research evaluates the planning and management process of the watersheds and water basins in Turkey based on the sustainability structure defined for water resources.

1.1 Purpose of Thesis

The main goals and sub-goals of the thesis are:

- The thesis's first goal is to establish relevant parameters and determine priorities within the water resource protection framework. Following this goal:
    - The main factors and subfactors related to water resource resilience are recognized and explained.
    - In the prioritization of the parameters, various academics and professionals' viewpoints are categorized and compared to understand the different and similar perspectives.
    - A numerical weight is considered for each determining factor by using method AHP that allows for a more clear categorization.
- Second goal of the thesis is to create a comprehensive model for watershed planning and management that can be integrated into the urban planning process. To do so:
    - The achievements and challenges of integrated water resources management as a holistic approach are analyzed in the framework of Sustainable Development.
    - Various dimensions, primarily social and physical dimensions of a water basin planning and management, are determined, and the planning strategies and technique are recognized for improving the water resource situations
    - The relationship between water resource management and plan with the other national, regional, spatial, and local plans are studied.
- The third goal is to achieve the protection strategies and policies in Turkey's water resources planning based on specified parameters through the following sub-goals.
    - The current water resource management systems and planning approaches are analyzed in Turkey.
    - The strategies and policies defined in the main plans of some water resources in Turkey are evaluated based on the determinant sustainability structure to understand the missed aspects.

- The advantages and disadvantages of the water management systems in Turkey are discussed through discussion meetings with the academics to achieve the possible solutions and mitigate the current problems are recommended.

1.2 Research Background

The importance of water in all aspects of human life, agricultural production, economic and social development is undeniable. Furthermore, water is necessary for natural systems, wildlife, and environmental resistance. However, with growing cities and populations, water resources have become frustrated, and water scarcity has started happening in most countries. Today, one-third of the people of the globe live in areas with water scarcity (Hoekstra et al., 2012), and most of the water basins are suffering from the mismanaged governmental institution and inadequate knowledge about the fundamentals of the riverine ecosystems and their dynamics (Mencio et al., 2010).

Water has been placed in the center of sustainable development laid in 1987 Brundtland Report. Many Millennium Development Goals at the Millennium Summit (September 2000) as the most significant meeting of world leaders in history were directly or indirectly connected to water issues. A holistic approach is needed for water sustainability considering water issues from the water resources and water distribution to the water uses and wastewater discharge. Water sustainability deals with water issues at a small scale (water uses and water supply in urban areas) and cases of water resources at larger scales like water basins and watersheds. Sustainable development in urban areas requires easily accessible, equitable, and reliable water. However, on a larger scale, the water resources are associated with various aspects of social, ecological, economic, etc. Thus, water resources planning and management have emerged as a critical challenge in spatially developing countries. In this way, it felt to need a holistic and optimal solution involving socio-economic and environmental dimensions in the management approach.

Sustainable Water Resource Management (SWRM) has become one of the most significant Sustainable Development Goals (UN, 2014). “Integrated Water Resource Management” as a sustainable approach to water management has been introduced to the world since the late 19th century. Following the Global Water Partnership (GWP) report and the Japan Water Forum presented in the fourth world conference on water in 2006, many countries have planned to obtain IWRM as a global index. In 2006, the UN secretary asked all states to provide a progress report on the development of IWRM in 2008.

Previous approaches towards Sustainable Water Resource Management (SWRM) have highlighted creating various indicators, including multi-dimensional economic, social, and environmental aspects (Singh et al., 2009). The SWRM is not an easy task. It deals with the water supply system, water distribution, water consumption, discharges, different actions of upstream and downstream, surface and underground water, and so on (Kharrazi et al., 2016). Furthermore, as a multi-dimensional process, it is interconnected with socio-economic, ecological, and governance and built environment, which has been caused it too much more complicated. This research, trying to provide a clear framework for sustainable planning of watershed management, identifies and the primary factors and sub-factors of sustainability in the watershed management and planning process. Finally, with the use of the Analytical Hierarchy Process (AHP) method, the determinant criteria are prioritized.

Analytical Hierarchy Process (AHP) can provide a more holistic understanding of watershed systems. AHP has been found as one of the most appropriate tools for decision-making scenarios, such as prioritizing the relative values of a set of alternatives, choosing one factor from a group of factors, resource and water allocation, and so on. AHP method has been used in land suitability, urban land-use planning, and urban growth studies. Therefore, AHP can lead to a sustainable decision in watershed planning and management by providing a framework for choosing a preferred alternative among a set of potential solutions to a problem (Yavuz and Baycan, 2013).

In Turkey, over the last decades, the water uses for the various needs of the population have increased, which has caused ecological water degradation. Turkey has initiated significant steps toward the protection and management of the water basins. This study can help Turkey evaluate the planning and management process changes conducted over the last years. Therefore, the research background includes reviews of two groups of studies: researches performed on water resources, their protection, management, and planning in Turkey, and the AHP method and its application in various related researches.

1.2.1 Researches on water resources in Turkey

Various studies, research projects, and educational thesis have been conducted on Turkey's water basins over the past ten years.

- There are some known studies on landscape characterization, including cultural values of water resources in Turkey. In research by Uzun et al. (2011), functions of different landscapes are determined considering habitat and biodiversity for the Lake Sugla located in the south of Central Anatolia as a case study. They analyzed the patch's classes in the forest matrix in the Sugla basin based on four criteria (size, form, the edge of the patch, and core areas). The study shows that human interventions and agricultural actions are enormous on Lake Sugla that caused fragmentation. Another landscape evaluation has been performed again on Sugla lake to evaluate bio-cultural diversity for ecotourism opportunities. Parameters of ecotourism development opportunities were assessed through the SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis by Açıksöz et al., (2016). It proved that the area covers rich cultural and natural landscape values for ecotourism development. The main actions focus on infrastructure development, increasing awareness of landscape heritage, enhancing forest rehabilitation, and monitoring water quality at Suğla Lake (Açıksöz et al., 2016). The third landscape project is on providing Landscape Atlas for Yeşilırmak water basin by Uzun (2016). Turkey is membered in the Landscape Atlas of the European Landscape Convention since 2014. The Landscape Atlas acts as a tool for contributing to sustainable management by considering the balance of protection and use of landscapes. It aims to integrate landscape planning approaches into different sectors (e.g., urbanization, conservation, forestry, agriculture, industry, energy, etc.) by providing decision-makers with information about the diverse landscapes.
- In Turkey, the water resources protection has started by basin protection action plan for the Meriç-Ergene water basin as the primary source of Turkey's agricultural production in 2009. Uncontrolled industrialization and urbanization of Ergene Basin and other issues have reduced its water quality. A multi-dimensional Basin Protection Action Plan was prepared to raise the water quality of the Ergene Basin. The monitoring stations have shown that water discharge increased over the last years due to industrialization using the groundwater. This plan suggested some actions, like cleaning the stream beds, wastewater treatment plant, identifying the main water-polluting, and re-arranging discharge standards. Later, water resources protection based on the

ecosystem functions has been addressed in a project by Tezer et al. (2015) for the Melen Basin in Düzce province. In this research, the ecosystem services of Melen Basin were evaluated by integrating the maps showing both lands uses and the ecosystem service potential. In another study, Omerli Water Basin's ecosystem-based planning was suggested (Tezer et al., 2016). It evaluates factors that have caused changes in the ecosystem services and land use in the basin. Through the spatial analyses and integrated evaluation of the Omerli water basin's ecologic and socio-economic qualities, some main opportunities were attained to solve the actual problems. The research has recognized the areas with absolute conservation of ecosystem services functions, the areas with the rehabilitation of ecosystem service, and the areas under the measure, control, and protection (Tezer et al., 2016).

- Two examples of research on water resource planning in Turkey can be described here. One is research by Baycan and Yavuz (2016), which aims to prioritize the planning strategies on Beyşehir Water Basin facing the environmental problems and socio-economic problems. Through this research, 457 households in 44 regions were participated to determine protection strategies by the SWOT method. The strategies were provided for water use regulation in rural areas, water quality improvement, stakeholder engagement, environment-oriented tourism development, and the agricultural development in the Beyşehir Water Basin, as the largest drinking water reservoir in turkey (Baycan and Yavuz, 2016). The second research relates to water resource planning is sustainable planning for Gediz River Basin on the Menemen Plain in Izmir between 2013-2016. The Menemen Plain is an essential agricultural basin that feeds the population of Izmir and has a significant vulnerability to groundwater resources. The wells are at risk due to the density of farming activities. According to the Groundwater Directive (2012), no structures, solid and liquid waste discharges are permitted in distances of less than 50 meters to drinking water wells.
- In 2017, multi-dimensional research was also carried out by Demirel and Velibeyoğlu, which confirms the relations between water, energy, and food for local development and sustainability. The results suggest climate-sensitive agriculture, multi-layered solutions from strategic planning to urban design solutions, risk and conflict analyses, a multi-scale approach to climate

adaptation, and the integration of blue-green networks at different ecological scales (Demirel and Velibeyoğlu, 2017).

1.2.2. AHP application in urban planning and water management

Water management as a multi-objective issue usually needs Multi-Criteria Decision Making as an appropriate decision support tool. Applying the Multi-Criteria Decision Making in watershed management is growing, particularly in water supply planning, water policy, and infrastructure evaluation (Hajkowicz and Collins, 2007). The simplicity of the Analytical Hierarchy Process (AHP) has resulted in its widespread application in multiple decision-making scenarios, such as prioritizing the relative values of a set of alternatives, choosing one factor from a group of factors, resource and water allocation, and so on. AHP method has been used in land suitability, urban land-use planning, and urban growth studies. Watershed planning and management decisions contain multiple targets that cause conflicts among interest groups and stakeholders. Considering various stakeholder values and alternatives for future impacts, AHP provides a more holistic understanding of watershed systems. AHP leads to a sustainable decision in watershed planning and management by providing a framework for choosing a preferred alternative among a set of potential solutions to a problem (Yavuz and Baycan, 2013). Here some examples of research using AHP are explained.

- Weighing driving factors in Urban Growth Kathmandu valley, Nepal (2010): The AHP method was used to weight the main drivers of urban growth in Kathmandu valley/ Nepal (Thapa and Murayama, 2010). Seven main criteria are regarded in growing the site, according to the urban and regional experts, researchers and residents, and academics (Figure 1.1). So, through a set of questionnaires, the respondents stated the relative importance of each driver considering the others. Based on the results, population growth, economic opportunities, and political situation are the highest-ranking drivers affecting change in the core, fringe, and rural areas, respectively.

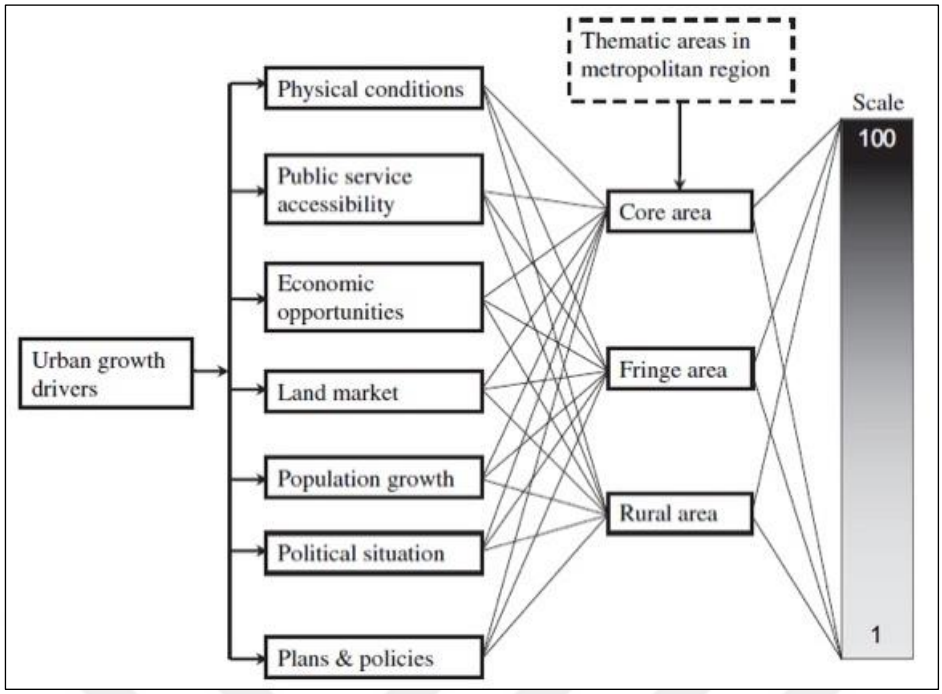

Figure 1.1: Criteria and sub-criteria of Urban growth (Thapa and Murayama, 2010).

Drivers of rural development in Chile (2007): In this research, the AHP method was used to determine and prioritize the activities supporting rural development in Chile (Oddershede et al., 2007). Firstly, the primary activities impacting the region's progress were identified by experts, local decision-makers, and government representatives. With the AHP, the values of the selected attributes related to each function were obtained by the experts' preferences based on their expertise and knowledge (Figure 1.2). In the region, the activities encouraging urban growth were the harbor activities, industrial, agricultural, fishing, tourism, and commercial activities. The tourism sector is recognized as more important for the community's development rather than the other sectors. Therefore, the activities related to tourism should be the primary concern. Regarding the environmental issues, the leading actions are to create social awareness and encourage non-polluting industries by providing incentives (Oddershede et al., 2007).

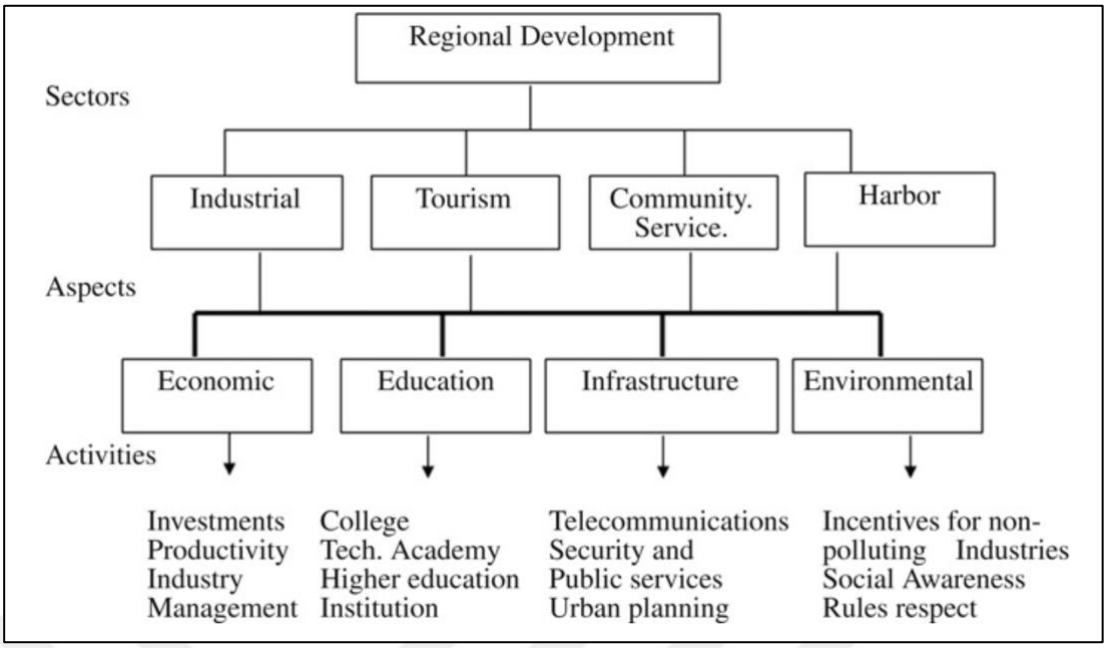

Figure 1.2 : The Hirarchy Stucture of AHP in the research (Oddershede et al., 2007).

- AHP application in urban sustainability indicators' prioritization (2013): AHP was also used to eliminate the derivers which are less effective in urban sustainability through research by Michael et al. (2013). A list of urban sustainability indicators was provided from the sources and compared to each other to obtain their priorities. According to the result, the indicators related to environmental dimensions are more important, followed by the economic, social, and institutional dimensions (Michael et al., 2013).
- AHP approach for assessing urban renewal proposals (2008): It used the AHP method for finding the best design proposal. Three main factors (economic, environmental, and social sustainability) consisting of various design sub-criteria are prioritized regarding their relative importance. Therefore, a series of pairwise comparisons were performed by the experts. According to the answer, the weight of the green design factor is the highest because it enhances environmental and economic sustainability. Green design with proper building orientation and facade design can mitigate natural resource consumption (Figure 1.3**)**, (Lee and Chan, 2008).

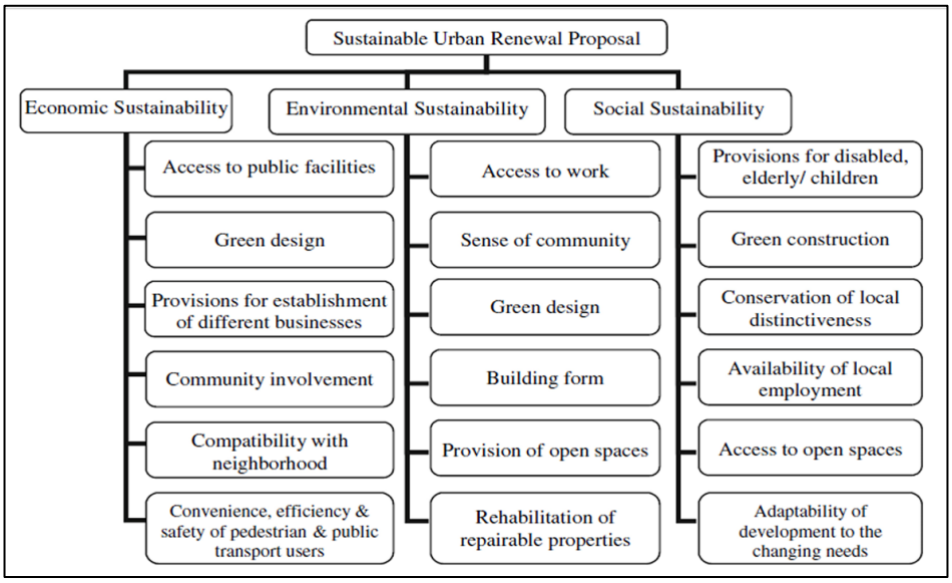

Figure 1.3 : The main criteria ad sub criteria recognized for Urban Renenovation (Lee and Chan, 2008).

- Pedestrians' mental satisfaction's relationship with physical characteristics on sidewalks using AHP (2015): AHP method was also applied in urban social studies such as research for pedestrians' satisfaction in Tehran/Iran. First, the potential physical and mental characteristics of sidewalks that affect pedestrians' satisfaction were determined to research. AHP was used to rank four selected sidewalks in Tehran to achieve each sidewalk's overall rank (Figure 1.4), (Shafabakhsh et al., 2015).

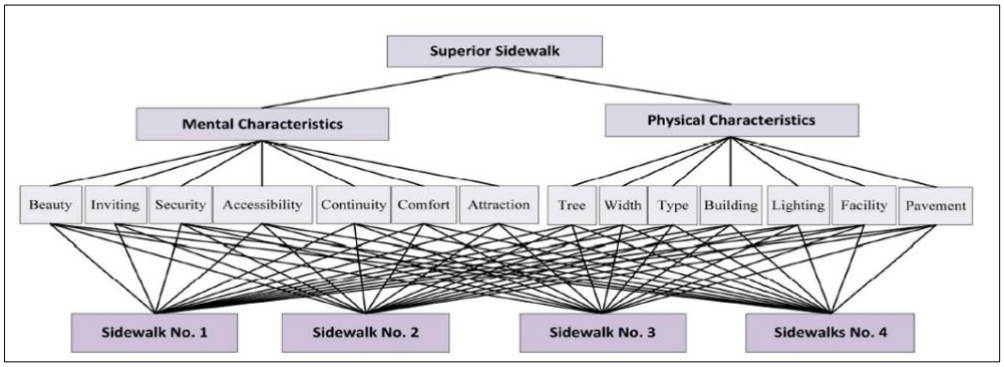

Figure 1.4 : The AHP structure presenting the related sub-criteria of the physical and mental characteristics (Shafabakhsh et al, 2015).

- Public choice of urban water service management (2013): In research by Ruiz-Villaverde et al. (2013), the AHP was used for a decision on urban water service management in Granada (in southern Spain). The method was used to select the responsible manager of the water service by the public (Figure 1.5). The water services can be managed by one of the local entities: a public

company, a private company, or a mixed company. The preferred alternative is a mixed public-private company.

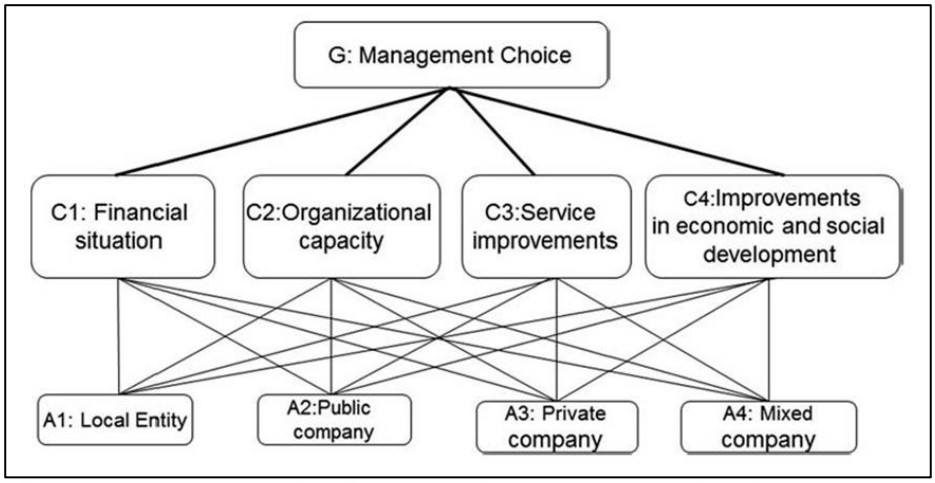

Figure 1.5 : Hierarchy for the case study of Granada (Villaverde et al., 2013).

- Stakeholder participation in integrated water resources management with the use of AHP (2017): To apply Integrated Water Resource Management in the Pranburi watershed in Thailand, the AHP model was used for selecting the suitable alternatives for water resource management (Thungngern et al., 2017). Sub-criteria of the awareness campaign for ongoing sustainable water management and stakeholders' participation within the Pranburi watershed has been recognized as the most important factors. The selected alternatives for water resource management were the strategies for watershed planning and training in water resource management and techniques.
- Use of AHP in watershed management in Beyşehir Lake (2013): In Turkey, a combination of SWOT-AHP was used in Yavuza and Baycan (2013) research to analyze the inhabitant's perceptions towards successful management of Beyşehir Lake that suffers from various environmental and socio-economic problems. The problem hierarchy was structured in four levels to develop the best strategy for the basin's socio-economic and ecological sustainability. Yavuza and Baycan (2013) showed that improving water usage in rural areas and agriculture is the optimal approach to solving the inhabitants' basin problems. The decrease in the lake water quantity was accepted as the basin's primary problem by the inhabitants, and rural tourism was the lowest-rated strategy.

1.3 Hypothesis

Various sustainability factors, covering ecology, society, economy, and land uses, are included in the water resource management and planning. Involvement of different issues in the process has made water resource planning a complicated task that requires a holistic and comprehensive approach. This research's primary goal is to determine an evaluation model of water resource plans based on sustainability indicators. It attempts to discover the inter-relationship among water resources sustainability variables according to the experts' opinions.

The involvement and participation of diverse groups of stakeholders and water users is a particular item in decision-making for plans and management strategies. Sometimes, there is a vast discrepancy in viewpoints between stakeholders and public users, academics and professionals, local managers and regional planners, or even among researchers of different fields of land-use planners, landscape architects, economists, environmentalists, and watershed managers.

Therefore, before deciding on an evaluation model for sustainability criteria in the water resource plans, it seems essential to discover the conflicting views that might happen among the experts. According to the explanations:

- ✓ A brilliant framework should be achieved that covers sustainability parameters of water resource planning and management.
- ✓ Opinions and judgments of various experts and stakeholders should be taken in the water resources planning and management process.

In this way, the central question of the thesis can be:

Whether it is possible to define an evaluation model for the water resource plans?

- Academics (knowledge holders)and professionals (who have experience in water resource planning and management) have various perspectives and evaluations.
  - The academics are influenced by their various educational knowledge!!
  - The professionals working at different institutions may be influenced by the institution's regulations, scopes, and operational targets!!

2. WATER SUSTAINABILITY

2.1 Water Scarcity

The total amount of water in the world is 1.4 million km3, and 97.5% of this water is salty water in the oceans. Only 0.5% remained, in which 2.5% is available as freshwater. More than 90% of fresh water is in poles and underground, and the rest is used in various sectors (70% in agriculture, 19% in industry, and 11% in domestic).

At the world level, there is enough freshwater to meet the global water demand. However, the temporal and spatial differences of water demand and water availability have resulted in water scarcity in several global locations. Nearly 1.7 *109 individuals live in places where groundwater is being overexcited, and around 4.0 billion persons are under extreme water scarcity, at least over some part of the year. Half a billion people experience severe water scarcity at all time of the year, in which 180 million live in India, 73 million in Pakistan, 27 million in Egypt, 20 million in Mexico, 20 million in Saudi Arabia, and 18 million in Yemen (Mekonnen and Hoekstra, 2016). The annual variations of water consumption and blue water availability (fresh surface water and groundwater) have led to colossal water scarcity (Hoekstra et al., 2012).

Over the last few decades, water reduction has threatened sustainable development due to a regularly increasing freshwater demand (Mekonnen and Hoekstra, 2016). The primary driving factors for the increasing global water demand are enhancing living standards, changing life patterns, increasing global population, and the spread of irrigated agriculture (Ercin and Hoekstra, 2014). Also, climate change will exacerbate the degree of water scarcity in the following decades (Vörösmarty et al., 2000).

According to the United Nations estimation, 2 billion people will face absolute water scarcity, and that two-thirds of the global population will be suffered from water shortage in 2025 (UN). The World Economic Forum (2014) rated the ten most serious concerns of the world, of which four of them are directly or indirectly related to the water issue. They are about the food crisis (rank 8), extreme weather phenomena (rank

6), climate change (rank 5), and the water crises (rank 3), (United Kingdom Department of Economic and Social Affairs, 2014).

Furthermore, large water consumption has reduced river flows (mainly over the dry seasons) and decreases basin water and groundwater levels. Water overconsumption affects human life during droughts periods, leads to harvests shortage, income loss for farmers, and pressure on whole societies (Hoekstra et al., 2012). According to the Mekonnen & Hoekstra study (2016), 71% of the world population (around 4.3 billion people, two-thirds of the world population) live in conditions of moderate to severe water scarcity at least one month of the year. Approximately 66% (4.0 billion) people are under severe water scarcity at least one month of the year. Furthermore, some businesses that depend on water in their operations or supply chains also experience water scarcity risks (World Economic Forum, 2015). Other effects are biodiversity losses, land subsidence, low water navigation, soil salinization, and groundwater pollution (SOLAW, 2011).

Sever water shortage emerges in places with either dense population (like Greater London) or the sites with irrigated agriculture (like High Plains in the United States), or both (India, eastern China, Nile delta). High water shortage levels may occur in regions without huge populations density or extreme irrigated agriculture but in areas with less natural water availability, such as in the glob's arid districts (for example, Sahara, Taklamakan, Gobi, and Central Australia Deserts) (Figure 2.1), (Mekonnen and Hoekstra, 2016).

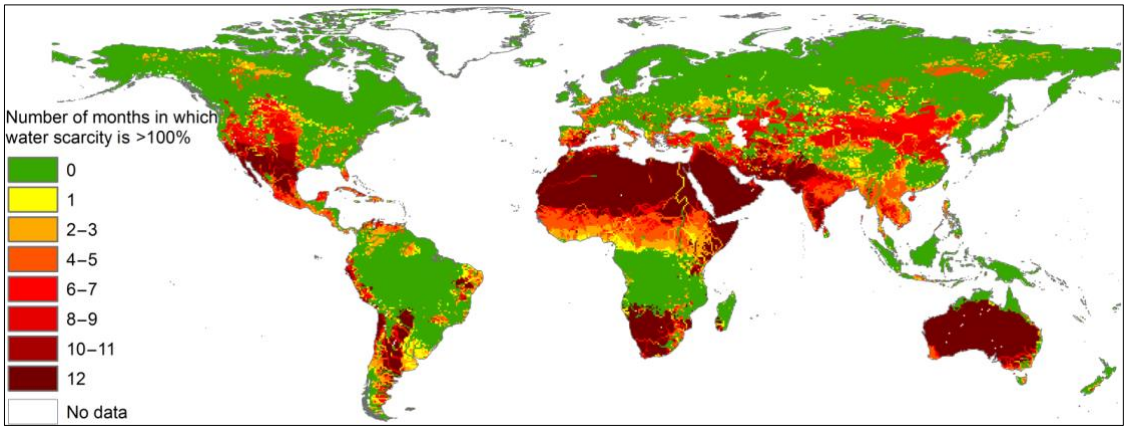

Figure 2.1 : Annual average of monthly blue water scarcity in the world between1996–2005 (Mekonnen and Hoekstra, 2016).

Year-round, less freshwater scarcity is occurred in the forested regions of South America (the Amazon basin), Central Africa (the Congo basin), Malaysia-Indonesia (Sumatra, Borneo, New Guinea), and in the northern forested areas of North America, Europe, and Asia. Other regions with less water scarcity can be in South China, the Eastern half of the United States, and vast European areas. There are many areas at higher latitudes, in Southern Europe, the Western area of the United States, Central Asia, Turkey, and North China, that experience moderate to severe water scarcity in the spring and summer. Sites with mild to severe water scarcity over more than half of the year contain parts of Argentina and northern Chile, North Africa and Somalia, north of Mexico and regions of the western United States, Southern Africa, Pakistan, Australia, and the Middle East. Groundwater shortage is found in many China, the United States, India, Pakistan, Mexico, Iran, and Saudi Arabia (Figure 2.2), (Mekonnen and Hoekstra, 2016).

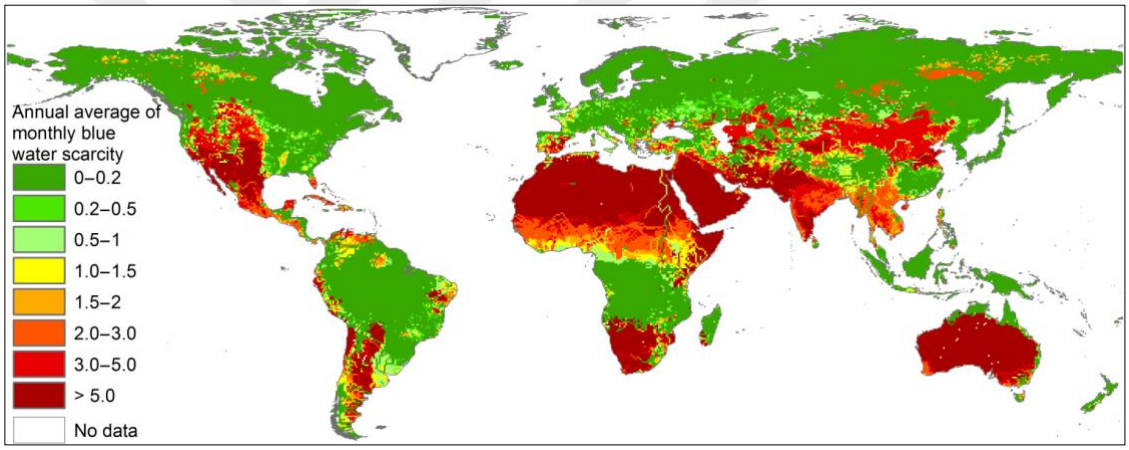

Figure 2.2 : The number of months per year in which blue water scarcity exceeds 1.0 between 1996–2005 (Mekonnen & Hoekstra, 2016).

Today, one-third of the global population lives in areas with water scarcity. According to the statistics, by 2025, this degree will exacerbate to over two-thirds of the world population. Therefore, enhancing the planning and management of water resources is a substantial challenge that impacts users, businesses, and policymakers (WBCSD, 2006). The scientific society has studied to develop techniques and tools to evaluate the consequences of water consumption and promote appropriate water management strategies and policies (Manzardoa et al., 2016).

2.1.1 Global water use

Water Use is the volume and amount of water consumed by several people, a country, or used in industry, agriculture for crop production, or any other particular goal. Global water use has been increased speedily in the last decades. A lot of water is consumed and polluted through human functions and activities. At a world scale, most of the water is consumed for agricultural activities. However, there is also a plentiful amount of water used and contaminated in domestic and industrial sites. Water pollution is associated with some human activities such as irrigation, washing, cleaning, bathing, cooling, and processing.

There are different ways and measures of water consumption, such as total water use, drinking water use, non-consumptive use, withdrawn water use from surface and groundwater sources, water footprint, etc. Each of these measures and the degrees of water use is suitable for particular intentions and purposes. Water Footprint is a known measure of water use related to signal consumption of a person, a group of people, or a production chain. Figure 2.3 shows the world countries' water footprint in which green countries are the nations with equal water footprint or smaller than the global average. Regions in red color have a water footprint beyond the global water footprint average. As Hoekstra and Chapagain's (2017) research shows, there are large differences among countries: the USA average water footprint is 2480m3/cap/yr while China has an average water footprint of 700m3/cap/yr (Figure 2.4).

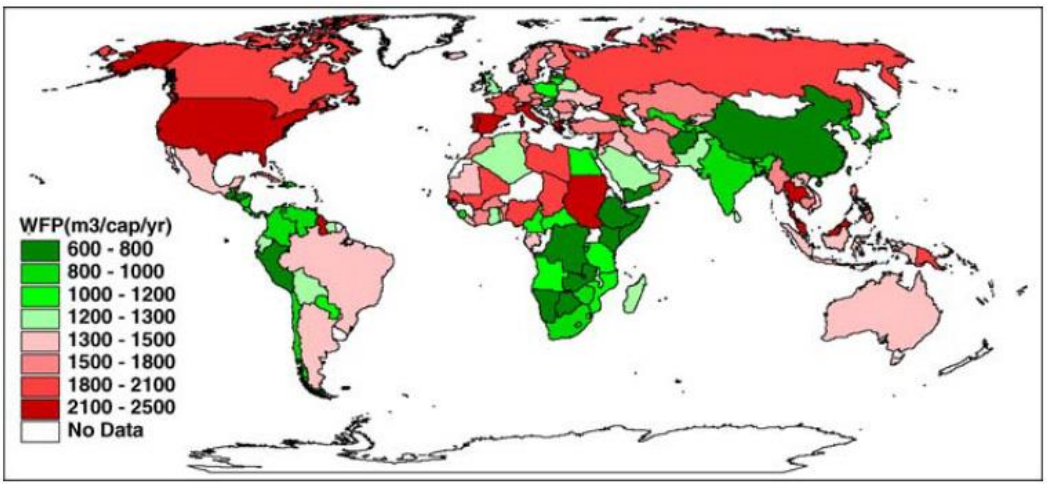

Figure 2.3 : Average national water footprint per capita (Mekonnen & Hoekstra, 2016).

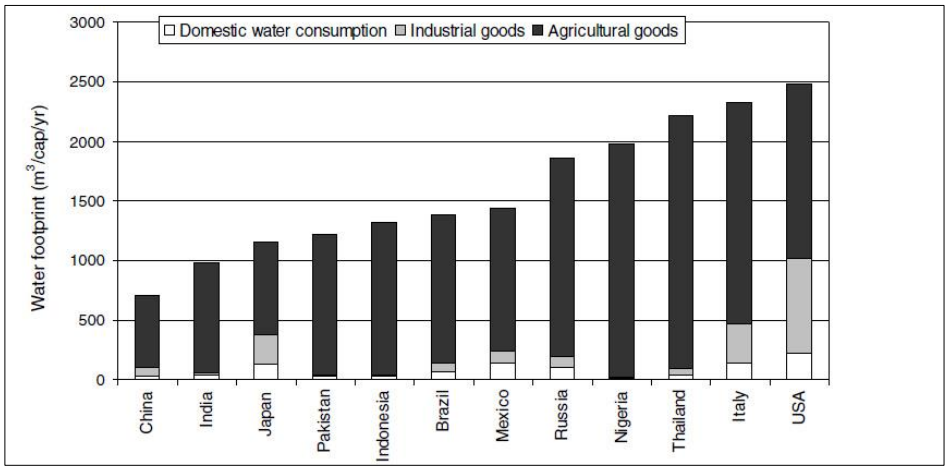

Figure 2.4 : Countries' water footprint (per capita) considering water consumption in different sectors (Hoekstra and Chapagain, 2017).

The most important drivers as to the large water footprints were recognized by Hoekstra and Chapagain (2017), which are respectively:

- Gross national income of a country that explains the reason for the large water footprint of Switzerland, USA, and Italy,
- Water-intensive consumption patterns can partially explain the giant water footprints of Canada, Spain, France, the USA, Italy, Portugal, and Greece. High use of industrial goods and meat causes a large water footprint. For instance, the average meat use in the United States is 120 kg/yr, more than three times the world average meat consumption.
- Climate is another factor of different and high water footprints of the countries. In areas with high evaporation, such as Mali, Senegal, Chad, Sudan, Syria, and Nigeria, the water need per crop production unit is almost large.
- Water-inefficient agricultural activities in Cambodia, Sudan, Thailand, Turkmenistan, Nigeria, and Mali, Water productivity in terms of output per drop of water is relatively low (Hoekstra and Chapagain, 2017).

Decreasing water footprints can be performed in different ways (Hoekstra and Chapagain, 2017), which are:

- To disconnect the current relationship between increased water consumption and economic growth through utilizing production methods that need low water per unit of production. For instance, water productivity can be grown in agriculture through supplementary irrigation and rainwater harvesting techniques.

- To change and replace consumption patterns into the patterns requiring less water and decreasing meat consumption. As there are subsidies in the water sector, water cost is not usually reflected in the product price. Consumption patterns are affected by awareness-raising, pricing, product labeling, or incentive programs that make individuals motivated to replace their consumption behavior.
- To move production from regions with low water to places with high water productivity, thus raising global water use efficiency. Like what happened in Jordan for externalizing its water footprint by importing wheat and rice products from the USA (having higher water productivity). Currently, 16% of global water use is not designated for domestic production but export productions. Thus, studies on water policy should consider and analyze interregional or international virtual water flows.

2.1.2 Urban water scarcity

Rapid population growth, urban expansion, and economic growth have posed significant global water challenges in urban areas (Yang et al., 2016). Cities are facing spreading vulnerability to water stress due to several reasons, including rapid development, climate change, population growth, water pollution, increasing water use (Kennedy et al., 2012), declining revenues, aging infrastructure, and a range of other challenges (Whitler and Warner, 2014). In 2014, 54% of the global population (3.9 billion people) lived in cities. Two-thirds of the world population will be living by 2050 in urban areas. Besides, most of this population growth occurs in developing countries with limited capacity to handle these challenges (WWAP, 2015). Main water-related challenges in the cities are access to sanitation and water supply, pollution and wastewater management, institutional capacity and water governance, climate change, and water-related disasters (WWAP, 2015). Here some primary reasons for water scarcity in the cities are explained.

- Population Growth of Cities: the world's population has increased to 7 billion people, that more of them live in megacities than in rural regions. Today, 3.3 billion persons live in cities, according to the United Nations Population Fund, this number is predicted to increase to 4.9 billion by 2030 (UNFPA, 2007). This rapid population growth will be in Asia and Africa between 2000 and 2030. It is measured that 70 percent of the world population will be living in

urban areas by 2050 (UN-Habitat, 2009). It means that the cities will absorb the world population growth (Leeuwen and Sjerps, 2016).

- Climate Change: it assumes that climate change will become drier, hotter with more variable climate regimes, especially in locations of the world that are already arid (Kennedy et al., 2012). Climate change will cause more extreme and frequent weather, which will change the water quality, quantity, and seasonal water availability in urban regions. There is a risk of climate-related disasters in the coastal cities located close to water bodies (Bahri, 2012).
- Urban Rapid Development (Urbanization): today, there are more than 400 cities, more than 1 million residents, and 23 megacities (mainly in Asia) in the world (UN, 2012). Metropolitan regions with more than 10 million are becoming large and standard (Cohen, 2004). There were only two megacities in 1970 (Tokyo and New York), ten megacities in 1990, and 23 megacities in 2011. They will be 37 megacities by 2025 (Leeuwen and Sjerps, 2016). While the expanded urbanization has resulted in greater socioeconomic chances and enhanced social welfare, it is developing additional pressure on water resources ecosystems (Savenije et al., 2014). Water resources are vital to preserve the environment and public health and to support the economy and community development (Whitler and Warner, 2014). Residential areas have increased beyond the urbanization plans because of the population growth that unfortunately caused illegal housing growth. Urbanization and community development, either legal or illicit, consumes a large amount of green land, forest, agricultural areas, which deteriorate the environmental and natural cycles. Therefore, increased urbanization presents planners and policymakers with many challenges and competition for water resources (Malano et al., 2014).
- Increasing Per Capita Water Use: overusing water resources is a global issue, mainly in large cities (Hoekstra and Chapagain, 2007; Notovny, 2010). The rate of water consumption rapidly increases in the cities as urbanization and population growth expand. Global water consumption grew sixfold (more than two times the population growth rate) between 1900 and 1995 (Bahri, 2012). Furthermore, economic development and new technologies like washing machines, showers, and dishwashers increase domestic water use and per-capita water use.

- Aging infrastructure: old water infrastructure, water pipes replacement, and water equipment need over time have been issues in many cities. Many water infrastructure has made problems due to surpassing their expected lifetime (Whitler and Warner, 2014). Planners should work with water sectors and institutions to analyze the water infrastructure upgrades required to ensure enough drinking water supply (Whitler and Warner, 2014).

2.2 Sustainable Development and Water

The cities' fast growth has raised challenges as to megacities 'impact on the natural resources and their future sustainability (Mitchell, 2006). According to the many kinds of research, the cities are related to leading global issues such as climate change, water scarcity, biodiversity degradation (Grimm et al., 2008; UNEP, 2012). In the late 20th century, people discovered that the only way for sustainable economic progress is to understand the relationship between environmental preservation, development of the economy, and social inclusion. In this way, sustainable development as a concept has emerged. The foundation of sustainable development was laid in 'Our Common Future,' known as the Brundtland Report from the United Nations World Commission on Environment and Development (WCED, 1987). It was defined as a "development that answers the requirements of the present's requirements, the ability of future generations to meet their own needs." Sustainable development considers economic growth and prioritizes environmental issues, improves the equitable distribution of wealth, and empowers the community rather than marginalizing them (Chandniha et al., 2014). The concept of sustainable cities is an international movement, including making the towns healthier, greener, and sustainable places for their inhabitants. In another definition, sustainability is enhancing the quality of human life while maintaining the supporting ecosystems' carrying capacity (van Leeuwen et al., 2012). Sustainable Development has resulted in holistic agreements on several fundamental principles to shape practice and policies which are

- Integration of environmental protection and economic development;
- Making equity among rich and developing countries;
- Improving technical and scientific knowledge related to sustainability;
- Protecting citizens from ecological issues by governments;
- Making the polluter pay for restoring deterioration of the environment;

- Carrying out the environmental impact assessment and negative ecological consequences of projects before initiation;
- Considering the specific roles for young people, the needs of future generations, women, indigenous people, and traditional practices and knowledge as to environmental management.

Water is central to the sustainability concept (Gregory and Hall, 2011). Many Millennium Development Goals at the Millennium Summit (September 2000) as the most significant meeting of world leaders in history were directly or indirectly connected to water issues. Sustainable development in urban areas requires easily accessible, equitable, and reliable water. Supplying water demand to the fast-growing urban populations in developing countries has generated a complicated problem. It is exacerbated in cities where urban growth is unplanned, as it is difficult to project and monitor water demand and consumption (Russo et al., 2014). Water system sustainability deals with challenges related to infrastructure, sanitation, socio-economic conditions, and water resources. Meeting water demand and water infrastructure for the cities' growing population are among the main challenges in the cities' water sustainability (Kennedy et al., 2012). Most of the river basins suffer from mismanaged governmental institutions and inadequate information on the riverine ecosystem drivers and their dynamics (Mencio et al., 2010). Therefore, governmental and technical management should be considered in their sustainable management (Ludwig et al., 2014).

2.2.1 Sustainability

One of the most popular sustainability principles is the "triple bottom line approach," which comprises environmental, economic, and social sustainability dimensions. These principles have been vastly utilized to create other sustainability frameworks in different areas. In city development, two indicators of assets and governance are added to those three disciplines (Figure 2.5). In general, the sustainability concept covers five main groups, including the natural, economic, social, physical environments, and governance, which is explained in the following text.

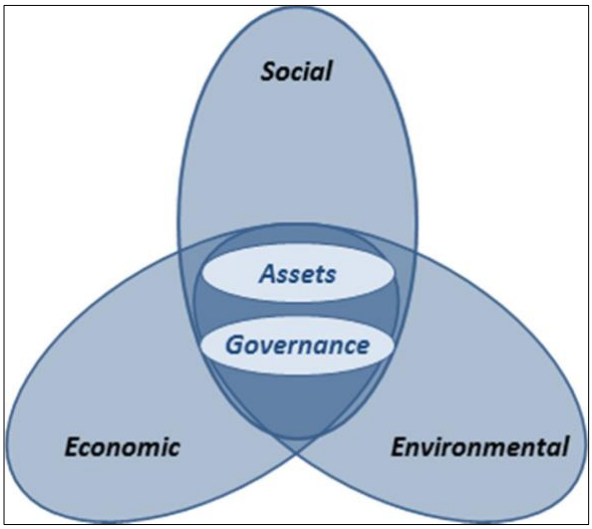

Figure 2.5 : Dimensions of city sustainability (Brattebø et al., 2013).

2.2.1.1 Sustainability and natural environment

The current usage of the natural resources has to be organized to maintain the necessary life-support cycles, thereby not compromising the use of coming generations of the same resources (Jønch-Clausen and Fugl, 2001). Natural resources include land, water, air, airspace, geology, ecosystem, minerals, energy, petroleum, gas, sand, forests, wildlife, fish, and aquatic resources. Mismanagement of renewable resources often makes them more ephemeral and limited than fixed geological resources. Conservation of natural wealth like water, vegetation, animal, soil, etc., is at the center of resilience. Three main aspects of environmental sustainability are:

Ecosystems, biodiversity, and ecological services

Environmental Sustainability also mean meeting human requirements without compromising the ecosystem's cycle and health. An ecosystem includes animals, plants, and microorganisms living in biological communities and interacting with each other and their chemical and physical environment. The synergistic feedbacks exited between organisms and their environment have sustained the functions of ecosystems. Human development should consider the production effect on ecological cycles and protect them in the current natural environment. Ecological systems play critical roles in sustaining life support systems on Earth by flood controls and drinking water supply, amelioration of climate, waste assimilation, generation of soils, recycling of nutrients, pollination of crops, maintenance of species, and maintenance of the landscape scenery, aesthetic values, and recreational sites. The services of ecosystems are categorized into four groups:

- The provisioning services that are the products achieved from ecosystems, such as genetic resources, food, pharmaceuticals, natural medicines, freshwater, and energy resources;
- The regulating services that are the benefits caught from the regulation of ecosystem processes, like water purification, air quality regulation, climate regulation, waste treatment, disease and erosion regulation, water regulation, and natural hazard regulation;
- The supporting services such as nutrient cycling and dispersal, soil formation, photosynthesis, and water cycling;
- The cultural services like the non-material benefits achieved from ecosystems to the people through cognitive development, spiritual enrichment, recreation, reflection, and aesthetic experiences (Novotny et al., 2010), (Figure 2.6).

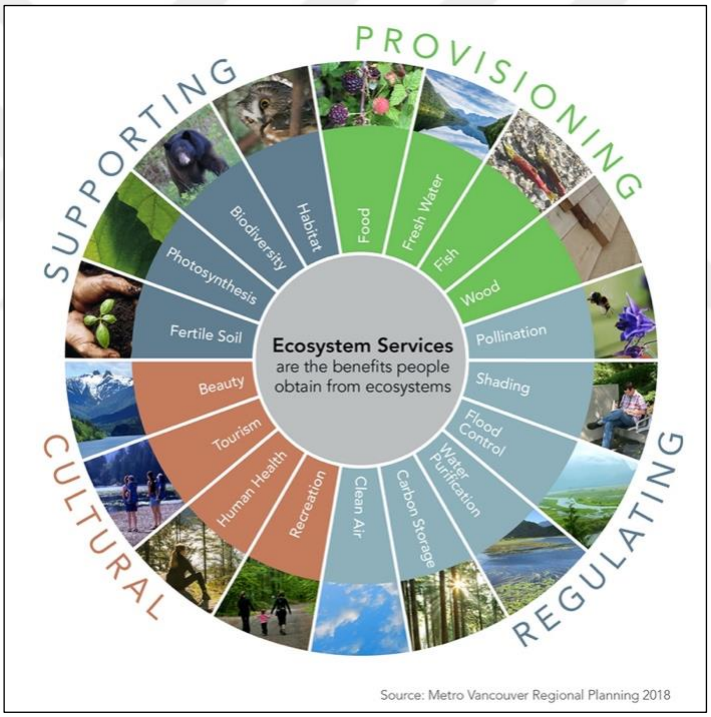

Figure 2.6 : Four categories of ecosystem services based on the Millennium Ecosystem Assessment.

Biodiversity at various genetic, species, population, and ecosystem levels contributes to keeping the ecosystem functions and services. The destruction of biological diversity has been a challenge and caused a reduction of physical heterogeneity in both marine and terrestrial species involving fora and fauna required for the stability of the ecosystems.

Natural sources (water, forest, and land)

Land and agricultural degradation is an issue defined not only with the reduced soil quality but also the diminution of the whole ecosystem and the involved biodiversity, ecological systems, ecosystem provisions like carbon sequestration, food prices, and affecting all life forms. Water quality and water quantity are the main factors in the resilience of natural systems. Water quality is related to the physical and chemical attributes of water resources affected by anthropogenic and climatic changes in the water basins (Diamantini et al., 2017). Human pollution through agricultural, urban, and industrial activities have reduced the quality of water resources. The least stream flows are needed to avert significant damage to water bodies and the surface water's ecological process. Activities like water resource protection and hydrological system conservation must maintain the watersheds' water quantity (Ouyang, 2012).

Climate robustness (rainfall, runoff-temperature-humidity)

Climate change mainly refers to weather change over time, primarily in forms of variation in precipitation, wind, temperature as the primary focus. Climate change will cause situations such as heavy precipitation, glaciers melting, unusually warmer weather, polar warming, more extended droughts and dry seasons, coral-reef bleaching, sea-level rise, distribution changes of plant and animal, natural disasters, and increased environmental degradation. It is expected that climate change intensifies runoff patterns by the frequency and intensity of flooding and droughts in the water basins (Räsänen et al., 2017). Environmental hazards such as landslides, flooding, droughts, and extreme weather-related events also matter in ecological sustainability.

2.2.1.2 Sustainability and social environment

Social sustainability occurs when the human processes and the human relationships positively support the capacity of the resource for current and future generations to create healthy communities and promote wellbeing, through understanding what the individuals need from the places where they live and work. Socially sustainable societies are diverse, equitable, and democratic that promote a good quality of life (Western Australia Council of Social Services). In general, social sustainability includes five dimensions, which are:

- Equity (socially and economically fairness),
- Diversity (cultural diversity, diverse beliefs, viewpoints, backgrounds, cultures, life circumstances, and ethnic and racial groups),

- Social cohesion (sense of belonging, participation people in social activities, individuals accessibility to civic and public institutions, and the connection between the people and groups in the broader community),
- Quality of life (appropriate and affordable housing, mental and physical health, education, training, and skill development opportunities).

Socially water sustainability deals with all persons' fundamental right to access adequate water with good quality and quantity. The scopes of this dimension are the user' satisfaction, their needs and expectations, and the public acceptance of water services (Marques et al., 2015), sufficient food, sufficient water, sanitation and access to safe water, education opportunity, stakeholder participation in decision making, demand management, water consumption, acceptance and awareness of water basin planning, and relevant roles in the community. Water availability means access of the city population with potable water (Shen et al., 2011). Socio-economic development and population growth continuously expand water demands, water pressure, and water shortage risks (Zhou et al., 2017). Therefore, accessibility to drinkable water is one of the central social dimensions of water sustainability.

2.2.1.3 Sustainability and economic environment

Economic sustainability means keeping the resources, both human and material resources, to generate long-term sustainable values through optimal use, recycling, and recovery. Sustainable development is mainly mentioned to sustain a permanent income for humankind, obtained from non-declining capital stocks (Hicksian income). Permanent stokes of human-made, natural, human, and social capital (Spangenberg, 2005) are considered essential and often adequate in sustainable development criteria. It also means long-term costs for using resources. Maintenance of human sources and technology in a long-time are included in economic calculations.

Material consumption, organic farming, employment, public debt, price of water, construction in the riparian area, development of agriculture, per-capita gross domestic product (Xing et al., 2018; Shen et al., 2011), payment for ecosystem services, energy production, hydraulic power generation capacity are some of the economic sustainability-related sub-factors. Moreover, efficient water and waste recycling can contribute to proper resource management by providing benefits in urban and rural areas (Shen et al., 2011). In a water reuse project in Shenyang, water from industrial

cooling was sold for an urban car wash at a low price, street cleaning, and urban greening (Xiao, 2010).

2.2.1.4 Sustainability and built environment

Built or physical environment concludes living space, buildings, infrastructural elements related to waste management, transportation, and other utility systems to serve the building areas produced or developed by people. There are various environmental problems in cooling and heating buildings, new building construction, and transportation between facilities. Examples of those environmental issues are the deterioration of water and air quality due to the pollutants released from construction sites, the natural scenery disruption, and noise pollution caused by construction. Building for sustainable development includes applying construction methods, designs, and practices that function for integral quality of environmental, social, and economic performance holistically. In sustainable building, the environmental quality, the entire life cycle of facilities, the applicable rate, and future values are considered.
The European Commission's policy on the Urban Environment (2004) highlights four main challenges facing Europe's urban areas, which are: urban transport, urban environmental management, urban design, and sustainable construction. Sustainability-related indicators of the physical and built environment are:

- Local community participation in the design and planning process;
- Site orientation and placement to maximize passive solar, ventilation, and views;
- Air quality to remove external sources of pollution;
- Improvement of transportation infrastructure, public transportation, and embodied facilities and energy;
- Improvement of amenities such as housing, employment, education, and healthcare;
- Social integration (tenure, density, etc.);
- Accessibility issues for those with disabilities;
- Recycling potential on non-renewable resources using their durability, adaptability, etc.;
- Reduction of energy demand by design, renewable energy systems, and use of district heating systems;
- Historical and cultural values;

- Land use issues including soil erosion, pollution impact, mixed-use, high building density, etc.;
- Assessment of the environmental impact, including greenhouse gas emissions, air pollution, etc.;
- Reduction of water consumption by water-saving devices, etc;
- Habitat and biodiversity protection;
- Facilities management and life cycle planning and management.

Infrastructure reliability and capacity, adequacy of the rehabilitation rate, adequacy of training, knowledge transfer, capacity building, and information management are some of the physical sun-factors in water substantiality (Brattebø, 2012). The lack of sewage treatment systems in most rural communities has caused upstream pollution and reduced drinking water quality. The sewage generated from the single-family accommodations and other small commercials that are not connected to the municipality's water treatment systems is leaked to creeks, rivers, and other sources of freshwater (Kosolapova et al., 2017).

There is no doubt that the technologies can play a central role in water sustainability by providing some techniques in water distribution systems, irrigation systems, wastewater treatment, nutrient recycling, and water storage. All those technologies can expand the water supply and mitigate water use by efficient water use and water demand management (Yang et al., 2016). For instance, it is possible to harvest the rainwater into water tanks or infiltrate it into green infrastructures through technology. Rainwater can serve as clean water resources for landscape irrigation purposes (Gregory and Hall, 2011; Ma et al., 2015). Gathering available water reduces water shortages, especially during drought periods and dry seasons. The technology could also mean re-conceptualizing treatment plants from energy consumers to resource generators creating methane as a fuel source or fertilizer in agriculture (Russo et al., 2014).

2.2.1.5 Sustainability and governance

A right governance level is necessary, mainly when the resources are too limited to provide the people's minimum need. Governance for sustainable development refers to reforming societal institutions to improve the welfare of society. It includes a commitment to guarantee that the decisions respond to the current time's critical development priorities without undermining future generations' perspectives (Figure

2.7), (Meadowcroft et al., 2005). It is dealing with the government and the governance functions of other social actors. In general, sustainable governance is concerned with planning and managing social changes by democratic interactions and specific reforms. In developing courtiers, it needs the fundamental transformation of production and consumption to reduce the human impact imposed on nature. One main challenge with governance is corporate governance that can create an environment of confidence where the stakeholders, government, public, and service providers corporate. The European Commission has highlighted some excellent governance qualities that contain participation, accountability, openness, effectiveness, and coherence. Some of the fundamental requirements of sustainable management are:

- Integrating the economic, social, and environmental dimensions into social decision-making;
- Incorporating educational and cultural practice into sustainable development;
- Adapting to long term focus and changing unsustainable activities located in core economic sectors like construction, transportation, energy, manufacturing, resource extraction, and agriculture by multisectoral governance having connections among institutions at local, regional, national, and global levels into other decision-makers of stakeholders, citizens, and communities;
- Integrating diverse types of knowledge (natural and social sciences) into decision-making processes;
- Promoting a better understanding of social/ecological interactions;
- Sustaining appropriate political frameworks and supports for long term adjustment;
- Applying engagement as an education process by governments by acquiring experiments, experience, lessons, and options;
- Distributing the costs and benefits among social groups and identifying the public interest and government's appropriate role (Meadowcroft et al., 2005);
- Fortifying the persistency of social institutions and their capacity to adapt to unpredicted crisis and shocks;
- Creating suitable political structures for future decisions, policy design, goal setting, and performance monitoring.

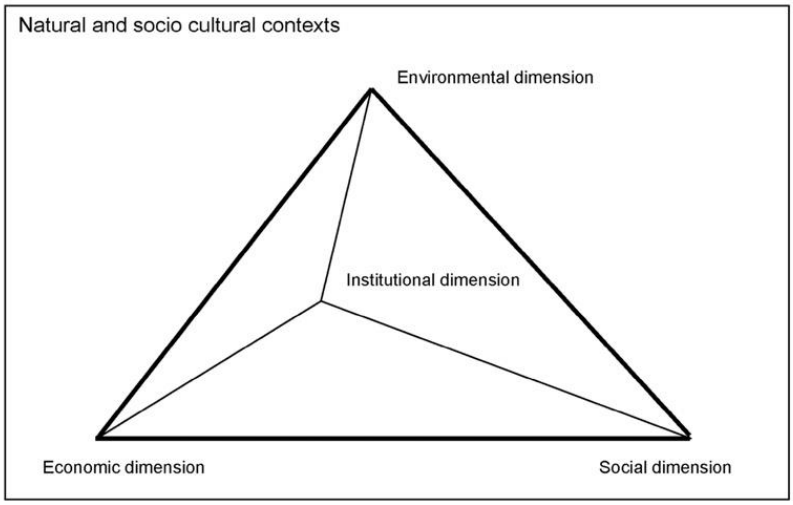

Figure 2.7 : Charter of sustainability (Meadowcroft et al., 2005).

Governance on water-related efforts means sustaining continuous administration over a long time of water basin planning. Cross-agency coordination for equitable allocation and ecosystem protection is vital in supporting water basins (Agyenim, 2011). There is also a need to integrate institutional aspects towards the water basin's sustainability (Belay et al., 2010). The responsibility of the government and public authorities, especially during the decentralization process, is essential. Governmental funding and annual financial input in education and institutional capacity building are often necessary for water basin sustainability (Dinar et al., 2007). Central government support is advantageous as long as it permits the stakeholders to take responsibility and conduct the reform process. In water sustainability governance, there is a need for stakeholder participation (Ludwig et al., 2014) to allow various users and policymakers involve at all levels (Durham, 2002). It contributes that all state and public stakeholders communicate in the decision-making process to enhance the people's awareness on the main problems like water shortage and resources management, improve the understanding of the regional water cycle, and develop knowledge of alternative water resources (Thomasa and Durham, 2003).

There is a set of general water criteria, principles, and indicators to develop a flexible and adaptable water sustainability framework. By utilizing the sustainability indicators, the local and regional water sectors can enhance their water sustainability by evaluating the condition. The leading sustainability indicators (social, natural environment, economic, built environment governance) related to the urban water, water resources, and management are summarized in Table 2.1.

Table 2.1 : Sustainability factors of water systems are recognized under each category.

Water Sustainability	Leading indicators related to the urban water and water resources
Natural environment	Water quality protection, efficient use of water, conservation of rivers, forests, and other natural resources, rehabilitation, and restoration of degraded ecosystems optimize energy and material uses, pollution prevention and control, wastewater management and treatment (Loucks and Beek, 2017).
Social environment	Water availability, human uses, health, quality of services, quality of drinking water, accessibility to financial and physical water services, acceptance of water payment, awareness of new water sources, role and social responsibility in water affairs (Marques et al., 2015).
Economic (financial) environment	Payment for water-related ecosystem services, ensure economic investment, approaches to risk/cost management (direct cost and indirect cost), water efficiency, risk-sharing policies, prices for irrigation and drinking water, the capital charges, the equitable cost for operation and maintenance, economical and environmental externalities, costs of water reuse, water recycle (Loucks and Beek, 2017).
Physical/Built environment	Land uses and density, build areas and location, cultural protection, adequate infrastructure, technical performance, reliable technology and their flexibility (Loucks and Beek, 2017), adaptability to climate change; engineering structures for dams and storage reservoirs and water-lifting devices, planning facilities for navigation, facilities required for the drainage systems, sewerage and industrial wastewater treatment plants, pumped-storage plants, hydroelectric power storage, so on.
Institutional environment /Governance	Institutional coordination, public participation, access to information and documentation, the mechanism for accenting collective and individual uses, clearness of policies, and strategies align with city planning (Marques et al., 2015).

2.3 Evaluation of Water System Sustainability

There are various methods and tools to assess water system sustainability using water managers and urban planners at multiple scales. Spatial variations, socio-political characteristics, and data availability determine the evaluation methods (Russo et al., 2014). In general, there are three primary evaluation methods for Sustainable Water Management in the cities.

2.3.1 Indicators and indices

There are various categorizations of urban water sustainability indicators that address extensive water resources such as lakes, aquifers, and urban water systems. The framework of water sustainability covers the necessity of environmental quality, water infrastructure, human health and welfare, economics and finance, institutions and society, and planning and technology. Align with those principles, Mays (2006) provides seven factors for water system sustainability. They are basic water needs of human and ecosystem health, a minimum standard of water quality, long-term renewability of water resources, institutional plans to resolve water conflict, accessible data on water sources for all sectors, and participatory water-related decision making (Juwana et al., 2010). According to Srinivas et al. (2018), sustainable watershed management and planning are complicated operations covering economic, social, environmental, and technical factors.

The water index and indicators should quantify and simplify the data and information for evaluating ecological values. The indicator method provides simple numerical data, making it possible for the cases to be compared (Juwana, 2012). Developing indicators need serious effort to assess the link between water use and sustainability dimensions. There are no definite urban water sustainability indicators, as urban water sustainability should consider the city's temporal and spatial variables. However, some indexes may play an important role in sustainability. Peter and Nkambule, in their assessment (2012), assessed 25 indicators in four groups of financial, social/environmental, technical, and institutional.

According to their research, even though all criteria are essential, the social criteria involving equity and technical criteria (the system's functionality) are critical. In Table 2.2, some general indexes addressed water in sustainable development are defined.

Table 2.2 : Standard indices that address water in sustainable development are defined.

Index	Founder/ Year	Objectives	Main Indicator
Water Poverty Index (WPI)	Sullivan , 2002	To provide clean water to the people who are "water poor" have no available water because of different reasons such as long distance of water sources, high cost of water, and insufficient water infrastructure (Novotny et al, 2010).	-The water availability, -The people's capacity to access water.
The Canadian Water Sustainability Index	Policy Research Initiative, 2007	To measure community well-being in terms of the water resources, ecosystems, services, and community's ability to be effective water stewards.	-Resource (availability, supply, demand); ecosystem health (quality, stress, native fish); human health (reliability, access, impact); infrastructure (demand, treatment, condition); capacity (financial, education, training).
The Environmental Performance Index		To mitigate the environmental crisis to human health and to fortify ecosystem vitality and natural resource management (Novotny et al., 2010).	It covers environmental health and ecosystem vitality and provides a rational basis in environmental policymaking (Novotny et al., 2010).
The Watershed Sustainability Index	Chaves and Alipaz /2007	To integrate the Environment, Hydrology, Life, and Policy aspects of a watershed under three Pressure, State, and Response parameters to create an integrated assessment of the current situation of watershed management for a specific period in a given basin (Chandniha & et el, 2014).	The human activities, the quality of the watershed in the base year of study, the quantity and quality of natural resources, and the society's degree of intent to address ecological problems in the watershed (Juwana & et al., 2010; Chandniha & et el, 2014).
City Blueprint Index as Water management indicators	developed in the Netherlands	As a baseline assessment of urban water cycle services' sustainability, allowing a city to quickly understand how advanced it is in water management and compare its status with other towns (Novotny et al., 2010).	Sanitation, drinking water, infrastructure, water security, water quality, climate robustness, governance, and biodiversity and attractiveness (Van Leeuwen et al. 2012).

2.3.2 Product-related assessment

Product-related assessments can provide data on energy, water, and land needs for a specific product or a supply chain. Awareness of environmental protection and the negative impacts of both consumed and manufactured productions on the environment have led to developing tools to evaluate these impacts. Here, two methods of Life Cycle Assessments, Water Footprint are explained.

2.3.2.1 Life cycle assessments (LCA)

The life cycle is a series of consecutive stages of a production system, from natural resources or raw materials to final production and disposal (ISO 14040). Life cycle assessment evaluates the inputs, outputs, and the potential environmental impacts of a

product chain throughout its life cycle (ISO 14040). Four steps are recognized in an LCA assessment:

a) The scope definition step, including the system boundary and detail level, depends on the assessment's intended use and subject;

b) The inventory analysis phase (LCI), as the second stage is a data inventory of input/output based on research. It includes a collection of information that is necessary to catch the defined goals of the study;

c) The impact assessment phase (LCIA) is the third phase to achieve additional data needed to assess a product system and better analyze its environmental qualities.

d) The interpretation phase (the final step) summarizes and discusses the results of an LCI or an LCIA, or both as a basis for suggestions, conclusions, and decision-making regarding the definition of the scope (ISO 14040), (Figure 2.8).

LCA is one of several environmental management methods (e.g., environmental auditing, environmental performance evaluation, environmental impact assessment, and risk assessment) that might not suit all situations and cases. LCA defines a product system through stages of unit processes with a system boundary with defined input and output flow as elementary flows. The unit process is connected through flows of intermediate products or waste for treatments (ISO 14040).

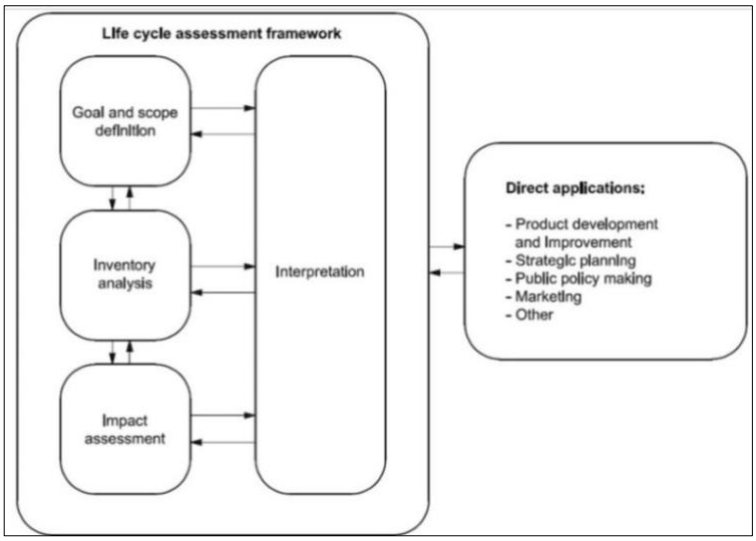

Figure 2.8 : Life Cycle Assessment Process (ISO 14040).

2.3.2.2 Water Footprint (WF)

A footprint family is a group of indicators that relate using the consumers' pattern and demand of production to the natural resources (Novotny et al., 2010). Three general

categories of footprint family are the ecological footprint, carbon footprint, and water footprint. A footprint enables quantitative assessments that describe the effect of human activities on natural sources and global sustainability. The concept of Water Footprint (WF) was introduced by Hoekstra and Hung in 2002 and further developed by Chapagain and Hoekstra (2007) as the total used water by an individual, household, business, sector, city, or country for various purposes from domestic use to the agriculture and production. It estimates the amount of direct and virtual (indirect) water consumption (Hoekstra et al., 2011). WF methodologies are being useful and applied in several cases at regional and global levels. In Southeast Asia, several Middle East cities have the largest footprint concentrations (van Leeuwen et al., 2012). However, its urban-level experiences are limited due to the lack of local data (Paterson et al., 2015).

Water is considered in three forms of blue water: rainwater and greywater (Hoekstra et al., 2011). The blue water footprint refers to the use or consumption of freshwater resources, including surface and groundwater. The green water footprint refers to the use of rainwater, which does not recharge in runoff or the groundwater. Rainwater can be stored in the soil or stayed on the top of the soil, consumed during the production process. The grey water footprint is the amount of freshwater needed for dilution of pollution load so that the water quality remains above the water quality standard. According to Hoekstra et al. (2011), a WF assessment, like Life Cycle Assessment, has four steps summarized in Figure 2.9.

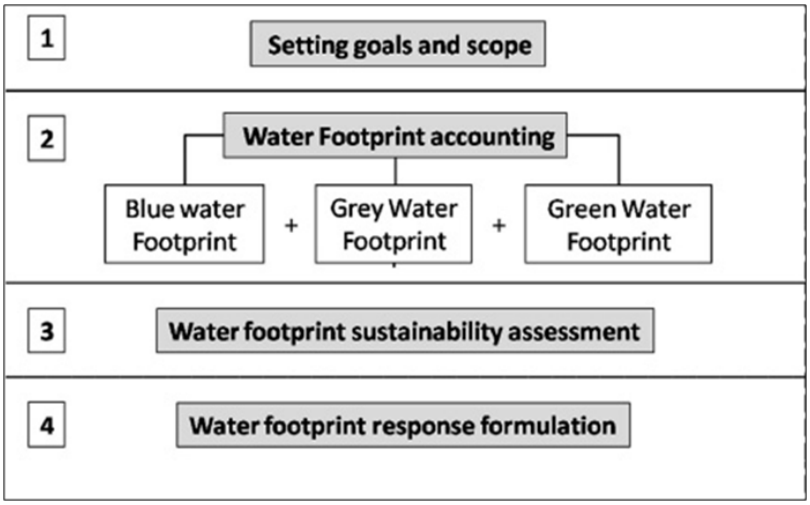

Figure 2.9 : Four distinct phases of Water Footprint assessment according to the Hoekstra et al, (2011).

The WF can be applied in one unique process phase or a whole production chain. For instance, the WF can be described as the WF of a user or group of consumers or the water footprint of a producer or the whole industry chain.

2.3.3 System-based tool

One of the System-Based tools is "Emergy," which is defined as the available energy used directly or indirectly in a production (Odum, 1996). This theory emphasizes that all functions of the world's current systems (ecological, economic, and social) are generated through energy transformation. This tool is based on energy flow and its pattern in the ecosystem and human structure. and defines energy quality in a hierarchical order (Ma et al., 2015). For example, to generate phosphate fertilizer, it requires more energy investment than generating wind energy, as phosphate needed fossil fuel in mining and phosphate formulation. Similarly, phosphate fertilizer has higher "energy quality" (Ma et al., 2015). Therefore, water quantity is not the only matter, but also the energy quality of water is an important issue. Emergy applies to water systems with elements such as drinking water, surface/groundwater, wastewater, stormwater, water basins, and their related infrastructures (Ma et al., 2015).

All material, energy, and information flow having different qualities can be holistically analyzed in a cycle. Thus, a system's attributes and pattern, including interactions with subcomponents, can be optimized, and its sustainability can be evaluated.

Emergy analysis of the urban water system concluded that the drinking water and wastewater treatment processes are massive energy-chemical-intensive processes. The energy values for drinking water are high due to the high energy requirement of electricity, and wastewater treatment comes from raw materials like soil, organic matter, fertilizers in food, and modern agricultural techniques (Ma et al., 2015).

2.3.4 Integrated assessment

Integrated sustainability assessment is used to assess urban water decision making. Integrated assessments aim to do a holistic review using impact assessment, cost-benefit analysis, risk analysis, and dynamic models. It provides robust quantification through a system perspective. Integrated Assessment is applied to resolve natural resource issues internationally. Integrated Assessment is defined as the scientific principle that integrates knowledge on a problem and makes it available for decision-

making processes. In another definition, the Integrated Assessment is an "Integration of knowledge from various disciplines aiming to solve complex societal problems, arising by the interaction between the environment and humans, in a way to sustainable development" (Croke, 2007). Integrated assessments include several standard features, which are:

- A problem focused function and a focus on key elements;
- Linking of policy to research;
- An adaptive, interactive, transparent framework improving communication;
- Connection of complexities between natural and human environment;
- Recognition of essential missing knowledge for inclusion;
- The team shared values, objectives, and experiences;
- Characterization and decrease of uncertainty in projection;
- And recognizing spatial dependencies, feedbacks, and impediments.

Integrated Assessment models need an adaptive process that incorporates both scientific knowledge and stakeholder in model development. As a part of an integrated assessment, models must be produced to act for other disciplinary components that contributed to the evaluation. That process should permit trust between stakeholders and scientists to contribute and resolve conflicts arising from the model application. Modeling and participatory processes should include stakeholder groups and the public at large (Croke, 2007). Models should be rather identifiable, with proper sensitivity to primary changes to the factors and data. A simple model can be easily discussed with the stakeholders. Hydrological models should develop inevitable consequences at levels of the catchment and scales of social and economic groups relevant to the issue being considered. The choice of scales and models in integrated modeling also depends on the modeling scopes.

2.3.4.1 Multi-Criteria Decision Model

The Multi-criteria decision model is an integrative process utilized to assess urban water sustainability with a central concentration on stakeholder participation. It assesses urban water cycle sustainability through weighting techniques that gather stakeholders' perspectives and preferences. Multi-criteria decision analysis could be described as a process that considers all factors and variables that can effectively solve problem-solving and determine the effect of those factors on the issue. Multi-criteria decision making has various stages, including determining scopes and objectives,

selecting elements to measure the goals, identifying alternatives, appointing weights to the details, and applying the proper mathematical formula for ranking options. The model includes some.

- In this method, all types of qualitative and quantitative data and attributes are included.
- The main criteria, goals, and scores are transparent for an open discussion.
- This participatory process is traceable, which lets you communicate the results and reviewing the model.
- It makes it possible to calculate one single aspect of sustainability or to regard all factors of the dimensions, which are beneficial for policy-making;
- As the procedure describes the results by the scores and weights, it is theoretically trustable.

After scoring each criterion based on the stakeholders' judgments regarding the sustainability principles, a simple aggregation model can be applied to stimulate the sustainability score for each urban water cycle. The responders or decision-makers may use the seven groups of the judgments, including 'no,' 'very weak,' 'weak,' 'moderate,' 'strong,' 'very strong' or 'extreme' difference to score the differences in preference (Marques et al., 2015).

The Analytic Hierarchy Process (AHP)

The decision-making process requires evaluating different factors, assessing alternatives based on the factors, and aggregating the assessments to get the partial ranking of the alternatives considering the problem (Bhushan and Rai, 2014). The the Analytic Hierarchy Process (AHP) has provided a better assessment and explanation of a problem by presenting a hierarchical structure model. For the first time, Professor Thomas L. Saaty produced the Analytic Hierarchy Process (AHP) as a Multi-Criteria Decision Making model in the 1970s. The AHP could achieve widespread application in various areas. Through this tool, the subjective evaluations are turned into numerical weights and values. Four main steps are defined in AHP, which are:

- Step 1: Determining goals, criteria, and sub-criteria

The most crucial part of decision making is decomposing the issue or problem into a hierarchy of scope, criteria, sub-criteria, and alternatives. It is fundamental to the AHP process that the decision problem is structured as a hierarchy (Bhushan and Rai, 2014). Various levels form a hierarchy structure: the first level is the research goal, the second

level includes the main criteria, and the other levels are related to the other sub-criteria (Figure 2.10).

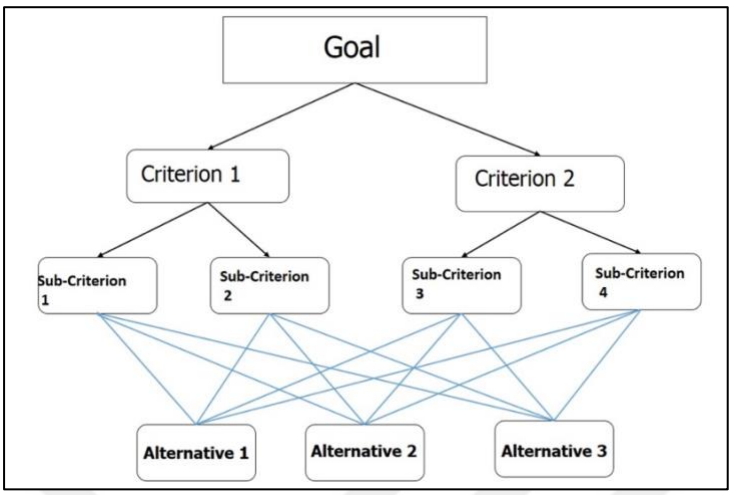

Figure 2.10 : AHP's method structure in decision making with three levels.

- Step 2. Collecting data

In the second step, information and data are gathered from decision-makers through a questionnaire. Then, a pairwise comparison of criteria and alternatives is asked based on the hierarchy structure. Experts can give value and rate to the comparison as equal, slightly strong, strong, very strong, and extremely strong (Table 2.3; Figure 2.11). The comparisons are performed for each criterion and turned into quantitative numbers (Bhushan and Rai, 2014). The experts must first develop priorities for the main criteria by a pairwise comparison matrix. The expert's members are then asked to compare the sub-criteria under the main criteria Finally, the alternatives are evaluated concerning each of the sub-criteria (Saaty, 1980).

Table 2.3 : Scores for the importance of variables.

Importance Scale	Definition of Importance Scale
1	Equally Important Preferred
2	Equally to Moderately Important Preferred
3	Moderately Important Preferred
4	Moderately to Strongly Important Preferred
5	Strongly Important Preferred
6	Strongly to Very Strongly Important Preferred
7	Very Strongly Important Preferred
8	Very Strongly to Extremely Important Preferred
9	Extremely Important Preferred

The number of judgments needed for a particular matrix of order = **n(n - 1)/2**

Where n is the number of elements being compared

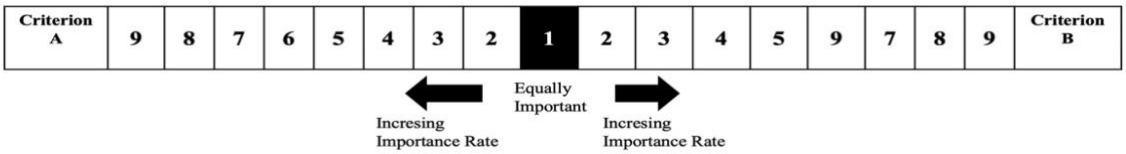

Figure 2.11 : The importance rate in pair comparison of two criteria of A and B; the importance rate of criteria is increased with choosing high numbers close to each criteria.

- Step 3. Developing comparison matrix

It is organizing the pairwise comparisons of various levels into a square matrix. The diagonal elements of the matrix are 1. The criterion in the *i*th row is better than the criterion in the *j*th column if the value of the element (*i*, *j*) is more than 1; otherwise, the criterion in the *j*th column is better than that in the *i*th row (Bhushan and Rai, 2014), (Table 2.4).

Table 2.4 : Pair comparison of the criteria level.

	Criterion1	Criterion 2
Criterion 1	1	3
Criterion 2	1/3	1

- Step 4. Calculating Principal Eigenvalue

There are several methods for calculating the eigenvector (Coyle, 2004). The principal eigenvalue of the comparison matrixes and their normalization give the relative importance of the diver's criteria being compared. Multiplying the numbers in each row of the matrix and then taking the nth root of that product gives the eigenvector. The nth roots are summed and used for normalizing the eigenvector elements to add to 1.00. The normalized eigenvectors identify the weights of each criterion or sub-criteria among the others (Bhushan & Rai, 2014), (Table 2.5).

Eigenvalue =Nth Root of data multiple =Π= $\sqrt[n]{a1a2a3a4 \dots \dots .}$

Table 2.5 : A Square Matrix of the pairwise comparisons among three sub-criteria, as an example.

Criteria	Sub Criterion 1	Sub Criterion2	Sub Criterion3	Nth Root of Value Product	Normalization Eigenvector
Sub Criterion 1	1	2	8	2.51	0.594
Sub Criterion2	1/2	1	6	1.44	0.341
Sub Criterion3	1/8	1/6	1	.275	0.065

Furthermore, the AHP rates each alternative's rank based on the considered importance of one alternative over another for a common criterion (Bhushan & Rai, 2014). Therefore, each alternative's weight and value according to each sub-criterion are achieved.

- Step 5. Prioritizing the alternatives

Each alternative rating is multiplied by the sub-criteria's weights and aggregated to gain local ratings concerning each criterion. The local ratings are then multiplied by the weights of the criteria and aggregated to get global ratings.

Local derived scale (local rating) =∑(weight of each alternative × weight of each sub-criterion).

Global derived scale (global rating) =∑(weight of each alternative × weight of each sub-criteria ×weight of each criteria)

- Step 6. Consistency Rate (CR)

It is a mathematical index of the accuracy level of pairwise comparisons. For example, if item A is more preferred over item B, and item B is more preferred over item C., thus item A should be more preferred over item C. If not, then the comparisons are not consistent. And, inconsistencies arise in comparing three items, A, B, and C.

- *To get $A\omega = \lambda_{max}\omega$ and $\lambda_{max} \geq n$.*

Saaty (1980) proposed that a consistency ratio less than or equal to 0.10 is acceptable in the decision-making process. A lower consistency range enhances the accuracy. The bigger consistency ratio of a matrix is unacceptable, which means the decision-maker should review the judgments (Coyle, 2004).

- *The consistency index by CI = (λ max _ n)/(n _ 1)*

Where: λ max = maximal self-value (the maximum eigenvalue) of the comparison matrix of rank-n; *n* = the number of compared characteristics.

- *Consistency ratio (CR) =CI/RI*

where: *RI* = random index, dependent on the matrix degree.

The final step is to calculate the Consistency Ratio for a set of judgments using the CI for the corresponding value from large samples of matrices of purely random judgments using Table 2.6 derived from Saaty's book (Coyle, 2004).

Table 2.6 : The upper row is the order of the random matrix, and the lower is the corresponding index of consistency for random judgements (showing RI).

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
0.0	0.0	0.5	0.9	1.1	1.2	1.3	1.4	1.4	1.4	1.5	1.4	1.5	1.5	1.5
0	0	8	0	2	4	2	1	5	9	1	8	6	7	9

3. WATERSHED MANAGEMENT

Thousands of years ago, efforts to control rivers were initiated, and in the late 19th and early 20th centuries, the concept of the river basin as a unit for managing and planning water has emerged (Molle, 2006). In ancient times, human beings chose to live in a watershed like the Yellow River banks in China and the fertile crescent of Nile, Euphrates, and Tigris to provide their requirements and manipulate the basin for cultivation, floods, and drought control. Modern watershed management has roots in Romans and Greeks' urban water supply systems and tree planting on slopes and hillside terracing in Mediterranean landscapes. However, with watershed degradation, several parallel movements had emerged in the 19th century. Through top-down planning, Watershed management failed to protect the downstream assets due to less attention to the upstream communities. In the second half of the 19th century, the development and construction of large dams on river basins had followed various purposes: improving technology in building dams, the fear of water depletion, and industrial pollution of streams.

3.1 Concepts of River Basin and Watershed

River basins and watershed have been recognized as appropriate units for management and planning approaches (Wani and Garg, 2014). hydrology, a river basin, receives and collects the precipitation and surface water (snowmelt and rain runoff) and drains them off into a water body like a sea or lake. Water basins have covered a system of rivers (Russo, 2008) that contain the earth's groundwater.

According to their sizes, water resources are named differently: water basin, watershed, subwatershed, or water catchments. Watersheds are the geographical areas located inside the water basin that are smaller than water basins.

There are two kinds of water basins: close and open once. The closed drainage basin is streams that cannot reach their waters to the sea or pour into the lake. In the formation of closed basins, the ground shapes and the climate are practical. Open basins that drain into the sea emerge in coastal areas and humid climates. A particular

water basin response to different hydrological processes depended on its divers hydrological, physiographic, and geomorphological factors. Each watershed area has specific living and nonliving elements having interaction with each other and the environment. River systems are interconnected transfer systems that carry water, nutrients, contaminants, sediment, and biota across space and time.

Some definitions used in the determination of a water basin or watershed boundary:

- The confluence: the junction of one stream with another stream,
- Outlet: the lowest junction (the lowest elevation),
- Headwaters: the places where surface waters first begin flowing,
- Stream order: used to categorize the streams within a watershed. First-order is when a stream first begins (Figure 3.1).

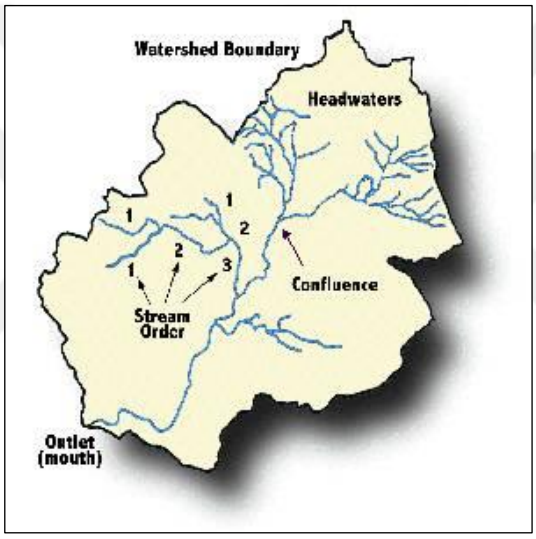

Figure 3.1: A shematic image of a watershed structure showing the Stream Orders, Headwaters, Confluence, Outlet, and Watershed Boundary.

3.2 Watershed Natural Structur

There are various forms of biotic materials (plants and animal species) and abiotic (non-living) components like air, water, and soil within the watershed. A watershed is not restricted to these physical and biological structures but includes interactions (called ecology) and various climatic, geomorphic, and hydrologic processes (Watershed academy web). In general, six necessary ecological attributes are identified by the EPA's Science Advisory Board (U.S.) for a healthy watershed, which are:

3.2.1 Hydrology

A Watershed is a hydrological unit that conducts the stream water and is drained out by a single outlet. Climatic processes, topography, geology, hydrological factors, surfaces, and underground characteristics play a critical role in creating basin discharge. Hydrological processes occurring on the land can be affected by various structures such as drinking water and sewerage network, roads, ponds, and other land and water use. The main factor which causes large fluctuations in discharge is rainfall over the year (Meybeck et al., 1992). Precipitation falling over the watershed can be stored on the water bodies, move as runoff to stream channels, infiltrate to the ground, or go as evapotranspiration. Quantity and fluctuation of water flow are dependent on the natural regimes and hydrologic connectivity, including interactions between the water surface and water ground.

3.2.2 Geomorphology

The topography and shape of a catchment are physical factors that determine how fast rainwater and runoff reach a stream or river. However, the watershed size, soil type, and construction influence the water flow in getting the stream. The structure of the sub-soil is also an essential factor of any watersheds. For instance, particular soil types like sandy soils are very pervious, and rainfall on these soil types is more likely discharged into the ground (Meybeck et al., 1992). In the impervious surfaces, the precipitation creates surface runoff having a high risk of flooding. Watershed components like sediment, water, organic matter, and valley characteristics such as slope, bedrock, width, soils, and vegetation define a river channel's morphology. Watershed inputs, sediment size and amount, and channel form should balance stream slope and flows. This natural balance called dynamic equilibrium is created in nature through various variables.

3.2.3 Landscape condition

Land cover and vegetation are leading factors in assigning the chemical and hydrologic characteristics of a water body. They regulate watershed hydrology, stabilizes soil, and protect habitat for aquatic and terrestrial species. The quantity, type, and structure of the land covering a watershed and various landscapes (Riparian forests, agricultural and urban landscapes) have different aquatic ecosystems. For example, the riparian forests regulate shading, temperature, and organic matter to headwater streams, while

agricultural and human landscapes increase runoff, sediment, and nutrient by reducing water infiltration. Therefore, it was suggested the protection of four types of landscape zones in the watershed, including 1) vital habitats, 2) water corridors, 3) undeveloped regions like forests, 4) buffers to filter water pollution hazards from aquatic resources, and 5) cultural areas including both terrestrial and marine ecosystems (EPA, 2012). There are four primary considerations in the watershed landscape, which are:

- Interconnection of the landscape patches, wetlands, and habitats are essential as they maintain the ecological process and natural functions.
- Natural connectivity through green infrastructure, rooted in Frederick Law Olmsted's idea of linking parks (Novotny et al., 2010), can create open and green spaces to meet both ecosystems and humans' needs.
- River as natural hydrology is a landscape element that establishes connectivity among habitats, terrestrial, and riverine elements.
- The natural disturbance regime (e.g., floods, fires, droughts, landslides, and debris flows), frequency, and intensity affect watershed ecosystems.

3.2.4 Water quality

Water quality is the chemical, biological, and physical quality of water containing organic matter, nutrient loadings, inorganic constituents, suspended solids, pH and dissolved oxygen, and physical parameters such as water temperature and turbidity (Novotny et al., 2010). These constituents are related to the natural hydrology of wetlands and are mainly dynamic. Various pollutants from different natural sources of anthropogenic actions are transferred in the water bodies through terrestrial, hydrological, or atmospheric processes and finally moved to the rivers (Mainali and Chang, 2018). Dissolved oxygen fluctuations in waterways are based on biotic activity, nutrient amount, streamflow, and temperature. However, the primary source of nutrients in the river is human involvement through agricultural and urban land-use. The monitoring of these parameters should be considered a part of a watershed ecosystem assessment (EPA, 2012). The primary focus of a water resource management and plan is about measuring and restoring water quality.

The water quality of rivers shows large spatial and seasonal changes (Mainali and Chang, 2018). Pollutions based on their sources are in two groups: point sources of

pollution appear where damaging substances are sent directly into a water body, like from sewage treatment plants or industrial sectors. These sources are easily detected since pollutants are discharged from one source (New York State Department of State, 2009); nonpoint pollution sources emerge where pollutants indirectly come in the water at several points and locations from various sources. Pollutants that impact the quality of water are categorized into five types according to their sources which are:

- Nutrients from sources like on-site septic systems, livestock waste, and lawn fertilizers leading to the growth of algae and aquatic plants: Those plants are consumed by bacteria that cause the decrease of oxygen in the water. The low amount of oxygen can hurt fish communities and disturb water quality (New York State, 2009);
- Organisms like pathogens associated with low and slow overflows: that may cause polluting drinking water sources, and destroy shellfish beds, and diseases;
- The sediment of construction sites, eroding streambanks, or road surfaces: disturb water quality. Recreational activities and boating may be affected by deposition, and deposits may impair the habitat due to altering substrate composition and turbidity water temperature (New York State, 2009).
- Hydrocarbons in grease and oil leaking from cars on parking lots and roads: can be transported to the rivers or accumulated in the sediment at the stream bottom. It can hurt aquatic organisms;
- Trash and floatables from road runoff: can pose both health problems and aesthetic issues. They often have grease, heavy metals, oil, and other toxic ingredients affecting water quality.

3.2.5 Biological condition

Biodiversity contains the primary aspect of a watershed biological condition: the number of species in a region and the life diversity at all levels from genes to ecosystems. The natural state determines a watershed's ability to maintain and support an integrated, balanced biological diversity condition and their composition in the area. Biological community and genetic diversity, species health, composition, population size, and other species' conditions affect watershed health and support ecological process. Aquatic habitats are affected by vegetation cover and landscape conditions through the dynamic linkage among aquatic and terrestrial elements in a watershed.

For many biological assessments, it uses reference conditions as a model to determine the watershed's biological health. Reference condition is a natural aquatic community model without human pollution and intervention (EPA, 2012).

3.2.6 Habitat

Aquatic habitats, riparian, wetland, floodplain, lake, and shoreline communities are directly related to the watersheds' physical and chemical characteristics of water and geomorphic processes—different habitat types (number and distribution), hubs, and connectivity influence the population health. Various habitats serve different ecosystems like cool water rivers, support diverse species, and regulate minerals inputs to the aquatic system (Figure 3.2). They needed to have hydrologic connectivity with the river channel and surrounding ecosystems to be maintained. The biological communities are adapted to the wetland's environmental conditions. Nutrient availability is low in some wetlands due to the low oxygen availability to the plants and slow decomposition. However, in other wetlands, the organisms feeding species of shellfish, amphibians, fish, and insects are developed because of the high levels of nutrients productivity. Furthermore, many birds and mammals depend on the wetlands for water, food, and shelter, especially over breeding and migration.

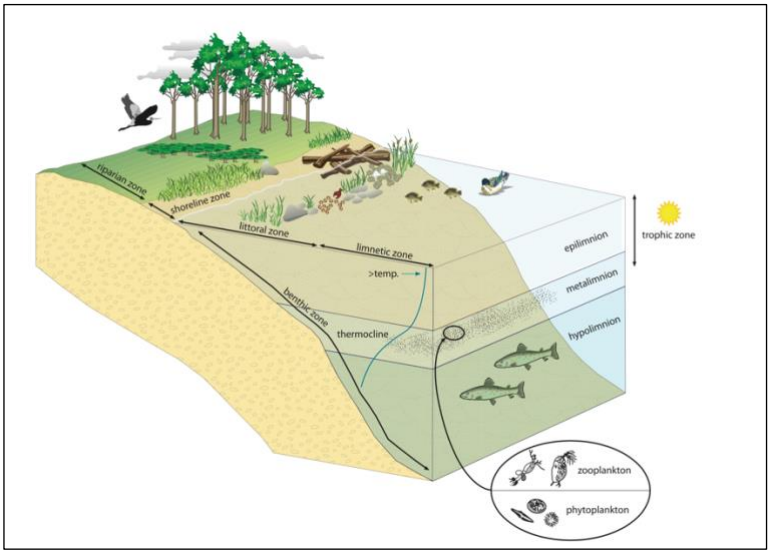

Figure 3.2 : Three habitat zones of the lakes: the littoral zone (with sufficient sunlight), the limnetic zone with no light penetration, and the benthic zone (consisting mud and sand supporting many fish life) (EPA, 2012).

3.3 Watershed Protection

Watersheds are associated with social-ecological systems, which means that human communities' health and well-being are dependent on the health of the watersheds and vice versa. This relationship is protected by maintaining their diverse ecological and social structures and adapting to unexpected characteristics of natural processes (EPA, 2012). There are also many economic benefits to protecting watersheds, including:

- Creation of water-related recreation opportunities like fishing, swimming, boating, and ecotourism opportunities;
- Minimization of the vulnerability to floods, fires, and other natural disasters;
- Contribution to water supply for human needs, agricultural and industrial uses;
- Reduction of costs needed in drinking water treatment by protecting surface water sources and aquifer recharge zones;
- Mitigation of the climate change effect by holding vast amounts of carbon (U.S. Environmental Protection Agency, 2011a) and regulating flows during droughts and large storm events.

However, watersheds are under various threats posed by humans by changing land uses, water pollution, environmental degradation, and intervention in rivers' hydrological cycle by bed streams and landscape changing. For instance, phosphorus, nitrogen, and potassium fertilizers have adverse effects on the ecological processes. The drainage basin carries the mineral components to the outlet (mouth), and with their aggregation, the natural balance is disturbed. Watersheds should be protected as integral systems by understanding their critical ecological attributes (Figure 3.3). For maintaining the ecological integrity of aquatic ecosystems, it requires understanding the chemical, biological, and physical condition of water bodies and vital watershed functions and attributes (hydrology, geomorphology, and natural disturbance pattern). Those processes generate freshwater ecosystem characteristics, including stream channel, organic matter inputs, habitat structure, soil productivity, and so on.

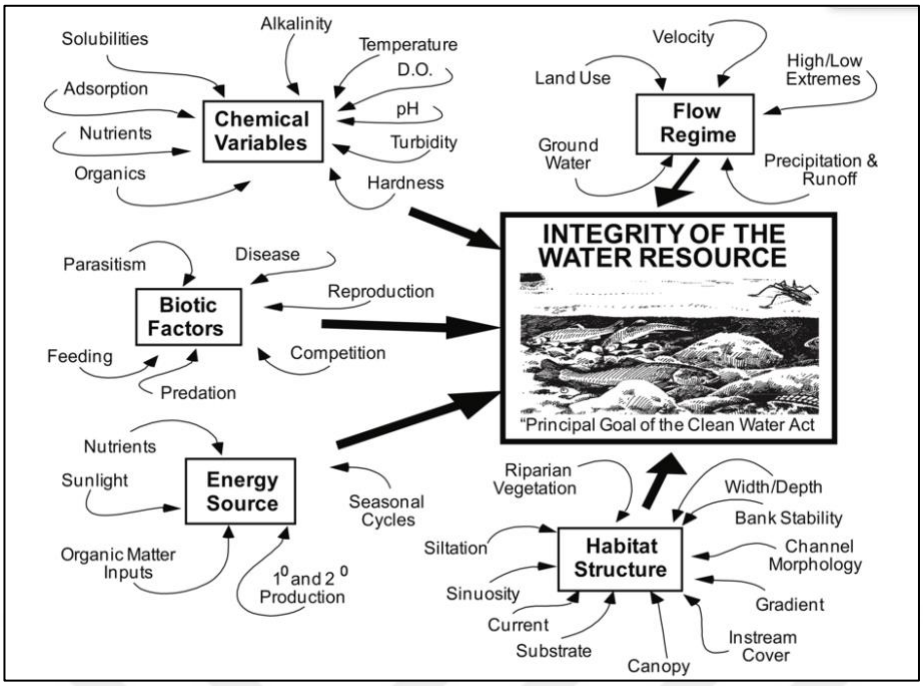

Figure 3.3 : The five main factors that determine integrity of the wetlands (EPA, 2012).

Wetland protection means to support the ecological process of the aquatic region such as rainfall-runoff, groundwater recharge, plant succession, sediment transport, and other processes that provides beneficial services and functions. The watershed's natural functions are categorized into three ecological functions:

1. Storage and transportation of minerals such as organisms, water, sediments, energy, and so on: As a watershed is a region that drains into a common outlet, its primary function is temporary storing and transporting water and other minerals besides water.

2. Natural transformation and cycling: divers components, biota, and materials in the watershed are associated with cycles of nitrogen, carbon, and phosphorus. Biogeochemical cycles involve the components transported in the watershed and cause the chemical transformation and change.

3. Ecological succession: in watershed terms, succession is a process that circulates a large volume of the watershed's water, energy, and materials from the abiotic environment back into the biotic or from a group of predominant organisms to a set of dominant microorganisms. Succession may gradually establish vegetational structure changes affecting the habitat and diversity and create renewable resources for humans.

3.4 Watershed Management Approaches

Basins are the largest watershed management unit. Water Basins, including surface and groundwater, collect almost one-third of the world's available freshwater. The water basin is used for industrial and domestic water consumption and agriculture (Du et al., 2018). Each basin covers a group of watersheds and smaller watershed called sub-watersheds. They contain vast areas from several hundred to thousands of square miles, including agriculture, forest, suburban, and urban areas. Livestock and people are the indispensable part of a watershed, and their functions influence the productive situation of watersheds and vice versa. Therefore, the watershed is not only the hydrological unit but a social, ecological, and political entity that has a significant role in providing social and economic security, food, and life-related services to rural residents (Figure 3.4).

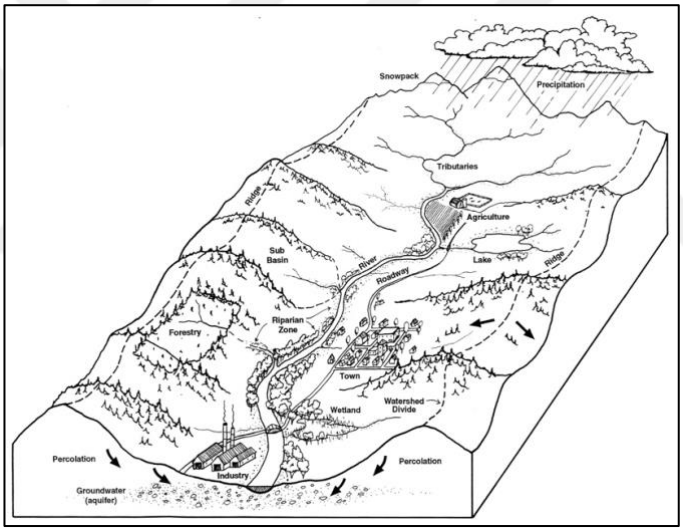

Figure 3.4 Perspetive of a watershed.

3.4.1 Integrated Water Resource Management

In the past, water-related sectors, including wastewater treatment, water supply, solid waste management, stormwater drainage, and sanitation, have been planned as isolated sectors under a central administration. Fragmented water resources management has posed the water resources degradation in many watersheds as it had failed to distinguish between different water qualities for various uses (Bahri, 2012). All domestic water was treated to drinking water standards, and water was used only once and disposed of with a considerable volume of materials and energy. Lack of appropriate infrastructure and high transaction costs in the centralized management of

water basins had worsened the problems (Dinar et al., 2007; Kharrazi et al., 2016). With population growth, it became expensive to aggregate water services over vast areas and transport water over a long distance by pumping energy. Besides, the whole system was vulnerable to hazards, such as draughts and salt loads (Raucher and Tchobanoglous, 2014). Therefore, due to these problems, conventional water management became outdated, and a new paradigm of "integrated water management" has emerged at both levels of urban and basin water management.

3.4.1.1 Theory framework

The concept was described in Agenda 21 through the International Conference on Water and the Environment in Dublin (1992) (van den Brandeler et al., 2018). Dublin-Rio Principle (UNCED Rio de Janeiro, 1992) emphasizes that blue water is limited while necessary to sustain life, the environment, and economic development. Thus, watershed management should consider the water resource social, economic, environmental, and technical dimensions. The Global Water Partnership defines IWRM as a process that promotes the coordinated management and development of land, water, and related resources (human-environment relations), to improve the economic and social welfare equitably without compromising the resistance of critical ecosystems (Molle and Mamanpoush, 2012). The new paradigm at the basin scale highlights the decentralization of watershed management to the lowest level, the stakeholder participation, cross-agency coordination, and the protection of the ecosystems (Agyenim, 2011). It provides several tools and strategies that should be planned for a watershed to improve the surface water and groundwater (Safavi et al., 2015). Main integrated management goals in watershed planning are:

- Soil protection and control of erosion, landslide, flood, overflowing,
- Water production at the desired quantity and quality,
- Improvement of the socio-economic situation of the basin and rural development,
- Achievement of forestry objectives,
- Conservation and development of wildlife and biodiversity production,
- Land use purposes and organize,
- Preserving cultural resources,
- Land and water management integration,
- Sustainable irrigation for agriculture,

- the best development of natural resources, watersheds, infrastructure, agriculture, social services, etc.,
- Recreational goals,
- Reclamation of the degraded land natural resources in a conservative approach,
- Development of methods in the use and control of natural resources with the advancement of civilization and technology,
- Conservation of water ecosystem, their enhancement, and sustainable water use.

3.4.1.2 Integration aspects

Adopting an Integrated Water Resource Management (IWRM) that considers all relevant technical, social, economic, and environmental factors need to consider integration at relevant scales and water sectors, at relevant disciples, at administrative levels, and in the environment systems. Biswas (2004) presented 35 categories for the integration aspect, but according to Grigg, 2008, we consider seven main types which are;

- Integration across policy sectors: the governments establish the inherent interdependencies of nature and economic and social sectors in IWRM through primary policy sectors such as environment, natural resources, agriculture, public health, transportation, energy, and emergency management (Grigg, 2008).
- Integration across water sectors: it integrates water sub-sectors such as water quality, water supply, irrigation, environmental water and flood control, hydropower, navigation, and recreation. This integration can expand to contain all aspects of water use, water quantity and quality management in upstream and downstream, surface and groundwater integration, and freshwater and coastal zone management (Kidd and Shaw, 2007).
- Integration of geographic units and the surrounding environment: it involves basin management and management between basins. The water supply of a basin may be wastewater from another basin (Grigg, 2008).
- Integration across government units: it includes integration of vertical levels such as the national, regional, and local levels, and horizontal dimensions such as government units at the same level.

- Integration among management functions: it needs alignment among experts, planners, finance staff, engineers, and other organization members.
- Integration among organizational scales and administrative tools: It is integration across phases of management like policy, design, planning, construction, implementation, treatment, recycling, and so on (Grigg, 2008; Jønch-Clausen and Fugl, 2001).
- Human sectors and disciplines integration: Disciplines and professions should be included in water resources management as an interdisciplinary process. This integration is cross-sectoral integrations for spatial planning and water management on both sides and inter-agency integration among public, private, and voluntary sector interest in water management (Kidd and Shaw, 2007).

3.4.1.3 Main techniques and achievements of IWRM

Each water basin is a complicated system with various ecosystems inside, with cultural, ecologic, social, and specific nature. For providing an appropriate integrated management plan, it should create the water basins characterization, goals and the problems identification, setting of data collection networks, environmental impact assessment, risk management, and data communication through raising awareness.
According to the various studies and projects, some main achievements through the integrated river basin management are identified, which are:

- Decentralization: it means the devolution of authority from the center to the lowest sector and admission of responsibility by local communities in the watershed management (Dinar et al., 2007). The lowest level refers to the water users and stakeholders' involvement in basin management. Governments, international agencies, and organizations are responsible for decentralization and subsidizing water resource management from centralized administration to the basin level management. One central aspect of decentralization is how much the stakeholders and users involve in the decision-making process (Thomasa and Durham, 2003).
- Stakeholders' participation: the stakeholder's involvement in the watershed level concerns all water-related functions such as planning, watershed assessment, implementation techniques and strategy, water quality maintenance, water allocation methods, monitoring, basin guideline, flood control, and monitoring (Chenoweth et al., 2001). The users' participation in

the decision- making process enhances public understanding of the regional water cycle and improves their awareness of water scarcity and alternative water resources (Thomasa and Durham, 2003). That may lead to efficient water use. Water resource management should be based on transparent participation in decision-making, which ensures access to the information. In this way, the community must address local issues in an integrated way (Safavi et al., 2015). Furthermore, to manage the water basin, the government and the water boards need the co-operation of other governmental organizations, citizens, land users, and the business community (Billib et al., 2009). There are various ways, such as public hearings, comment and notice procedures, and advisory committees, for public involvement in water resources management.

- Governmental budget: the government and public authorities are responsible for the large scale of water, including maintaining and monitoring the quality and quantity of groundwater, river, and lakes rivers (Thomasa and Durham, 2003). According to Dinar et al. (2007), the political economy plays a critical role in the decentralization process of the basin. It impacts the fulfillment in transaction costs and compromise required in the process. Sharing the decentralization process's budget and price needs many organizations and a considerable length of time within a river basin. Dinar et al. (2007) emphasize that water basin management's success is associated with the combination of three primary financial sources: central government support, basin revenues remaining in the basin, and financial responsibility on the part of water users. Payment for Ecosystem Services (PES) as a market-based tool is used to internalize the benefits provided by natural capital (Smith et al., 2015), which can ensure both ecological and economic scopes and demands (Fu et al., 2018).
- Water and Land Use Allocation: land-use changes the watershed and groundwater cycles (Du et al., 2018). Evaluating and assessing the land-uses in a watershed will contribute to the local stakeholders with appropriate decision making on protection and management strategies. Studies have proved that land-use activities such as agriculture have negatively affected the stream water quality. Upstream water quality in a forested area was better than that in a deforested stream (Tarlé Pissarra et al., 2008). Water allocation means sharing water between various regions and competing water users. It is necessary when the natural sources and water availability are limited and fails

to meet all water users' needs. The national water allocation plan and a local water availability assessment determine the amount of utilizable water in the watershed. The watershed allocation plan should also assess the water required for environmental flows. The water allocation is generally divided among priority purposes to meet inter-basin requirements, strategic objectives like for hydropower schemes, and the water supply of different regions according to administrative boundaries or some other division (Speed et al., 2013).

- Inter-basin water transfer projects: water resources are distributed unevenly in diverse spatial and temporal scales globally. However, the population and socio-economic growth occurs in many places and increases water demand and the water bodies' pressure, leading to water shortage (Zhou et al., 2017). Inter-basin water transfer has been a useful engineering project and method that will ensure water accessibility to water-scarce places. However, challenges on inter-basin water transfer are too complicated due to the demand changes. Thus, the crucial task is to optimize the water allocation plans between the supplying and demanding water. In China, plenty of water transfer projects have been implemented that involved reservoir establishment, complicated water diversion works, long tunnel construction, and massive water pumping. As the impacts of inter-basin water transfer projects on the water-supplying basin and their socio-economic systems are comprehensive, intelligent water allocation strategies are critical to mitigate these adverse effects before and after project implementation (Zhou et al., 2017).

- Climate Adaptation: researchers who work on watershed planning and management face issues on how to determine policy based on a future climate change and how to evaluate its environmental effect (Ahn et al., 2014). The impact of climatic change on water resources is hard to precipitate. Simultaneously, with population pressure, increased water demand, and waste and pollution, it could be very extreme in single water resources (Ludwik, 1991). A warming trend could change precipitation and streamflow regimes and cause floods or drought. It will damage the watershed forests impacting the entire river basin by soil erosion, downstream flow changes, and overall water quantity reduction (Ludwik, 1991). Climate change will influence the

river basin ecosystems and their interrelated elements and systems. Commissions already placed in many watersheds will have the function of managing watershed ecosystems in a different environment and adapting to new climate conditions (Ludwik, 1991).

- Flood risk management: flood risk management acts as a tool to improve water sanitation and health. For flood management, a wide range of flood control techniques and measures, including structural measures like bridges and dikes, and non-structural measures like early warning systems and land use planning, are needed (Räsänen et al., 2017).
- Adequate wastewater management: integrated water resources call for collecting and treating wastewater before discharging into nature, watershed restoration, and wastewater recycling (Zhou et al., 2017).
- Water Quality Monitoring: there is a need for well-equipped and carefully managed monitoring networks for pollution analysis. Research of Diamantini et al. (2017) identifies the importance of statistical analyses of physical and chemical quality of water basin (such as pH, water turbidity and temperature, electrical conductivity, biological oxygen, and chemical oxygen demand, dissolved oxygen, available nitrogen, phosphates, phosphorus, and chloride) considering temporal and spatial trends of pollution changes in the river basin by statistical data analyses. The control and monitor of topographical, physio-chemical characteristics (monthly, seasonal or annual), and erosion evaluation of water have been used as environmental degradation indicators in the watersheds (Tarlé Pissarra et al., 2008). That indicates the ecological health of watersheds (Tarlé Pissarra et al., 2008).
- Water Footprint Accounting: the grey and blue water footprint analyses are not only water use indicators, but they can also provide water utilization data useful in decision-making (Wang et al., 2013). Water accounting through water footprint is also necessary for water demand management in domestic and agricultural sectors, water extractions control from sources, and water transfer analysis from other basins (Safavi et al., 2015). The WF at the basin scale shows the threat and pressure on its water resources that make the spatial and temporal comparisons possible. Furthermore, in regions with water scarcity or a contaminated area, WF accounting can provide valuable data to the management sectors (Pellicer-Martínez & Martínez-Paz, 2018).

- Supply and demand management incorporation: IWRM aims to incorporate supply and demand management. Water availability in watersheds alters between dry and wet seasons. However, the human water demand differs based on construction rate, population growth, agriculture patterns, etc. When watersheds become urbanized, proper supply and demand planning will be necessary. In exceeding demand over water supply and exploitation, the surface and groundwater resources become polluted.
- Sustainable Irrigation: one of the main objectives of IWRM is irrigation management and planning at the basin scale (Billib et al., 2009). Causapé et al. (2004a) highlight that the three crucial factors determine the quality of irrigation containing irrigation management and irrigation system, soil characteristics, and crop water requirements. Some vital suggestions for enhancing irrigation are to raise the efficiency of flood irrigation, apply the pressurized systems in the previous soils, and reuse the drainage water for irrigation. There is a suggestion for conjunctive management of surface and groundwater for irrigation to develop the watersheds' sustainable use and protect the water of high quality in the primary reservoirs (Billib et al., 2009).
- Sustainable farming: sustainable farming pinpoints crop diversification by utilizing advanced technologies, the use of a good variety of seeds, and the application of stabilized fertilizer (Wani and Garg, 2014). It refers to carrying out appropriate changes in the existent cropping patterns towards a more balanced agriculture system to increase cropping capacity and mitigate crop failure risk.

3.4.1.4 Main challenges in IWRM implementation

- The lake of definition: the experience of developing the IWRM approach for the Sâo Francisco river basin in Brazil has been applied by Braga and Lotufo (2008). A broad number of stakeholders have been involved in the plan preparation. However, unclear definitions on some aspects, such as water allocation, negatively affected the whole project. There is no compromise on the fundamental issues of IWRM, such as what dimensions should be integrated and how by whom it will be possible.
- Larg gap between concept and actions: in Latin America, several examples of IWRM have been implemented, mainly focused at the constitutional level, and

just a few efforts have resulted in the end-user (García, 2008). The discussion of Silva-Hidalgo et al. (2009), according to a case study in Mexico, indicates that the IWRM application should be flexible for today's development, understandable, and available to the public. It should also integrate diverse viewpoints and concentrate on efficient solutions. Biswas (2008c) criticized IWRM for the problems of implementation in the real world. At present, the IWRM has more questions than answers regarding what precisely the concept means and how the performance is. There is either no experience in conducting the IWRM for macro-scale policies and projects. Real-life political, social, and physical factors also make IWRM challenging to achieve in practice (Sandoval-Solis, 2020). For these reasons, water professionals have called for a greater focus on refining IWRM concepts through research and quantifying its implementation results.

- Institutional barriers: institutional coordination has been one of the main challenges of integration (Billib et al., 2009). Analyzes of the water development and decentralization process in Mexico (Scott and Banister, 2008) showed that significant advances had been established in river basin councils, irrigation management, user participation, groundwater management, energy policy, and water legislation. However, implicit procedural and institutional contradictions in allocating the water resource stayed a challenge (Billib et al., 2009).
- Lack of systematic data collection: Doummar et al. (2009) present an IWRM case in Lebanon's Lower Litani River Basin. They discovered the approaches that can obtain multiple economic, environmental, and social advantages. Their results identify that the IWRM process's performance depends on data (the quantity and quality) gathered in the area, especially in developing countries.
- Low legal basis and Legitimacy: IWRM principles have low priority as they are planned to fit into different agencies' activities. However, they should be followed as part of an integrated approach. Many actions should be divided among various agencies, including private companies, government agencies, and non-government organizations. Due to the low legal basis, the achievements are not noticeable in the practical phase even though the concept has creditably. So, the results have low efficiency and effectiveness (Mitchell, 2005). Furthermore, staff, time, and other resources are needed to perform the

integration. Integration does not emerge without costs designated and care taken in deciding on the necessity of an integrated approach (Mitchell, 2005).

3.5 Examples of Watershed Management

In the past, as it was mentioned, systems of wastewater, water supply, and stormwater have been planned and managed separately. Integrated Water Resource management approaches the water management systems as a single connected process, impacting other sectors of land use patterns, agriculture, and energy. To address aging infrastructure, climate change, and population growth while balancing environmental, social, and economic needs, water professionals have focused on implementing IWRM principles. World countries have been initiated modifications on their water policy and water management systems based on the new paradigm.

In developed countries like United States, Canada, England, and some European countries, various successful water projects have been performed. They could address the issues of communities participation, water infrastructure investment, water resources conservation, sustainable management of river streams, harvesting storm water and green infrastructre, ground water regulations, pollution management and control, water quality and supply management, more cost-efficient management, distribution of water between ecosystem needs and consumptive uses, and so on. Here, four watershed management cases are clarified in terms of their management approach, water policy reformation, and the relevant achievements and challenges. Two cases including the Rhine river basin management plan and the Mississippi watershed management in developed countries and two cases, including the Poyang Lake Basin in China and the Mexico watershed management from underdeveloping countries, are chosen to explain.

3.5.1 The United States

Before, in the United States, water management has been performed by federal agencies and states. In the 1960s, due to the management coordination failure, the federal agencies' role in policy-making decreased. The lack of water resource management cooperation at the basin scale caused environmental degradation and challenged social and economic development priorities. In the 1970s, the federal government turned its role of managing regional river basin into a national and

supportive legislative role dealing with pollution reduction, land management, resource conservation, and species protection.

In the twenty-first century, water management has turned into a local catchment level and basin-scale institutional arrangements as the focal point of water resource management. IWRM became popular in the late 1990s in the United States through the works of Global Water Partnership (Biswas, 2008). During past decades, infrastructure, water supplies, and economic and land resources were managed independently, without much coordination. Furthermore, there was no protection to the environment until the Clean Water Act (2008) and the Endangered Species Act. The American Water Resources Association Board supported the national water strategy and called for implementing IWRM across the United States. The executed cases highlight integrating physical and human systems through holistic management of the public's resources, participation, and water use sectors (Sandoval-Solis, 2020).

The main elements contributing to the US's watershed approach are geographic management units, stakeholder involvement, management schedule, and coordinated management activities. Coordinated management is provided by a series of departments and agencies responsible for wetlands protection, waste management, water, air pollution control, drinking water source protection, transportation, agriculture, and navigation. Thousands of 'watershed partnerships' have formed in watershed management in the past 15 years. They have involved federal agencies (e.g., EPA, Department of Agriculture, National Oceanic and Atmospheric Administration, and US Fish and Wildlife Service), state and local government agencies, environmental interest groups, concerned landowners, and citizens, non-government, and volunteer groups. All of these groups' functions involve watershed management. The Mississippi river basins Rhine river basin management plan are explained here to understand the US watershed management activities Russo et al., 2008).

3.5.1.1 The Mississippi watershed management and protection plan

The Mississippi River drained into the Gulf of Mexico stems from northern Minnesota. The river's significant inflows originate from Ohio, Missouri, Arkansas, Illinois, and White. So many rivers and estuaries contribute a volume of sediment, water, and nutrients to the Mississippi. It remains enormous biological diversity and performs various activities. The river itself provides a wide range of functions and activities

such as barge access, hydroelectricity, commercial, industrial, recreational water-related opportunities, public drinking water, residential land uses, and stormwater and wastewater discharge. Thousands of lakes, small and large rivers feed freshwater into the Northern Gulf of Mexico, creating an environment that sustains a huge diversity of life.

The Mississippi River basin includes the Northern Gulf that provides 80% of the freshwater inflow, 91% of the nitrogen, and 88% of the phosphorus load over 1972–1993. Nitrogen amounts have risen around threefold since the 1960s that caused the reduction of bottom oxygen amount in the northern Gulf in summers and springs. The relationships between land use and nutrient loading have been analyzed by using statistical modeling in the river. The significant sources of nitrogen loading were identified that originates in the upper Mississippi Basin. It showed that non-point sources posed 90% of nitrogen loads was rooted in the cropping and population density (Russo et al., 2008).

The first Mississippi Watershed Management Plan was prepared in 1986, addressing land use, surface water quality and quantity, and storm drainage without the existing commission's approval. It identified main point and non-point watershed pollution sources especially groundwater pollution rooted in past commercial and industrial activities. Gulf of Mexico Watershed Nutrient Task Force was established to deal with federal and state agencies' nutrient management. The plan's main objectives were to reduce hypoxic areas, encourage voluntary, cost-effective actions and adaptive control, recognize additional funding sources to maintain existing programs on the federal regulatory mechanism, and provide measurable consequences (Russo et al., 2008).

Conservation projects for the Mississippi River basin have been considered to preserve through activities to reduce the harmful effects of development on watershed habitats. The main factor is nutrient pollution extracted from agricultural runoff and issues related to toxins and sediment. This plan cooperates with producers and local farmers through programs to mitigate nutrients pollution. The Mississippi River/Gulf of Mexico Watershed Nutrient Task Force deals with dead zones in Mexico Gulf, new farming practices, and nutrient run of management. The Action Plan (2001) aims to decrease the nutrients discharges into the Gulf, protect the Mississippi River streams

through sedimentation reduction programs, improve the life quality to enhance communities across the River Basin through land management and an incentive-based approach.

The 2008 Action Plan determines a national strategy to address water quality improvement and the nutrient pollution in the Gulf of Mexico in the Mississippi River. The 2008 Action Plan was a reassessment for the 2001 Action Plan. According to the 2008 Action Plan, several five Annual Operating Plans are required until the next reassessment suggests strategies to sustain the Plan goals. The Mississippi River's nutrient amount decreased to 12%, even though reducing the hypoxia region to 5000 square kilometers was not achieved (Mississippi Watershed Management Organization, 2011).

The Upper Mississippi Watershed Forestry Partnership emerged from 2004-2008 to diminish the Mississippi River watershed's changed landscapes. Surrounding forests have been recognized as essential parts to protect the Upper Mississippi River Watershed water quality. Around 70% of the Upper Mississippi Watershed forests have been turned to land for agricultural and urbanization that damaged water supplies, the wildlife habitat and contributed to nitrogen loading in the Gulf of Mexico. It was suggested identification of the forest, woodlands, and habitats' ecosystem services and incentives to form wetlands and forest buffers to maintain the water quality. The Mississippi River Basin Healthy Watersheds Initiative (MRBI) (2010 to 2013) was developed to enhance the Mississippi River Basin health. The initiative has selected 12 states in watersheds involving partners, past attempts of producers, and state and federal agencies in this area. It also introduced local producers in the watershed to conservation programs to monitor nutrient runoff from agricultural areas. Each state chose three area watersheds based on the site's future growth and current water quality data to reduce nutrient discharge, with particular consideration to watersheds having the most considerable impact on managing nutrients.

The Mississippi Watershed Management Organization focusing on the Mississippi River aims to create the long-term management of land and land source within the watershed. During the watershed plan preparation, all participants and agencies were asked to determine exact issues and problems. The Mississippi Watershed Management Organization goals are divided into eight ones composing surface water

quality and quantity, public participation, erosion and sediment measurement, recreation, groundwater, wetlands, land use, and cultural and historical resources.

Implementation will concentrate on three areas: policies and standards, projects, and programs. The plan also directs its member society to implement the Mississippi Watershed Management Organization's standards and guidelines through local plans and ordinances. The fifteen specific goals, policies, and projects for the Mississippi Watershed Management Organization programs are outlined in Table 3.1 (Mississippi Watershed Management Organization, 2011).

Table 3.1 : The goals and actions defined by the Mississippi Watershed

Main Areas	Goals	Defined Actions
Surface Water Quantity	Flood prevention.	• Cooperating with different government and non-governmental agencies and organizations to determine suitable scopes. • Conducting flood control programs as well as improving water quality.
	Mitigation of the drought effects.	• Measuring water supply plans suggested by organizations like the US Environmental Protection Agency, the Metropolitan Council, Minnesota Department of Natural Resources, etc. • Regarding the works of other agencies in developing a response plan of drought. • Controlling water demand and designing programs, policies, and projects toward water resource conservation.
Surface Water Quality	Protection of the surface water quality; Diminishment of non-point pollution sources.	• Generate detention ponds and grit chambers to treat stormwater runoff. • Creating programs to expand awareness of non-point pollution sources.
	Cooperation with other agencies to enhance surface water quality;	• Educating children on watershed issues through partnerships with schools about watershed problems.
Recreation	Chance development for public outdoor recreation in a way that protects the environment;	• Cooperating with the Minneapolis Park and Recreation Board and other municipal departments for enhancing water quality while developing chances for public enjoyment.
	Development of a continuous river corridor.	• The land will be purchased along the river when available to be appropriate water quality improvement, public interest in outdoor recreation, cost, other agencies/entities' interest, and feasibility of purchase.
Public Participation	Enhancement of community participation in management programs;	• Planning for comment and review with the public.
	Awareness raise of the communities living in the watershed on environmental impacts of non-point pollution sources and rebuild programs on the Mississippi River;	• Publishing a newspaper minimum once a year, which is broadly distributed within the watershed.
Groundwater	Protect quality and quantity of groundwater.	• Developing appropriate management practices to enhance groundwater resources through participation between the Mississippi watershed management and brownfield transformation.
	Restore and protection of the wetland resources.	• Providing an inventory of watersheds and wetlands. • Analyzing the wetland functions by adopting a methodology. • Building an on-going education program in the wetland. • Evaluating the regions in the watershed in terms of restoration.
Erosion and Sediment Control	Control of soil erosion.	• Assessing to identify the amount of erosion along the Mississippi River.
Land Use	Reduce and restore of the human impacts on shorelines habitats and natural corridors.	• Developing a technically suitable and consensus-based management framework for protecting, restoring, and improving the wetland ecosystem. •
Historical and Cultural Resources	Protection of cultural values related to the Mississippi River history.	• Preserving cultural sources through groups and agencies like Metropolitan Council, Minneapolis Historic Preservation Commission, the Minnesota Historical Society, various non-governmental organizations, and citizens.

Management.

3.5.2 Europe

Stable hydrological situations and large rainfall are significant in northern Europe. In the late nineteenth century, infrastructure and navigation development became the critical priorities. They caused a reduction in fishing in the Rine (crossed five countries) and the Danube as two European main continents rivers. The water quality deteriorated significantly with the industrialization (especially after the Second World War) and urbanization across the rivers. National operations obtained the strategic purposes at basin scale after the International Commission for the Rhine Protection. Most of the pollution reduction goals had been acquired by 2000. The European Union described the Water Framework Directive (2000), linking all member states for ecological conservation and protection and water quality improvement. The Water Framework Directive (WFD) requires the member states to guarantee that water bodies attain good ecological status regarding environmental health as a focal point in water policy. The WFD also endeavor to appose divers of pieces of EU water policies and legislation into one exclusive framework. Before the WFD, member states were eager to carry out the purposes like rive salmon restoration.

3.5.2.1 Rhine river basin management plan

The Rhine River starts from its origination in Switzerland (1320 km), crossing France, Germany, and the Netherlands to the North Sea, including a basin area of 170,000 km2 covering parts of Austria, Italy, Leicht- einstein, Luxembourg, and Belgium. Pollution of the Rhine River that emerged in 1850 was extremely challenging after the population growth. The river was polluted by hydrocarbons, heavy metals, organic chlorine compounds, pesticides, domestic, industrial, and agricultural wastewater discharge. This caused worse toxicological issues in the ecosystem. The Rhine salmon population crashed in the 1950s due to overfishing, water quality decline, and socio-economic development.

The Rhine river was a dead river by the 1970s, and regions of the Rhine basin have faced several struggles between ecological targets and development increase. The industries' preferences have led to the dams and weirs development and the ecosystem damage due to changing river sedimentation and velocity in spawning regions. Constructions of dams and dikes developed agriculture around the river. It caused an

85% decrease in the ecological alluvial floodplains and plant and animal habitats, depending on those floodplains (Wang et al., 2016).

One of the essential factors for solving the socio-economic and ecological issues in the Rhine basin was the collaboration between upstream and downstream regions. The International Commission for Protection of the Rhine basin (ICPR) was developed in 1970 to enhance international cooperation among the Rhine countries.

The ICPR is responsible for assessing the extent and type of Rhine pollution, suggesting techniques and measures mitigate it, and providing agreements among occupied countries. However, the commission acts only as an advisor to basin management, and the funding and implementation of projects and research are under the commitments of individual states. The Rhine protection agreements against chemical and chloride pollution were developed by the commission and approved by all sectors in 1976. Since their operation, oxygen levels in the downstream region have reduced to suitable levels, the salinity came back to a more natural condition, and the biodiversity has improved. In comparison, Nitrogen reduction had not been met in the Rhine's Swiss region by the early 2000s.

The Rhine action plan as an adaptable and flexible plan was formed in 1987 to fortify technology, desist from environmental pollution, and cultivate ecosystem restoration. That plan aimed to restore the mainstream's ecosystem and revive the ecologically important zones surrounding the Rhine. It contained initiatives to strengthen the Rhine ecosystem and promote the native and migratory species. The ICPR established the "Action Plan on Flood Defense" due to destructive floods of riparian regions in 1995 and 1997. The utilization of modeling has helped understand how the diverse land-use and urbanization scenarios around the Rhine could influence river runoff. The Rhine states have recognized that successful international watershed management must turn from an "upstream-downstream" attitude to a holistic ecosystem protection approach. It points out that linking flexible conventions, basin-scale research and information sharing, and the systematic release of data and resources to implement the accepted measures (Wang et al., 2016).

3.5.3 China

China is a country that has droughts and severe flood disasters. China's fast economic development and massive population growth have caused pressure on water resources. The master planning of river basins has been defined as the basis for water resource management. Since 1949, water management practices have evolved over three periods.

- First, river basin planning emphasized the river systems rehabilitation, the watercourse drainage to improve flood discharge, the construction of river embankments, and the reduction of flood and drought impact.
- The second planning phase was to experience fast social and economic development, water pollution, and water shortage. The Master Plan includes a development plan of water resources, essential river basins, and various thematic programs.
- At the beginning of 20 century, in a period of extreme economic development and water resources development, a series of thematic plans as to human well-being like a plan for securing urban drinking water safety and dangerous reservoirs and water-saving reform of irrigation regions had emerged.
- Finally, innovative planning by the principle of sustainable water resources development and scientific development has emerged to solve water resources management's critical issues. Master plans of the river basin are the basis of water resources development and the basis for social control of watersheds. The experts and public involvement have also been encouraged over the planning process.

3.5.3.1 Integrated watershed management of Poyang Lake Basin

This case can be considered a successful model of integrated watershed management for developing countries. Poyang Lake having a 162,250 km^2 catchment, is situated on the Yangtze River within Jiangxi province as the biggest freshwater lake in China. The alignment of the watershed geography and Jiangxi regional boundary in practice makes it more effective basin management. It has made possible the administrative activities and conflict resolution between ecological protection and economic development and better control over land uses and industry throughout the watershed.

Poyang Lake is the habitat of 19 bird species included as threatened species (Wang et al., 2016).

The population growth has led to the transformation of forest to crop agriculture, land reclamation from the lake, ship traffic, pollution, and overfishing in the Poyang Lake basin. In the early 1980s, the basin was affected by soil erosion. Water pollution in the Gan River's upper areas and forest cover decreased to 31.5 % in the catchment and the surface area. The other adverse ecological effects on Poyang Lake are:

- Biodiversity loss.
- Degradation of wetland habitat and water quality.
- The spread of disease posed by parasitic worms over the last few decades.

Furthermore, ecosystem degradation has increased poverty due to the linkage between the river basin and its economy. Management of Poyang Lake could provide a unique case of partnership among local communities, local government, and international organizations to create holistic monitoring and systematic research in the watershed and improve economic and ecological conditions. Over the last 30 years, various projects at basin scale have been performed in the Poyang Lake basin aiming at sustainable water resources management, ecosystem function preservation, and economic development enhancement by an integrated approach. Management techniques and strategies have also concentrated on the restoration of the ecosystem. The farming land was returned to the forest and increased forest regions by 623,333 ha between 2001 and 2008 by afforestation and planting of bare lands and agricultural lands.

It improved the forest landscape linkage and decreased the ecological effect of landscape fragmentation in the agricultural land. Fifteen protected regions for waterfowl and 77 wetland parks in the watershed identifies the necessity of waterfowl preservation in management initiations. However, there are remained some issues in the basin-like habitat damage and biodiversity loss. Since the 2000s, Poyang Lake has experienced severe low water levels and an earlier dry season, which resulted in adverse environmental and social consequences, including water shortages for irrigation and domestic use, lack of appropriate habitat for wintering migratory of the birds, and deterioration of water quality (Wang et al., 2016).

One of the main challenges to manage the Poyang Lake watershed is the changed flow dynamics between the Yangtze River and Poyang Lake following the dam's construction over the Yangtze River. In 2008, the regional government suggested the

Poyang Lake hydraulic project for restructuring the barriers with less control of the waterway over the flooding seasons so that the lake and river could naturally be connected. The increased accommodation over dam closure may increase the nutrient amount and result in water pollution (Wang et al., 2016). This would negatively affect sensitive aquatic regions and species. The Chinese governments analyze the dam's effect on these issues and review the plans' engineering suggestions over 2016–2020. As submerged vegetation, the Poyang Lake ecosystem requires a shallow water level to obtain enough sunlight and bird species feeding on this vegetation. Therefore, in many recent proposals, the controlled water depths nearly imitate the natural seasonal fluctuations in Poyang Lake (Wang et al., 2016).

3.5.4 Mexico Watershed Management

Mexico has significant water-related issues such as excessive exploitation and pollution of groundwater and surface water sources. Serious measures are needed to prevent social, environmental, and economic effects. Water management has historically been too centralized in Mexico. After passing the Federal Irrigation Act of Mexico, in 1926, water resources management emerged in Mexico. The 1992 National Water Act encouraged participation between state and local water users and civil society defined the roles of local stakeholders, and announced the creation of river basin councils. However, due to the gap between water supply and demand, environmental deterioration was going on.

The main reforms related to water have been the National Water Commission (CNA) that emerged in 1989 and the National Water Law in 1992 (Hearne, 2004). Today, many of the CNA functions like water resource planning have been decentralized to the regional sectors. The national water plans and policies are formed through a bottom-up approach. Public policies related to water reform have also been organized to the privatization of infrastructure operation and development. The leading institutional transformations happened in three main areas:

- Management of Mexico's large Irrigation Districts has transferred from the Federal government to the farmers, water user associations were established, and 3.5 million hectares have been changed and returned into farmland as to the primary water consumption sector.
- The municipalities have attained responsibility for water supply and sanitation services.

- Water scarcity of Mexico followed by its population growth and the industrial developing plants, especially in the border crossing cities, have caused lower water quality (Hearne, 2004). Water Management institutions have formed to improve water quality in the Northern Border Region (Hearne, 2004)
- The National Water Commission regulates for collecting fees for pollution and effluent discharges.

Both internal reasons like deteriorating water quality, water shortages, and external items such as neoliberal reforms, macroeconomic crisis, and decentralization approach helped Mexico's institutional change in the water sector. It shows that the water sector is related to the varying social, political, and economic situation. Therefore, water sectors and institutions have evolved with the Mexican society. Water sanitation, cost recovery, and sanitary coverage, wastewater treatment, and potable water have increased. Water users have been reported, and new institutions have been established for irrigation systems management and environmental problems along the northern border with the United States (Hearne, 2004).

During the last twenty years, Mexico has built considerable improvements in assessment and monitoring of quantity and quality of surface and groundwater, bottom-up and top-down approaches to water basin planning, dam safety and implementation of hydraulic infrastructure, the formation of river basin councils, discharge control, and water rights administration. It researched the sustainable and integrated water management in regions with overexploited wetlands. Mexico also has substantial developments in basin planning in some key basins like the Lerma-Chapala where specific actions were needed to address water quality issues. In Lake Lerma-Chapala, water scarcity and reductions in the water quantity was continuing. A sophisticated allocation plan of the watershed has been created to handle these problems.

4. WATER RESOURCE PLANNING

4.1 Water Resource Planning Approaches

Water resource systems have lots of benefits for both people and natural ecosystems. However, many of the water systems are not supported due to diverse issues. Problems such as inadequate and infrastructure, pollution caused by agricultural and industrial activities, eutrophication of nutrient loadings, infestations of exotic animals and plants, and salinization from irrigation are seen in the water bodies. Extreme withdrawals of streamflow, heavy fish harvesting, habitat change, and floodplains by developing functions and alteration in sediment and water flow regimes have exacerbated their situation. Thus, planning and decision-making at water basin levels and watersheds are required to meet various water resource systems' needs.

Watershed planning ensures adequate and sustainable supplies and water quality by addressing socioeconomic factors, including adequate education, population growth, and poverty (Loucks and Beek, 2017). Barrow (1998) stated that river basin planning is water allocation between different stakeholders and human needs, and environmental objectives. According to Brooks et al. (2013), watershed management organizes the land and other natural resources on a basin for providing the expected services and products without negatively affecting soil and water resources. Water resource planning concentrates on the relationship between land cover and land use, water quality, water storage, and water movement regarding the basin area as a functional unit for water management and planning. It plans to manage the land and how it is used through recognizing the relationships between social, economic, and ecological processes (New York State, 2009). Although each water resource plan considers various aspects and reflects specific management strategies and unique purposes, there are some common qualities covered in every water resource planning program. The water resource planning is:

- a dynamic process because the variables of the plans are almost altering. Therefore, the plan will change with them;

- a holistic approach that considers all the beneficial functions of a water area, the factors needed to maintain the processes, and the strategies required to treat water quality;
- a geographic area that is determined by a drainage basin. A water resource plan should cover a geographically vast area to ensure that the plan will address all causes of impairments, the primary sources, and threats to the water area;
- an integrated process with other planning activities of national, state, provincial, and local planning functions through data sharing, stakeholder participation, and implementation of management measures (EPA, 2008).

Planning is an essential tool to improve and support operational management and supplies an opportunity to:

- analyze the current condition of the water bodies and the priorities over their use;
- prepare visions, set targets and goals, and orient the management;
- produce a structure for organizing law and policy, related research, and public participation;
- enhance the policy, public acceptance of water allocation, and water control, especially in times of stress;
- simplify the interaction and coordination among stakeholders and managers, and create a management plan (Loucks and Beek, 2017).

Today, most of the new water resource plans address the concerns and issues related to three trends:

4.1.1 Water security and the sustainable development goals

One trend is a growing concept for the sustainability of human development. Water security has been determined as one of the largest universal economic development issues by the World Economic Forum. UN-Water (2013) defined water security as a population's capacity to ensure stable access to an adequate amount of water (with standard quality) for maintaining human well-being, livelihoods, and socio-economic improvement and supporting protection against water-related disasters and water pollution. Efforts have recognized many aspects of water security and the ways to quantify them. UN Sustainable Development Goals have specified targets and

different goals for 2015–2030, such as the water supply for sanitation and drinking, water productivity in agriculture, energy and industry, environment, flood, and drought reduction. There is an expectation that many countries manage their water, considering Sustainable Development Goals as targets in their water basin planning. Therefore, proposed management and plans are needed to be evaluated by their impacts in terms of those defined goals.

4.1.2 The bottom-up participatory approach to water resource planning

There are identified two primary approaches in water resource planning and management. One, which is often called command and control, is from the top-down approach. In the past, experts of water resources have been involved in creating master plans to develop the river basins all around the world. These plans usually include several documents besides various appendices explaining all water resources use and management dimensions. Through these reports, suggested structural and nonstructural management items are determined and analyzed for recommending the preferred plan.

In the top-down approach which is dominated by professionals, the experts have assumed that one or more institutions can prepare the water resources development plan and manage the basin's activities influencing the basin ground and surface waters. Today, top-down approaches have become less acceptable and desirable due to current perspectives that call for developing cooperation and participation in management and planning activities and less government control and regulation.

The other approach is the bottom-up approach, which is called the grassroots approach as well. Over the last decades, the interested stakeholders' participation has increasingly happened in the water resources management and planning processes. Through consensus development, the plans are being generated from a bottom-up process rather than a top-down approach. Water resources management and planning don't mean the implementation and application of science. However, it creates a social environment for getting all people who should be engaged from the beginning, continuing the planning process. The successful operation of water resources planning and management needs the active cooperation and participation of all community institutions involved in resource management and economic development (Loucks and Beek, 2017).

Nongovernmental organizations, interested citizens, and professionals in governmental institutions cooperate to build adaptive and comprehensive water management policies, programs, and plans. The system being managed will be sustainable through stakeholder participation. Bottom-up planning must either comply with applicable regulations and laws or suggest changes to them. It should evaluate multiple performance criteria and various alternatives including sustainability factors, and recognize prioritizing correct strategies and trade-offs among conflicting targets. Through working together, both approaches will result in a holistic management policy and an integrated plan.

4.1.3 Demand-oriented approach

Until the 1960s, water management was designed to meet the primary functions of food production and health through the supply approach for more than three centuries. The supply approach's main problem was how to determine a water requirement and then how to make water available for that. These requirements were only understood after population growth, economic and agricultural development emerged, not as policy matters (Hoekstra, 2000). A common perception of this approach was that water shortage issues happened when there was not adequate water to supply productive and social demands. The water shortage problem is solved by increasing the water supply infrastructure that requires a vast water project expenditure. Despite these activities, by the end of the 20th century, nearly 1.2 billion individuals still suffered without access to clean potable water, and 2.4 billion lacked adequate sanitation services (Dieterich, 2003). Furthermore, it has resulted in overcapitalization, resource overuse, pollution, and other issues of varying severity (Ruelas-Monjardin, 2010). Due to those problems, the model of the water supply has been seriously criticized.

Water demand management has been known as a process that encourages the efficient use of existing water supplies rather than developing new ones. The proposes of water demand management can be obtained through economic, ethical, technological, and educational considerations (Ruelas-Monjardin, 2010). This approach's logic is that water demand cannot continue to increase as water availability is limited, and water uses should be in harmony with the available resources (Hoekstra, 2000).

In the Third World Water Forum held in Kyoto (2003), to develop the water industry's economic performance, the potentials of this approach were identified and promoted.

In this forum, water was valued as an economic commodity, and as a result, there was a need to price water for recovering the expenses of service delivered (Ruelas-Monjardin, 2010). In this way, by improving water use efficiency rather than increasing supply, the demand-oriented approach aims to satisfy the water needs. This approach puts the water demands themselves rather than engineering or structural solutions, as a point of concern. It shows the cheapest way of easy access to the available water, especially in areas where other demands are being considered on water resources. Following efficient water use, it should be allowed to market mechanisms and private sector participation. However, this approach deals with big problems and challenges, despite its international acceptance. Water management as a commodity has been identified as a complex issue. At least six prerequisites are needed to treating with water as another commercial good, which are:

- It must be able to be measured, controlled, and treated as a commercial commodity;
- The water demand must exceed the water;
- The water as a product must be provided when it is needed;
- It must be mobilized and transferred to where it is most needed;
- The water market must be accepted by society;
- The mechanisms of regulation and administration must be existed to ensure equity and fairness (Ruelas-Monjardin, 2010).

In addition to those difficult prerequisites, regarding water as a commercial good, it needs to consider the rights for its use both in terms of popular habits and law. For managing water issues, the supply and demand planning approaches still deal with various challenges and it is needed to achieve holistic management of water resources for preventing conflicts and meeting natural and social demands (Ruelas-Monjardin, 2010).

4.1.4 Integration of spatial planning and water resources management

Terrestrial and aquatic systems are tightly connected. Thus they both should be regarded when planning for water management or framing land-use dynamics (Mitchell, 2005). Integrated water management is probably more efficient if connected to the land-use planning or basic official plans. Despite the efforts and time allocated on integrated watershed management planning, it has shown little action through last

performed experiences. The cause is the IWRM has low legitimacy and legal basis. There is a challenge in the implementation, as many of the activities should be taken by various institutions and organizations involved in government agencies, personal companies, or nongovernment institutions (Mitchell, 2005).

Integrated watershed management should be created and implemented through linkage to other relevant sectors and initiatives having credibility due to their administrative power or statutory policy. The progress can be significantly achieved when the IWRM, spatial and environmental policies, agricultural programs, and protected projects have been connected to a statutory base of official plans and land-use planning at the local level.

Sustainable water resources need regulations that can only be developed by spatial management and planning (Figure 4.1). For instance, restoring water-related functions by conservation planning and implementation can be gained by incorporating the protective water zones into the overall spatial plan. Simultaneously, spatial development must be supported by appropriate water resources development (Asian Development Bank, 2016).

The integrating spatial planning and basin planning, which needs excessive coordination for developing and managing land, water, and related resources, achieved noticeable attention in many countries.

The European Union Water Framework Directive severely focuses on the need for strong ties between river basin management and land use planning.

Policies of land use planning are essential mechanisms for implementing the watershed plans. The watershed plans' scopes and requirements should be incorporated into official municipal plans, both to upper-tier and lower-tier ones. The upper-tier official plan should provide a regulatory way and direction to the lower-tier municipal plans considering the zoning plans and watershed plan's suggestions. The lower-tier plans should offer more data and detail. However, the formation of the connection between these two systems needs numerous efforts in linking separate institutions and policies. There is limited knowledge of how to apply the connection and integration, or what it means in practical terms for key planners and stakeholders (Asian Development Bank, 2016). According to the six rivers project (2009–2013)**,** the integration of spatial planning and water resources planning comprises two main inputs:

• Spatial planning inputs to the basin plans can be consistent projections for population growth, land use, settlement, other socioeconomic factors. The spatial plans show

future land allocations and provide the water demands for irrigation, industrial and domestic, or water required for flood protection considering population, settlement, and land-use projections to the basin planning projects.

• Basin planning inputs to spatial plans are water zoning requirements that address the various dimensions of water resources (runoff from the upstream catchment, urban runoff, erosion, etc.), and can be impacted by spatial management. Two basin planning and spatial planning processes have been achieved through several strategies and policy formation. The interaction between basin plans and spatial plans needs adequate communication in two phases of the planning process. It also needs to quantify impacts and requirements and conduct adaptations to suggested developments in spatial planning and water resources planning to optimize an overall development.

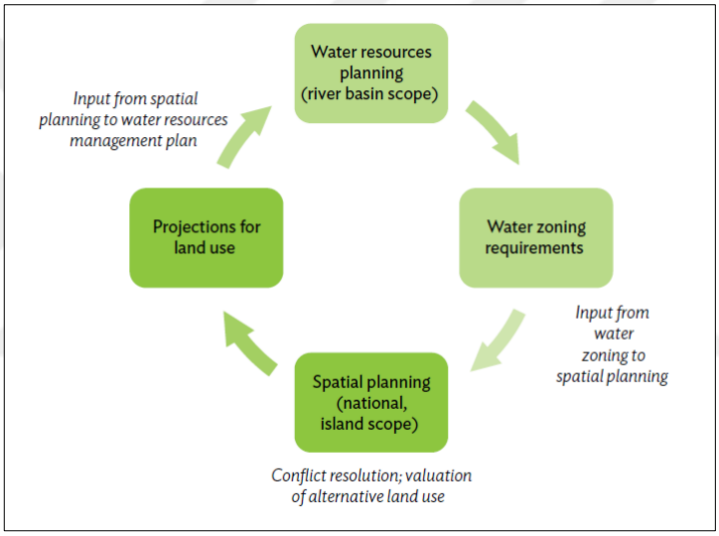

Figure 4.1 : Water Resource Planning Process in relationship with other areas of planning (Asian Development Bank, 2016).

4.2 Key Aspects of Water Resource Planning

In various sectors like domestic, agricultural, environmental, and industrial sectors, water resource management and planning have caused more contradiction and made an unsustainable system in the basin area. As a flexible plan, water resource planning needs broad participation of the community to support the water quality improvements and guides the restoration and protection of the water reservoirs. Watershed planning supports water quality improvement through balancing environmental and economic factors at the local level (New York State Department of State, 2009). Watershed planning also provides an opportunity for strengthening the interrelationships between water management and land use planning. The fact is that more urban area means

reduced infiltration, larger hard surfaces, increased rainfall-runoff, enhanced sedimentation, and erosion in the water resources. Therefore, three main aspects are identified in watershed planning: community involvement, land use planning, and management programs.

4.2.1 Community involvement

Stakeholder participation is recognized as a primary factor for environmental decision-making. In a general sense, stakeholder participation is a process that eases the inclusion of the knowledgeable individuals who are affected by, involved in, or having experience or expertise related to the water resource issues (Pigmans et al., 2019). It emphasized that whole community participation and involvement at all phases of project planning and implementation are undeniable. It is more critical when the new investment will affect the local communities' health, security, and prosperity (Dungumaro and Madulu, 2003). Involving the community and building strong partnerships right at the start of the watershed planning process will form a basis for implementing the proposed plan. The stakeholders' interests and views on the water areas' future can be captured by bringing people together. Community involvement needs three actions in watershed planning:

- The key stakeholders should be identified. A stakeholder is a person or group who will lose or gain something based on the water resource plan results. They are the individuals and groups, including officials, civic and business leaders, environmental groups, educational institutions, neighborhoods - who have an immediate benefit in the future of the water resource (New York State Department Of State, 2009).
- An advisory committee should be organized in the watershed. First of all, in the planning process, an advisory committee should be organized to examine all dimensions of building the water resource plan, efforts on the planning process and its implementation. This committee's responsibilities include providing input on watershed conditions, advising staff on managing the process, holding regular meetings, informing the society on the watershed planning, and working with the municipal team and others to complete various tasks. Members of the advisory committee should contain representatives from regional and local nonprofit organizations, local governments, property

owners, water managers and suppliers, and academic and business communities (New York State Department of State, 2009).

- Partnerships should be established. A partnership refers to an agreement between two or more entities to participate and work together following a specific purpose. The partners represent divergent viewpoints on the issues of the watershed plan, like improving water quality. The right blend of stakeholder partnerships leads to success in watershed planning. According to Pigmans et al. (2019), participants can establish mutual understandings, rights, and values, as the stakeholders' perceptions and preferences can change. The main potential stakeholders and partners include:
  - Local and county government - local boards, elected officials, and staff,
  - Regional planning or resource protection organizations,
  - Neighboring municipalities,
  - Federal and state government partners,
  - Academicians - universities, colleges, and local schools,
  - Representatives of industries and businesses in the water basin,
  - Property owners in the water basin,
  - Habitants in the surrounding area,
  - Neighborhood and community groups,
  - Nonprofit organizations with a benefit and stake in the community and the water basin (New York State Department of State, 2009).

4.2.2 Land use planning

Water management and land use planning have close interrelationships. As water basins are turned from forest and field to more dense land use, the water quality and aquatic habitats start to reduce. Particular land uses reducing storage capacity, increase sedimentation and erosion in water reservoirs. Thus, some regulatory measures and planning techniques should be designed and applied to redirect the development toward limiting impervious cover and protecting sensitive areas. There is also a critical need for law and restrictions on construction in flood-prone areas to limit flood risks.

The percentage of forest cover, pervious cover, riparian buffers, and cropland within a water basin is vital for water reservoir health. The portions can be understood by evaluating the zoning plans and the local land uses. By analyzing the intensity, type,

and distribution of land uses, land cover, and census data, important information can be achieved about water quality and watershed conditions. Land use analyses show where the future construction and development will happen, prioritizing the sensitive zones and lands for protection (New York Department of State, 2009).

Existing and new development are significant sources of water quality issues. The increase of impervious covers and surfaces leading to the sedimentation and erosion of streams causes over-fertilization of lawns, septic systems, and contamination of ground and surface water. The construction means more water and stormwater infrastructure and sewer, which puts barriers on drainage ways and contaminates waterways. Roads collect contaminants and convey them into water bodies. As important land use in many watersheds, agriculture is a source of pesticides, fertilizers, sediment, and animal waste, contaminating the water (New York Department of State, 2009).

The percentage of impervious cover is a good indicator of water basin health. Impervious surfaces, including roads, rooftops, driveways, and parking lots, can reduce the water quality. Rain can no longer penetrate the soil ground on a parking lot and flows through natural pathways such as rivers or streams. Rainwater moves across the impervious surface and carries up the oil, sediment, grease, and other contamination and trashes before it inters into a waterbody.

These pollutants are then transferred by a massive network of rivers, streams, and wetlands and raise the turbidity, increase the biological growth of algae, reduce water quality, and extend water temperatures (New York Department of State, 2009). Build-out evaluation can help understand how many rigid and impermeable covers could be added to the city over time under the existing land zoning and relevant regulations. Wang (2001) studied the effect of urban land uses on stream water quality, indicating that there are two critical urban areas within the water basin or watershed. One is close to the basin outlet, and another is at the upper left of the watershed. It is discovered that different types of point pollution sources are gathered in or close to the more urbanized areas.

Open spaces like vegetated and forested areas mainly decrease adverse effects on water quality from land-use activities and construction. Green or vegetated land surfaces conserve water quality by reducing runoff and velocity, supplying habitat for animals

and plants, and filtering pollutants before reaching streams and groundwater (New York Department of State, 2009). Therefore, it is essential to protect the open spaces such as lake or dam shores, wet bodies, buffers, groundwater recharge areas, estuaries, floodplains to protect aquatic habitat and water quality, and quarantine opportunities for public recreation.

Although researchers have shown more attention to the land use impacts on water quality (Wang, 2001), a water-quality as a factor is almost missing in the land-use planning process, and water-quality management is rarely performed over land-use planning. This is because of the separate administration of land-use planning and water-quality management by various agencies without coordination. Many planning organizations and local institutions don't have adequate data about the land use and water quality in the developing plans (Wang, 2001). Similarly, water-quality management centers typically address current water-quality issues rather than projecting or preventing them. Integrating land-use planning and water-quality management can enhance habitat health, biotic quality and prohibit the pollution from happening sources. This connection suggests water quality protection through land-use planning and habitat protection (Wang, 2001).

4.2.3 Management strategies and municipal programs

Stakeholders and government organizations have to jointly design particular priorities for each water resource in their management sector. Issues address drinking water source protection, pesticide and waste management, point and non-point source pollution control, riparian and wetlands areas protection, water supply, and air pollution impacts. Monitoring and measuring the chemical, physical, biological, and habitat situation of the water resource is a significant element of the watershed management program. It needs to identify the location and extent of problems, characterize the watershed, and assess different remedial operations' impacts. Data and information have to be gathered with comparable methods through numerous data collectors (Russo et al., 2008). Specific management models and municipal programs recognized in a watershed plan are:

- Identifying the boundaries: plan involves a spatial element defined as the physical area in which planning occurs. In terms of political boundaries, the site may be defined in terms of natural boundaries (such as hydrologic drainage

basins) or economic units such as trade areas. However, watersheds or water basins are geographic events as they do not identify local political boundaries (New York Department of State, 2009), and water resource studies look at watersheds. Urban water planning covers intensely developed areas that cross both political and watershed boundaries.

- Structural practices: structural operations are related to streambank fences, stormwater basins, grade and streambank stabilization structures, and other installations and construction for maintenance and habitat restoration. These practices are with an ecological restoration that requires a knowledge of biological communities.
- The green infrastructure: these approaches and technologies imitate natural processes by capturing runoff and rainwater and infiltrating it into the soil. Local green infrastructure practices may be porous pavements, infiltration planters, rain gardens, green roofs, trees, and plant boxes. The rainwater harvested can be used for non-potable needs like landscape irrigation and toilet flushing (EPA, 2008).
- Nonstructural practices: they prohibit runoff issues in the water bodies by managing runoff at its source point and decreasing pollution formation. These activities can be considered a regulation like a stream buffer or open space requirement or various voluntary pollution prevention activities and public education campaigns. Nonstructural controls are categorized into source control practices and land-use practices. Land use practices focus on decreasing runoff impacts on receiving waters by controlling uses in sensitive areas of the water basins. Source control practices aim to prevent or reduce potential pollutants at the source before accessing the groundwater and runoff. Source controls cover the pollution prevention practices that make attempts to improve public attitudes and behavior, like teaching citizens about the correct disposal of pollutions, efficient use of pesticides and lawn fertilizers (EPA, 2008).
- Regulatory approaches: they can be considered a regulatory stem for both non-point sources and point sources (EPA, 2008). Some of the regulatory approaches for non-point pollution sources are local stormwater permits and ordinances, federal or state forest management plans, state regulatory authority, and decentralized wastewater management. Regulatory approaches

for point-pollution sources may be considered on wastewater discharges from industrial sources, municipal stormwater discharges, combined sewer overflows, publicly owned treatment practices, and separate sanitary systems. Through the planning of watersheds, some of the leading technical achievements and strategies to protect the water bodies are suggested in Table 4.1.

Table 4.1 : Planning strategies suggested for the protection of water bodies and watersheds.

Objectives	Planning Techniques and management Strategies
Land Conservation	-Allocating tax and fund for land conservation; -Authorizing local governments to keep conservation easements; -Conducting a plan to get consensus among residents, developers, environmentalists, and local staff on changes suggested on-site planning; -Providing incentives for conservation design.
Soil Erosion Control	-Providing training programs for contractors on sediment control and practice installation; -Adapting design standards for erosion control and providing incentives to reduce the amount of erosion at development zones.
Urban Quality of Life	-Preserving and rehabilitating city precious as social and environmental properties.
Water Saving	- Designing a land cover for stormwater infiltration into the ground; -Combining previous with impervious covers so that the flows from the impervious surfaces are conducted into pervious areas; -Passing stormwater through vegetated patches and filter water from pollutants particularly; -Reducing hardcovers and increasing vegetative areas (Carmon and Uri, 2010).
Storm water Management	- Designing roads with the open space as receivers of stormwater; -Using two types of facilities point structures (a recharge well which receives runoff from a yard or roof drain) and linear structures (infiltration channel) for wastewater management; -Developing higher density to protect regional water quality, consuming less land and less runoff per house rather than the medium density; -Mixing housing, services, and business land uses (Carmon and Uri, 2010); -Designing local reservoirs of retention, detention, infiltration such as ponds and lakes, wetlands, aquifer storage, rain gardens, and bioretention, without hurting residents, especially children.
Water Quality Control	-Local controls by zoning subdivision regulations andlocal laws to regulate sediment control laws, vegetation retention laws, docking and mooring laws, or wellhead protection laws; -Municipal programs of fertilizer applications, and mowing regimes (New York State Department of State, 2009).
Aquatic Buffers	Adapting a law for regulating a local buffer including a minimum 100 ft width, with vegetative standards, without other uses; -Developing a management plan for invasive species in public open areas; -Encouraging riparian buffers considered as protected areas in new construction.

4.3 Water Resource Planning Process and Implementation

The process of water resources planning should provide a plan that conducts operational practices and development in the water basins or watershed. Planning and management processes should:

- identify and include the objectives, preferences, and expectations of the stakeholders,
- recognize and address the water-related issues in the region,
- act effectively based on the institutional or legal structure in the area,
- consider both short and long-term problems,
- creat a various list of alternatives,
- integrate the physical parts and ecological parts (biotic and abiotic) of the basin,
- consider the water allocation for natural systems needs and stakeholder-driven needs,
- follow a universal and holistic perspective,
- be adaptable and flexible,
- guide regulatory systems, not be affected by them,
- be the basis for policy decisions,
- strengthen coordination and harmony among planning sectors and the related plans,
- consider divers objectives,
- be a synthesizer, and identify and deal with conflicts,
- generate recommendations that can be operated (Loucks and Beek, 2017).

For the watershed planning and implementation process, five main steps (Figure 4.2), including several activities, are defined by the U.S. Environmental Protection Agency (EPA, 2008):

Step 1. Building partnerships

All groups of potential stakeholders must be recognized and included in the planning project. The main stakeholders can contribute and assist the water resource planning efforts. Involving the right blend of organizations and people to get together and implement the plan leads to success. Developing successful cooperation needs time, skill, and practice. Community-based activities are required at the beginning of the

water resource planning process to get stakeholders and potential partners aware of the challenges, call them to participate and teach them on the planning process.

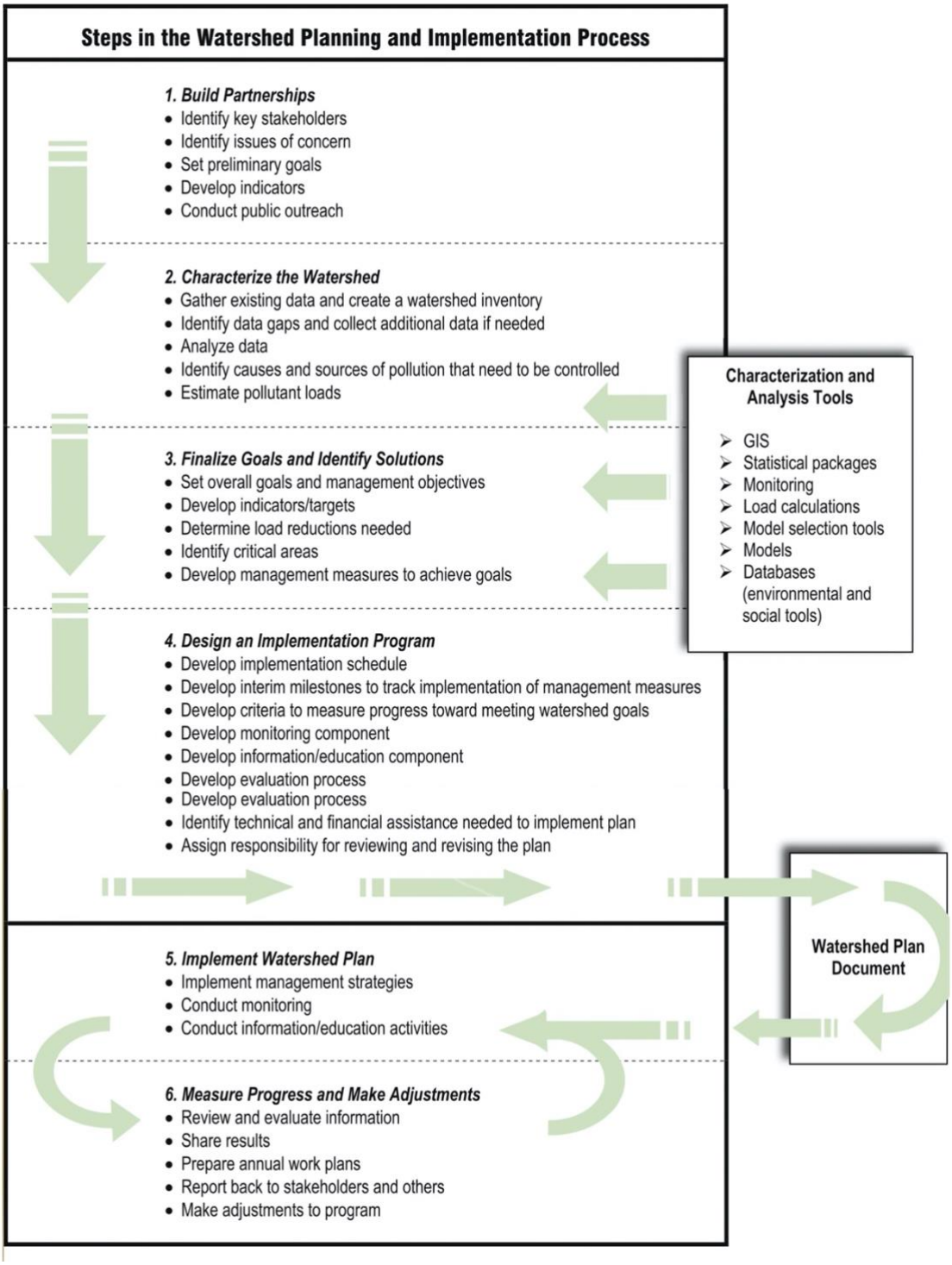

Figure 4.2: Steps in the Watershed Planning Process (EPA, 2008).

Step 2. Characterizing the watershed

The plan scopes should be first determined to guarantee that the watershed planning efforts are practical, focused, and efficient. In characterizing the water resources, it is

critical to converse with stakeholders who contribute to forming the plan's targets to assess concern issues. Then, it is needed to identify problems and evaluate the current conditions of the watershed. There are indicators to identify the existing environmental situation like water quality, aquatic resources, biodiversity and habitat, and land-use patterns. In general, five broad categories of data are used to characterize the water resource adequately:

- Physical and natural qualities, including water basin boundaries, topography, hydrology, soils, climate, habitat, and wildlife;
- Land use and population conditions such as land use types, land cover, existing management practices, and demographics;
- Water basin and watershed characteristics such as water quality standards, streams flow regimes;
- Pollution sources, including point sources and nonpoint sources;
- Water basin monitoring data like biology, water quality, and flow, and geomorphology.

The stakeholders can have useful information to be used; therefore, a data inventory is created to understand the data gaps.

Step 3. Finalize goals and determine solutions

After the water basin or water resource problems are characterized and quantified, the objectives are refined and established with more detailed scopes to develop a management strategy. The goals and management objectives should be achievable, financially and technically viable, and measurable. After the specific management objectives are established, the numeric and environmental indexes are developed to assess the goals quantitatively. The indicators are quantifiable factors that will be applied to relate the pollutant sources to the environmental conditions. There are three categories of indicators, including programmatic indicators, ecological indicators, and social indicators. After setting goals and indicators, the next step is to assign loading targets to meet the objectives. It needs to determine the management measures that should be site-based and specific practices and cost-effective management activities or structures to control pollutant sources. Management measures can be implemented for diverse objectives, like supporting water resources, aquatic and wildlife habitat, or downstream regions from flood risks and increased pollution.

Step 4. Design implementation program and assemble a water resource plan

Planning the implementation program creates a few essential components required for efficient water basin plans. Those include:

- An education or awareness factor in making public participation,
- A schedule for management measures implementation,
- Interim milestones (in terms of long term, midterm, short term) to determine whether management measures are being operated,
- Criteria for measuring progress toward decreasing pollutant loads and obtaining water resource goals,
- Monitoring indicators to assess the effectiveness of implementation programs,
- An evaluation structure and process,
- Analyses of the financial and technical resources and authorities required to implement the plan,
- Determination of responsibilities.

Step 5. Implement the water resource plan

The process of implementing the water resource plan includes four critical phases:

- Creating an organizational structure,
- Implementing activities,
- Preparing work plans,
- Sharing results.

Effective implementation practices contain:

- Making technical supports in the installation and design of management measures;
- Supplying follow-up and educational support to the responsible sectors and landowners in keeping and operating the management measures;
- Managing the funding mechanisms and checking expenditures for each practice and the project as a whole;
- Leading the activities of water quality monitoring, land treatment, evaluating, and reporting the data;
- Measuring success against milestones and designed schedules;

- Sharing the condition and results to the public and stakeholders;
- Coordinating implementation actions among stakeholders, multiple jurisdictions, and the implementation team.

Step 6. Measure progress and make adjustments

In this step, after implementing the water resource plan, it needs to control both land treatment and water quality to measure progress toward meeting goals. These reviews should cover a few major subjects:

- The program implementation process including the technical and administrative procedures applied to ensure agreements with stakeholders and landowners, build specifications, and involve contractors;
- Progress on the work plan and checking off factors in the annual work schedule that have been performed;
- Results of implementation and reports on where and when activities have been installed and operated;
- Feedback from stakeholders and landowners by reviewing their experiences about implementing, managing, and maintaining the process.

4.4. Examples of Water Resource Planning

There is a universal transformation taking place in the water basin planning approach, the same as watershed management. The driving forces of the current watershed planning approach are related to water demand increase, competition for available resources, water quality deterioration, and increased awareness of the need to manage water in a sustainable manner.

In developing countries, a number of current planning practices highlight their potential keys to success. Initiatives have aimed to improve participation among key stakeholders, establish water-related information systems, facilitate information access, improve assessment methods, build inter-disciplinary teams toward planning, provide research to support new initiatives, and provide upward feedback for policy formulation. Some of the achievements can be mentioned in developing countries such as:

- Water Policy development and institutional reform in Tamil Nadu, India: water Resources Control and Review Council was established to handle multi-sectoral

water planning and allocation and acts as water policy implementation (Saleth, 2005).

- Defining responsibilities in China's water sector: coordination between sectors and government at all levels is central to the planning process in China. Following the Water Law (1988) issuing, ministerial and government departments and cooperative agencies' responsibilities became clearly defined to prevent overlapping duties (Zhong et al., 2008).
- Water resource management strategy in Zimbabwe: due to the country's climate change, the government initiated a study to provide guidelines on the development of a water resource management strategy in 1993. Key activities to develop and implement the water resource management strategy were to assess critical issues, explore policy options, implement national guidelines, provide a resource assessment methodology, and establish a framework for water resource allocation (Manzungu 2004).
- Community action in Tigrai Region, Ethiopia: stakeholder interests lay at all levels, from individuals to the central government. The key to success lies in applying top-down and bottom-up approaches at the water catchment and sub-catchment scale. The strength of the community's commitment and the government's willingness has led to embracing participatory processes (Meniga et al., 2019).
- Surface water management in South Africa: South Africa has developed sophisticated surface water storage and inter-basin transfer schemes. Department of Water Affairs has developed relatively technical water resources strategies for all river basins in South Africa. South Africa's Water Act 1998 requires that the minister ensures equitable water allocation and beneficial water use while promoting environmental values (Molobela and Sinha, 2011).

Here, two water resource planning approaches are considered to explain: one in England as a developed country and the other in Indonesia as an underdeveloping country. Then, two cases in Canada showing the integration of water resource planning into spatial planning are clarified.

4.4.1 River basin planning in England

In England, water companies are responsible for creating water resource management plans to identify the water supplied to the customers while conserving the environment for over 25 years. The plans contain the actions to manage water demand by enhancing water efficiency, decreasing leakage, and raising the supply by developing new resources. They also include options to reduce water allocation effects on the water environment, which plays a vital role in setting the river basins management plans' environmental objectives.

In England and Wales, the river basin management plans are established by Environment Agency every six years for how to manage river basin districts. The UK has identified 16 river basin regions: 11 in England and Wales, three areas in Scotland, and four in Northern Ireland. One river basin, named Solway Tweed, is in both England and Scotland, and the UK shares three international river basins with the Republic of Ireland. Sustainable development promotion in England was among many innovations introduced by the Act for the first time. There is a wide range of planning reforms in England that are about five main subjects:

- more speedy decision-making processes to make possible planning authorities to form places;
- more holistic and practical processes of participation and consultation;
- more efficient cooperation with policymakers and other stakeholders;
- more evidenced-based reasoning in the generation of policies and strategies;
- and a focus on the achievement of outcomes (Rinne & Primmer, 2016).

In the UK, five various jurisdiction levels guide the implementation of Water Footprint Development in England, Wales, Scotland, Northern Ireland, and Gibraltar and a national level (European Commission). The river basin management plan is considered a detailed account of how the targets are set for the quantitative status, ecological status, chemical status, and protected area of the river basin within the definite timescale.

The plan will contain all the consequences of mentioned analysis, including the river basin's characteristics, studies of the human activity impact on the waters of the basin, evaluation of the current legislation effect, the "gap" to catch the objectives, and a series of techniques planed to fill the gap. Another factor is an economic analysis of water use within the river basin that enables a rational negotiation on the different

possible measures' cost-effectiveness. All interested sectors must be fully engaged in the discussion and the plan preparation as a whole. It results in the final key elements of the Directive, which is the requirements of public participation, including:

- an explanation of the condition of the estuaries, rivers, coastal waters, lakes, and groundwater in the region;
- a description of the impacts and pressures on the water area;
- targets for maintaining and improving the situation of the waters;
- a program of measures to achieve those objectives.

As a requirement of the Water Framework Directive and Regulations, the current plans cover the years 2015-2021. After the Water Environment Regulations in 2003 (England and Wales), river basin management plans in England, Wales, and Scotland were reported to the European Commission in 2010. In the following text, the strengths and gaps of the plans are explained. Strengths of the river basin plan in the UK following the EU Water Framework Directive are:

- In the UK, the measuring and control network is extensive, although not all quality factors are measured and monitored. The statistical methods applied for evaluating lake, river, and water bodies are also recognized as strengths.
- The measures program is detailed with data and information on a waterbody level, although a few measures are suggested.
- Good coordination between the UK and IE is also identified for the development of international river basins.
- Good data on the water area scale is available as reports and documents for England, Wales, and Scotland.
- There are a measurement program and an apparent reference to climate change.
- Awareness for people consultation was provided through the media such as printed materials, the internet, and meetings to the interested sectors. The consultation programs happened by face-to-face meetings, published consultation, and web-based presentations and could be available by libraries in England and Wales. The stakeholders engaged in the consultation programs included farmers, water companies, ports, industries, fisheries, protection bodies, local planning authorities, NGOs, consumer groups, and the general public.

The gaps of the river basin plans in the UK following the EU Water Framework Directive are:

- In some cases, methodologies for evaluating biological quality factors were not provided.
- The typologies reported first have changed; thus the types are now more ecologically relevant. The assessment that is being used is on the site by specific reference conditions.
- There is restricted data on the methodology to identify significant pressures.
- The significant uncertainties were reported as to the condition, pressures, and effect of potential measures, despite the UK's high monitoring volume.
- Even though agriculture has been identified as a critical pressure, no new compulsory measures have been accepted in the plans. Voluntary monitoring and standards have been mentioned rather than obligatory actions without further measures addressing agriculture's discharge pollution.
- For three river basin regions shared with the Republic of Ireland (Neagh Bann, North Western, and Shannon), no final international river basin management plan was performed for any of them. However, a high-level jointly confirmed report is available.
- The Environment Agency has no position in implementing the WFD on its own and depends on a vast range of collaboration with the other sectors for successful operations (Rinne & Primmer, 2016).

Other vital modifications introduced by the Water Act in England include new sectoral and territorial integration preferences. For instance, now, there is a system of statutory plans at both regional and local scales and a formal regulation for vertical integration. The new plans require connections with major national strategies like the Sustainable Communities Plan and with the European Spatial Development Perspective at an international level to be guided by the content and form.

This alternative model of IWRM approaches in England used in the current spatial planning system follows beyond its traditional land use borders and has a critical role in the many dimensions of public law and policy (Kidd And Shaw, 2007). The National Rivers Authority, Thames Region in London, shows a water environment perspective supported by an approach to connect land use and water-related challenges through land-use decision-making (Mitchell, 2005). The National Rivers Authority also recognizes the strengths of enhancing the water areas by the planning system's statutory development. `Thames 21' as an essential sector is in dialogue with local authorities to recognize the places of water-related policies needed to be more actively

followed. Partnership and participation between all partners and parties having a stake in the project is a significant dimension of the approach. The agreement can be a strong influence and tool for making a satisfactory generation, legislation, land use planning, and economic instruments.

Even though there are current achievements, significant challenges remain. One of the significant challenges is the diffusion of water pollution caused by many little point sources. Diffuse pollution is usually from rainfall and affects both groundwater and surface water. The Environment Agency has developed an overall approach to deal with the problems. Furthermore, there will be further problems in England and Wales due to land use development and climate change. Projections of how the UK's climate might be changed following greenhouse gas emissions have substantial implications for water resources management.

4.4.2 Water resources planning in Indonesia

Indonesia implemented new laws and regulations in 1998–2005 for IWRM. Through the IWRM principles in this law, three fundamental factors of utilization, conservation, and water safety, and two supportive elements including public participation and information management are identified.

Consequently, the water basin planning with people participation has become a legal regulation resulted in many strategic framework plans known as Pola and several more detailed master plans called Rencana at the river basin level (Asian Development Bank, 2016). These two planning approaches (Pola and Rencana) emerged in 2004 in Indonesia. In principle, the *Pola* generates the strategic options and regulations for the strategic plan, in which main strategies are listed in a matrix for various scenarios. The *Rencana*, completes the strategic plan and follows the Master Plan of Basin Water Resources Management's operational and tactical dimensions by selecting an essential system for a particular scenario.

- A *Pola* as a strategic plan summarizes the long-term objectives (20-year time horizon) for integrated water resource management in the particular river basin boundary. The *Pola* covers policy considering general targets and the way of water resources management. It has resulted in the matrix for operational regulations and procedures, including the different water resource management dimensions like conservation, utilization, disaster, etc., with various subfactors including water retention, erosion, water quality, etc.

- The *Rencana* following the *Pola includes* a tactical, strategic, and operational quality for the water sources. It covers the Master Plan's long-term aspects for 20 years and a medium-term dimension of a program for five years addressing the basic assessments and designs.

This will be pursued by detailed strategies, feasibility researches, and implementation plans. The short-term aspects covering one year is the annual work plans (Asian Development Bank, 2016)

The Pola and Rencana should follow the programs and objectives of other sectors like Millennium Development goals, public health, agriculture, energy, environment, spatial planning, etc. After creating the plan, these parties should consider the Pola and Rencana as tools to apply their goals and objectives. The main challenge is insufficient national objectives (about subjects like energy, infrastructure, food, and disaster) or local purposes (including flood protection for different types of land use) to guide the spatial plans, regional strategic plans, basin conservation plans, and several sectoral plans in Indonesia. However, these achievements have not yet been properly embedded in national policies. Unfortunately, water management plans don't have a national priority as the long-term and midterm national development plans and are not followed by regional and spatial development plans. In 2011, a particular development plan titled the Master Plan was created for Indonesia's Economic Development during 2011–2025. The plan identified food security and enhanced energy and water policies as requirements for its operation with no specific programs to support them.

4.4.3 Integrating Collingwood Harbour remedial action plan (Ontario/Canada) into spatial planning

On Georgian Bay, Collingwood harbor was one of forty-three areas of concern recognized (1977) by the Water Quality Agreement of Great Lakes, between Canada and the United States. "A Collingwood Harbour Remedial Action Plan" was created to decrease the enormous phosphorus loads to the harbor. The initiatives emphasize how integrated water resource management can combine with an official land-use plan with a statutory basis to improve the implementation of strategies as to an ecosystem approach. The program's major elements covered improving the municipal sewage-treatment plants, supporting existing wetland areas, rehabilitating wildlife habitat and fish community, and educating society. The approach requires integrating the plan's

principles into the official plan for the Town of Collingwood" to generate a refuge for a vast range of aquatic life (Mitchell, 2005).

Various actions to fix environmental problems and restore the harbor ecosystem have been operated, including cleaning up and conserving Collingwood Harbor's ecosystem through eight years of legislative, organizational, and data-gathering attempts and a comprehensive program of public participation and consultation (Krantzberg and Houghton, 1996). The community's decisions can protect the environmental quality and preserve valuable and sensitive natural features.

Investments in infrastructure, land use planning, water and energy conservation, sewer use through regulations, applications, and other practices offered great opportunities for the restoration action plan (Krantzberg, 2003). During the last five years, due to society's commitment to the plan, environmental quality has enhanced dramatically, and Collingwood Harbour is not anymore considered an area of concern in 1994 (Krantzberg and Houghton, 1996). Some of the planning achievements are recognized in this project:

- It engages local leaders committing to their community. Senior leaders who have regional influence called for community collaboration. It has been proved that the broad stakeholder participation leads to the more robust performance of the rehabilitation plan (Krantzberg, 2003)
- Agreements on scopes have created tools to overcome obstacles and conflicts over the plan's implementation and development. In case of conflicting views on the restoration plan's dimensions, it needs to be returned to the common visions, as the basic aims of the plan are to enable the group to recreate consensus-based decision making.
- Measuring the prosperity and the goals achievements allows the group to recognize progress. Delisting targets by measuring progress improves the possibility that investments lead to optimal environmental restoration in operation (Krantzberg, 2003).
- The encouragement programs for gaining the expected goals can be altered among the participants and should be explained, as the participants looked at the harbor ecosystem restoration for various reasons.
- Assessing the improvement like the economic benefits of environmental health caused the planning committee to form different partnerships with the business sector in operating many numbers programs and projects (Krantzberg, 2003).

4.4.4 Integrating the Don river watershed plan (Toronto) into spatial planning

The Don River flowing across the eastern part of Toronto had been one of Canada's most hurt urban rivers. At the first of the 21st century, the Don River water basin was 80% urbanized. It was projected that it would be 91 percent urbanized by 2021. As a home for 800,000 persons, this settlement degraded aquatic habitats and terrestrial wildlife and contaminated surface waters by human sewage, agricultural and industrial waste, road salts, chemicals, metals, oil, etc. Urban development had increased the warmer temperatures of water, soil erosion, and water pollution. In 1994, the Toronto Region Conservation Authority implemented the Watershed Task Force.

Many of the steps were linked to land-use and regional planning principles like reducing the load of fertilizers, keeping old landfill areas from leaching into streams, supporting lowland meadows, streamside plants, and upland forests, regenerating wetlands, and enhancing the green corridors networks linking to the natural lands. Those functions could be often performed through local municipalities' statutory authority and their land-use plans. The watershed plans have a special role in guiding and informing municipalities, regional and federal governments. The plan should update the programs and policies for environmental conservation, protection, and restoration within water use and land contexts.

The plan also establishes direction to local non-governmental institutions, agencies, and private landowners regarding best management opportunities and environmental stewardship practices. The Don River Watershed Plan, together with the implementation guides, could understand the general health of the watershed and strategies to maintain its hydrological and ecological integrity. These strategies will guide the establishment of municipal plans and policies so that the protection plan requirements for key development are connected to the land use planning process and official municipal plans (TRC, 2009). The Don River watershed plan has recognized three strategic items for the creation of the watershed:

- Build or re-build the communities to enhance sustainability and restore water balance: balancing the Don River's flow regime and its tributaries through controlling stormwater sources will be associated with several benefits.
- Regenerate the aquatic and terrestrial landscapes: some of the water quality factors have been improved; several in-stream barriers to fish have been

removed; marine flora and trees have been planted, and road and pathway systems have enlarged.

- Engage the Don river people: outreach education and stewardship have helped understand the connection between watershed health and landowner actions.

It was evident from the case studies that a transformation has been taking place in recent years to reform national water sectors. The driving forces behind these changes relate to rising demand and competition for available resources and increased awareness of managing water in an environmentally-sound and sustainable manner. The move toward a fully integrated approach to water resource development and planning is likely to be a long path requiring significant changes in attitudes, practices, and procedures. It needs realistic time-scales if the desired objectives are to be achieved. Institutional change does not guarantee sustainable resource development as it heavily requires a commitment to change, adequacy of mechanisms, human resource capabilities, and coherent policies. The process of change must be consolidated step-by-step by the support of politicians, professionals, and communities. Careful consideration needs to be given to ensure that political, social, and economic settings are compatible with the direction of changes.

5. WATER RESOURCE PLANNING AND MANAGEMENT IN TURKEY

5.1 Turkey Water Issue

Turkey is defined as a country having water scarcity (Öztürk, 2016). With an area of 783 562 square kilometres,Turkey is surrounded by seas from third parts; however, it is not rich in freshwater resources. Turkey, located in temperate and semi-arid climates, has 643 mm average annual rainfall below the world's yearly rain (800 mm). The annual precipitation is 643 millimeters that means 501 km3. Also, there is significant diversity between areas in terms of rainfall (annually 3000 mm in some regions, while 250 mm in some other territories) significantly due to topographic and climatic differences. On the other hand, there is a disproportion between the amount of water flow in the basins and the number of water users and economic activities (Yilmaz, 2014).

In Turkey, regions of Mediterranean and the Middle East have less water. Water quantity per capita is around 1300 m3. For the last two decades, annual water amount per capita in Turkey has decreased from 4000 m3 to 1430 m3. Considering that the population of the country will reach around 100 million in the future, it is thought that the amount of water per person will decrease to approximately 1,100 m3 / person per year. There is an increasing awareness of the protection and efficient use of water resources to prevent Turkey's condition.

In Turkey, there are 25 river water basins. Firat-Decle having the 28.4% of whole water potential, is the largest water basin. Among the water basins which contribute to the water potential are East Black Sea 8%, East Akdeniz 6%, Asi 6 %, Burdur Lakes 0.3%, Akarcay 0.3%. In Turkey, 75% of the fresh water (29.6 km3) is used for agriculture, 15% (6.2 km3) for human usage and treatment, and 11.4% (4.3 km3) for industry (Yalçın and Eken, 2006). The rate of the fresh water used for agriculture is 33% for European countries and 75% for Southern Europe. In contrast, in Central and Western Europe, most water (57%) is used for energy production for cooling purposes and urban drinking water (Union of Turkey Health countries, 2018). Water used in Turkey's technique and economy is around 112 millard cubic meters in a year (DSI).

In which 88% from surface water (98 Millard/m3) and 12% (14 Millyad/m3) is provided from groundwater (Öztürk, 2016). These problems and pressures on Turkey's water basins have stressed the necessity for the protection of water resources by improving water management policies and sustainability principles.

Since 1950, with population growth and urbanization, the natural environment has begun to deteriorate in Turkey. The unconscious use of pesticides and fertilizers was among the reasons for the water basins' environmental pollution. After the 1980s, insufficient infrastructure was added to the water resource management problems. Today, issues like incorrect land use, fertilizers, sedimentation, irregular water transfers, and unintegrated management approaches negatively impact Turkey's water environments. The main problems of water basins in Turkey are:

- Use of fertilizers: in Turkey, after 1980, some factors such as unconscious uses of pesticides and artificial fertilizers in agricultural areas threatened the environment and potable water resources. One of the main reasons for affluent and sewer is the access and penetration of the solid waste and organic sediment into water resources.
- Incorrect land uses: in Tukey, 74% percent of the land is suffering from the wrong land uses like inaccurate use of the grassland, deforestation, and inappropriate soil in agricultural activities.
- Sedimentation: natural erosion posed by wind and water have led to transferring the solid materials and sediments into the water reservoirs, which caused the disturbance of light and oxygen balance and, in consequence, the destruction of the fish life, river ecosystem, and the dam's resistance (Turkoglu, 2016).
- Wrong water policies: in water resource management, exiting unfit water policies has exacerbated the issue. In national development planning in Turkey, the economic preferences are in priority rather than ecologic elements. The responsibility of water basin management and planning has been given to the legislation's bureaucratic authorities and institutions. Each authority has its own water basin planning strategies, which led to complicated problems (Tanik, 2016).

5.2 Water Resource Management Approach in Turkey

Over the last years, a practical water management approach based on sustainability principles and integrated water resource management has started growing in Turkey. Until the 1980s, only the water volume was considered in water management. Plans have been made for personal uses, and thus personalized solutions were generated for the challenges. In the following years, the increase in water resources' pollution pressures led to an integrated perspective considering water quality (Turkey Ministry of Agriculture and Forestry, 2013). Therefore, the water resource has been started serious modification and changes over the last years regarding the Water Framework Directive of European Unions and integrated water management to protect Turkey's water resources.

5.2.1 Legal structure

In Turkey, since the second half of the 20th century, the water need for the populations, agriculture, energy purposes, and industrial development are being increased, which has resulted in the deterioration of the water resources. In the following years, many regulations and laws have been produced by public organizations to preserve water resources. An integrated viewpoint considering water quality has been started rising in Turkey's water resources management (Çiçek et al., 2015). Water resource management was also affected by national legislations such as the Bank of Provinces Law (1945), Constitutional Law of General Directorate of State Hydraulic Works (1954), Groundwater Law (1968), and Environment Law No.2872 (1983). Additionally, Turkey has signed a few international declarations and agreements related to water subject on water basins protection and planning. National legislation of Turkey water can be categorized into three periods which are:

- The first period includes the first thirty years of the Turkish Republic. The structural legislations and laws related to water had been enacted to define a legal ground for water planning and management. The primary priorities in this period had been taking measures to protect public health and the construction of individual projects.
- In the second period (from the mid-1950s to the first half of the 1980s), a priority was given to water resource systematic development. It had been

adapted a water management-oriented approach until the 1980s with serious attention paid to efficient public good and water resources.

- The third period was initiated from the first half of 1980, in which the water quality issue was considered as the main challenge. Water pollution increased following rapid urbanization and industrialization. Furthermore, sustainability concepts and environmental protection have emerged after the Brundtland Report. Thus, since this period, the water laws and regulations aim to balance conservation and development (Çiçek et al., 2015).

5.2.1.1 Water framework directive of European Union

Turkey has been in accession negotiations in the EU candidacy process since 3 October 2005. It has committed to implementing the Water Framework Directive (2000/60/EC) as the most critical directives covered in the environmental chapter. Water Framework Directive addresses both the quantity and quality of water, adopts an integrated basin-based management approach, and provides a structure for protecting all water of surface waters, streams, coastal waters, transitional waters, and groundwater (Yilmaz, 2014).

The Water Framework Directive established in October 2000 is the most critical water management directive addressed in the environmental chapter (Çetin, 2017). In this framework, there are more than 20 main factors related to water resources. The content covers:

- Prevention of excessive destruction of the water resources;
- Protection and improvement of water resources;
- Sustainable water use considering long- term protection;
- Progressive protection of the water ecosystems and their enhancement;
- Reduction of groundwater pollution;
- Decrease the derivers of doughts.

In applying this framework, the joined countries provide the river basin planning with people's help. In the framework of the EU Water Directive, with the use of integrated water management and the classic water management, a series of principles are suggested:

- The streams, lakes, coastal water, and groundwater all should be conserved,
- All water resources of the European Union till 2015 and those located in Turkey till 2025 should be planned,
- Water ecosystems should not be limited to political boundaries. The water basin boundary (natural border) should be detrimental in management plans,
- The water quality standard should be obtained through an integrated process,
- For the water resources that crossed the political border, transboundary activities among international institutions and countries are necessary,
- In the management activities of water basins, a joint commission of the public is necessary,
- The pollution exposed from agricultural, residential, and industrial sectors should be monitored, reduced, and controlled,
- Appropriate punishment and penalty should be considered for the sectors generating pollution over the definite level (Öztürk, 2016).

Since 2005, Turkey has been membered in European Union, water use optimization and ecosystem conservation have been improved. The directive has provided a basic structure through planning activities, data analysis, the management needs for wastewater and solid waste in the water basin, and water quality monitoring system.

5.2.2 Institutional structure

According to Law Article No. 168 of the Turkish Constitution on "Exploration and Management of Natural Wealth and Resources," natural resources are under authority wealth. Their management right belongs to the state. Therefore, the protection, management, utilization, and supply of water resources are under the state's responsibility and rule. Similarly, various activities related to water resources, such as water supply and protection, are managed by many organizations and public institutions in Turkey (Çiçek et al., 2015). The institutions do their activities based on the institutional framework determined for their responsibilities. Turkey Ministry of Agriculture and Forestry is the main responsible for water use at national levels. While separate sectors are dealing with groundwater, rural and urban water supply, irrigation and hydropower, and so on (Turkey Ministry of Agriculture and Forestry, 2013). Each sector needs to obtain prior approval from the Ministry for any investment in the water

sector or development project. In Table 5.1, the water-related institutions and their responsibilities as to the water resources are summarized.

Table 5.1: An overview of responsibilities of public institutions in drinking water management.

Institution		Main tasks and responsibilities
Ministry of Agriculture and Forestry	General Directorate of Water Management	Strategies and policy making, the protection and monitoring of performed projects; water management at national and international level; coordination of river basin management; preparation of plans for groundwater and surface waters; sectoral water allocation; establishment of National Water Information System.
	General Directorate of State Hydraulic Works (DSİ)	Providing drinking water and wastewater treatment services; irrigation and utility water supply; flood protection; spreading irrigated agriculture, hydroelectric power generation; groundwater surveys and exploration of wells or drilling; groundwater allocation, protection and registration; studies for investigation, conservation and utilization of ground water.
General Directorate of Nature Conservation and National Parks		Wetlands and conservation of biological diversity; management of protected wetlands.
General Directorate of Renewable Energy		Investigation of water resources for electricity generation.
Ministry of Health		Controlling, analyzing and monitoring of physical, chemical, and microbiological quality standards of drinking water.
Bank of Provinces		Providing credit and technical support to municipalities for the construction of water, sewage and wastewater treatment plants.
Municipalities		Water distribution; sewage and wastewater treatment services; control of industrial wastewater discharges; construction; operation and maintenance of wastewater treatment plants.
Special Provincial Administrations		Providing water, sewage and wastewater treatment services to settlements outside municipal areas.
Energy Market Regulatory Authority (EMRA)		Licensing for hydroelectric generation.
Ministry of Health		Drinking water and bathing water quality monitoring, taking precautions regarding environmental and public health, supervising health arrangements related to drinking and using water, sewage and media installation.
Irrigation Associations		Irrigation water distribution at the local level.
Culture and Tourism Ministry		Construction of wastewater treatment infrastructures in touristic areas
Ministry of Development		General planning of water resources investments (eg dams, reservoirs and water supply, sewage and treatment)
Ministry of Foreign Affairs		Transboundary waters, international conventions.
Research Institutions (universities, TÜBİTAK, SUEN, NGOs)		Research on water and data production, contributing to policy development

5.3 Water and Plans in Turkey

Various thematic plans in Turkey cover the development objectives, priorities, and strategies at the national, regional and local, and administrative levels. Five available plans include Country Development Plan, Regional Plans, Spatial Strategy Plans, Environment Plans, and Zoning Plans, including Master and Implementation Plan (Figure 5.1). This part has tried to evaluate their contents and covered strategies in terms of water issues to understand the plans' relationships with the water sectors. In the following, these plans are explained in terms of their water-related contents.

Figure 5.1 : Hierarchy of the primary plans exiting in Turkey at various scales of country to local levels.

5.3.1 Turkey Development Plan (Ulusal Kalkınma Planları)

During 1950-1960, Turkey's economy experienced an unplanned, unscheduled, and unsustainable growth process. The 1961 Constitution stipulates the preparation of Development Plans to achieve economic, social, and cultural development through democratic means. Turkey, entering the planned period in 1963, has felt the need to prepare a 15-year perspective plan that determines the target's priorities, assesses the country's socio-economic potential, and guides this potential in medium-term plans. The main objectives of all development plans are to keep stable growth of national income, to put forth Turkey's development vision, to meet the fundamental values and expectations of the nation, to raise the country’s international position, and to increase competitiveness and efficiency horizontally and vertically in all areas. It is also aimed that the economy will be carried out in a mixed economic system. The public and private sectors will be intertwined to complement each other. The plan will reduce the unemployment rate to 9.9 percent by the new plan for permanently lower inflation rates. Therefore, the first Five-Year Development Plans (1963-1967) were prepared

following a 15-year perspective plan covering the years till 1977. In this framework, it is essential to take structural and institutional measures to overcome the difficulties that may arise in the integration process with the European Union and anticipate and eliminate the issues resulting from the world's changing conditions. 11th Development Plan covering 2019-2023 was presented to the Grand National Assembly of Turkey. It is the Presidential Government System's first development plan and is prepared with a 15-year perspective that envisages a total change and transformation in every field. Water-related priorities in this plan are listed in Table 5.2.

Table 5.2 : Water- related priorities determined in the11th Five Development Plan (2019-2023).

Target areas	Priority num.	Water related objectives and policies
Climate change, food safety and effective use of water	80	Developing plant and animal species suitable for changing climate, protection of environment and biodiversity, and increasing qualified labor and technology in order to meet food demand with less resources.
Global trend and Interaction with Turkey	103	Increasing the sustainable use of land and water resources, food security and the conservation of agricultural population on the spot, increasing rural development supports and technology use in agriculture.
Economic and social development plan	143	Investments accelerating in order to improve the irrigation infrastructure, diversification of agriculture supports, food safety, soil and water sustainable use, modernization of agricultural holdings, plant and animal health.
	156	Continuing policies sensitive to environmental problems within the framework of sustainable development principles in the last period. In this context, efforts were made to improve the institutional structure, legislation and standards in the field of environment.
	158.	Continuing the Village Infrastructure Support Project (Koydes) and the Water and Sewerage Infrastructure Program (Sukap) and the Social Support Program for the priority provinces in terms of social development were implemented.
Development areas	404.2	Increasing agricultural subsidies, and providing a dynamic structure that focuses on water constraint, quality in production, farmer cost and income, supply and demand balance.
	406.2	Continuing public irrigation investments on the storage facility, attractive irrigation system, high level of peer irrigation rates.
	406.3	Extending modern irrigation systems, such as sprinkler and drip irrigation, to ensure efficient use of water in agriculture.
	406.4	Extending measures to prevent agricultural water pollution.
	409	Increasing production and export of aquaculture.
	409.1	Identifying new potential aquaculture areas and opening the use of entrepreneurs and production with various government supports.
	426.4.	Realizing potable water, sewage, solid waste disposal, and wastewater treatment in tourism areas

Table 5.2 (continued) : Water- related priorities determined in the11th Five Development Plan (2019-2023).

Target areas	Priority num.	Water related objectives and policies
Urban infrastructure	696	Providing the population to access healthy and reliable drinking and potable water and minimizing the effects of wastewater on human and environmental health, ensuring and disposing of recycling and recovery with an effective management.
	697	Implementing Basin-based plans, strategies and action plans within the scope of conservation, development and sustainable use of water resources in integrity.
	697.1	Completing river basin management plans, sectoral water allocation plans, basin master plans, drought management plans, flood management plans, and drinking water basin protection action plans for 25 basins for the effective use and protection of water resources.
	697.2.	Making basin-based planning for reuse of treated wastewater, especially agriculture, and reducing pressure on water resources.
	697.3.	Determining quality and quantity status of groundwater bodies
	697.4.	Expanding and sustaining national water information system.
	698	Ensuring that drinking water and wastewater services are provided efficiently, adequately in compliance with standards and improving operational performance and investment efficiency of responsible institutions.
	698.1.	Making legislative arrangements for the establishment of water sewerage administrations on a provincial basis other than a metropolitan municipality.
	698.2.	Developing a reimbursement system to ensure that DSİ's drinking water project financing is sustainable in providing drinking water investments and services.
	698.4.	Expanding models to operate wastewater treatment plants effectively and overcoming existing barriers such as supervision, lack of technical knowledge and capacity related to wastewater quickly and effectively.
Rural development	706.1.	Providing financial support for settlements returning from villages and towns to the neighborhood, for the construction of high quality and accessible road network, drinking water, wastewater facility.
	725.	Giving priority to the strengthening of everyday use spaces such as hospitals, schools, dormitories and critical infrastructures such as energy, transportation, water and communication, which are of special importance in disaster preparedness and post-disaster response.

5.3.1.1 National strategy for regional development

Regional plans aim to obtain development potential of settlements, socio-economic development trends, distribution of various activities and infrastructures, and sectoral objectives. Regional programs will determine the necessary strategic spatial decisions at the regional level. According to article 8 of the Development Law no. 3194, the State Planning Organization makes the regional plans if necessary (Özdemir Sari et al., 2019). Since regional development is related to almost all sectors, it is crucial to consider inter-sectoral interaction for regional development purposes and to strengthen coordination mechanisms in policy development at central and local levels. The establishment of institutions operating at the regional level besides the central government organizations means giving more authority to the local administrations and establishing a practical coordination framework between the central, regional, and local levels. *National Strategy for Regional Development* is a framework document defining the main strategies for regional development. Prepared with a strategic planning approach, it will guide regional policy development, planning, and implementation at the regional and local level while developing policies at the national level. The following general objectives will be pursued to achieve the vision of regional development:

(i) Wider spread of welfare across the country by reducing regional development disparities;

(ii) Contributing all regions to national development at the maximum level by assessing their potential and increasing competitiveness;

(iii) Strengthening economic and social integration;

(iv) Establishing a more balanced settlement throughout the country.

National Strategy for Regional Development is taken into account in developing sectoral and thematic strategies concerning regional development. It is also a reference in ensuring the coherence between these and regional development priorities. Cooperation with the relevant institutions will be prepared in the long term at the country level, following the National Strategy for Regional Development, the spatial strategy plans, the social, economic, and environmental strategies, the physical development, and the spatial strategy. Regional plans, regional programs, and action plans are essential tools for implementing the National Strategy for Regional

Development. The objectives related to the water resources and watersheds in this strategy are:

- Social and physical infrastructure accessibility: the objective is to improve the urban life quality in regions and cities by improving significant infrastructure having deficiencies, especially in the eastern provinces of the country, utilizing a potable water source, connecting water network to residences, and providing wastewater treatment services.
- Accelerating development in rural areas: the objective is to improve the rural environment and protect natural resources. Therefore, some programs are considered for promoting water-saving methods, constructing ponds for animal drinking water, supporting fire extinguishing, supporting micro-watershed-based programs, and producing regional market products.
- Natural structure, environment, and climate change: it aims a regional development, particularly in low-income regions, contributing to environmental sustainability. By this strategy:
    - It has developed an awareness of recycling and recovery in Turkey.
    - The population receiving waste disposal service has improved.
    - With potable water network investments, the ratio of persons benefiting from the drinking water within the municipal boundaries has risen from 88 % in 1994 to 99 % in 2010.
    - Basin-based approaches have been developed to ensure water management effectiveness, and the protection action plans have been completed for the Turkey water basins.
    - Thirty agricultural basins have been recognized, determining suitable product patterns in these basins to provide more biological diversity, protect soil and water resources, and ensure sustainable agricultural production.
    - Studies on biodiversity economics have been started to use the rich natural resources in a sustainable way.
    - Sustainable hunting was introduced to support rural development.
    - Nature conservation areas with national and international protection were declared.

- Studies for eliminating the factors that cause deterioration in marine ecosystems, especially land-based pollutants, were carried out with special environmental protection areas' priority.

- Enhancing cross-border and inter-regional cooperation: it aims to develop cooperation in the fields of environment, infrastructure, and service provision. So:
  - Joint disposal, recycling, drinking water system, and treatment plants are established by managing solid waste and wastewater systems in suitable regions.
  - The protection and effective use of water and soil resources are ensured by coordinating the river basin management plan measures, in line with the Watershed Protection Action Plans and the Water Framework Directive.
  - Use of daily maritime transport is increased. It will support transport in appropriate rivers and lakes (natural and dam reservoirs) and encourage local production and service sectors to transport in inland waters.

5.3.2 Regional plans (Bölge planlari)

Regional development is the basis for national development. A certain regional development, which is defined based on the region's economic and socio-cultural structure, includes a more complex network of relations than the national development plan. Local development is in line with regional development. The European Union has started to build its regional policies on development and global competition. Turkey also began its work to comply with the EU on regional development after declaring the European Union's candidacy.

The European Union organizes regional comparisons and regional planning according to the NUTS (Nomenclature of Territorial Units for Statistics) system. This system has divided the country into hierarchical sub-regions as NUTS I, NUTS II, and NUTS III. The population ranges determine regions in the context of NUTS classification. The interregional development level, the planning, and incentive programs of the areas are also considered within this framework. The NUTS classification outlines the implementation of the EU member states' regional policies and facilitates regional and national issues. According to the European Regional Development Agencies Association, Regional Development Agencies are the organizations that identify the

sectoral or all development problems of a region and create solutions and projects with different methods. Regional Development Agencies (RDA) are in an administrative position, independent of the central government as they develop a particular region's socioeconomic structure. The reasons for the existence of RDAs are realizing regional strategies, supporting local and regional entrepreneurship, giving importance to infrastructure services, researching local-regional solutions for the near future of the private sector, and seeking financial guarantees to meet the demands in the region (Dinçsoy, 2015).

Due to the raw material needs in the developed countries like Turkey, the economic developments got weight in some western and southern provinces. However, it led to the impugned difference in Central, East, Southeast Anatolia, and the Black Sea regions. Since 1963, five-year plans have been implemented, and regional policies have started to be organized accordingly. Planned development policies in the 1970s directed the development differences in favor of Western regions. In the 1980s, private investment begun in the Eastern regions. By the 1990s, because of problems such as increasing security and national competitiveness, economic policies were allowed to change. The first studies dealing with regional development agencies in Turkey began in the 1990s. After the 1999 Helsinki Summit and declaring the EU candidacy, Regional Development Agencies were accelerated in Turkey. The State Institute of Statistics and the State Planning Organization coordinated with the NUTS classification (Statistical Region Units) performed regional statistics gathering, the socioeconomic status analysis, and the identification of regional policy to become comparable with European Union in Turkey (Dinçsoy, 2015).

In Turkey, in accordance with the EU acquis, Regional Statistical Unit Classification was established in 2002 based on the NUTS criteria. According to the NUTS system, all public institutions, especially the Turkish Statistical Institute (TSI), have started to structure their organizational chart. NUTS region systematics developed in the European countries after the 1970s is a relatively new concept for Turkey. Therefore, the discussions related to the issue remain on the agenda. The most important objectives of development agencies is

- to develop cooperation between public, private, and non-governmental organizations by ensuring the effective use of resources,

- to accelerate regional development in line with the principles envisaged in the national development plan,
- to ensure its sustainability, and reduce interregional and intraregional development differences.

In this case, the RDAs with the same goals as RDAs in the world are established in Turkey. Names and boundaries of Turkey's geographical regions and divisions have always been a matter of debate (Dinçsoy, 2015). In the regional development agencies in the European Union, the initiative is mostly in the hands of private sector representatives and non-governmental organizations. But in Turkey, State Planning Organization is undertaken by the private sector and civil society organizations. Development agencies started to increase in 10 regions across the country, such as in Istanbul, Samsun, Diyarbakır, Konya, Erzurum, Gaziantep, Mardin, and Van provinces to become centers. With the decision of the Council of Ministers in 2009, within the framework of NUTS II; Tekirdağ, Balıkesir, Denizli, Kütahya, Bursa, Kocaeli, Ankara, Izmir, Hatay, Nevşehir, Kayseri, Zonguldak, Trabzon, Kastamonu, Kars and Malatya agencies have been created. Thus the number of RDAs in Turkey became 26. As a result, today, Turkey has 12 at I levels NUTS, 26 at II levels NUTS, 81 at III levels NUTS region. Agencies, duties, and powers are regulated by law.

5.3.3 Spatial Strategy Plans (Mekansal Strateji Planları)

According to Article 4, paragraph 1 of the Construction Regulation, Spatial Strategy Plans associate with Turkey's development policies and regional development strategies. Under the Ministry of Environment and Urbanization's organization and duties, it entered into force in 2011. These plans evaluate regional plans considering the economic and social potential and determine spatial strategies for the conservation and development, settlements, transport network, and directing urban, social, and technical infrastructure. When preparing spatial strategy plans, the main objectives set out by considering the national development plan, regional development strategies, and other strategy documents.

The spatial strategy plans are the high-scale plans on 1 / 250,000 or 1 / 500,000, or larger scale maps that direct the settlement, construction, and land use. They form a basis for the physical plans and applications of all types and scales. The principles adopted for natural sites and areas considered as cultural and natural assets are

fundamental. According to the Development Regulation, Spatial Strategy Plans are at the country level covering the whole country, territorial waters, and individual economic regions. At the metropolitan level, it covers development centers, new cities, development corridors, production, consumption flows and relations, urban and regional networks, the density of settlements, transport relations, physical thresholds, and so on (Gursoy and Edelman, 2017).

Large projects requiring decisions at the country and regional level should be evaluated based on the spatial strategy plan or environment plan. Local governments' plan decisions should follow the spatial strategy plans. Sector-based plans should be compatible with spatial strategy plans. The spatial strategy plans can be arranged at the basin and regional scale. The environment planning plans will not contradict the spatial strategy plans of the Environment and Urbanization Ministry.

By 2023, spatial planning at the macro and micro level will be prepared in all provinces. Spatial strategy plans will be revised in necessary periods considering new developments and regional movements. Spatial planning will develop a strategic planning approach to bringing implementation and monitoring processes into practice. Public institutions, local governments, universities and all relevant stakeholders should be cooporate with the participation of Spatial Strategy Plans to assess the current situation, problem areas, solutions, long-term sectoral development trends, potential sectoral targets and predictions, policies and strategies, and strategic decisions, and investments related to space.

5.3.4 Environment Plans (Çevre düzeni planları)

On November 11, 2008, the Environment Plan regulation was passed based on the Environment Law dated 28/8/1983 and the Law on "Organization and Duties of the former Ministry of Environment and Forestry " dated 1/5/2003. The Ministry of Environment and Urbanization published environment Plans within metropolitan municipalities' boundaries in 2003. Meetings were held in the provinces located in the planning region until the Environment Plan's approval. The Environment Plan has particular planning or management provisions for the water bodies found in the area. They included a set of strategies for plan implementation, explanatory documents, and reports on the scale of 1 / 100.000 (Url-1).

Environment Plans' decisions connect to all private and public sectors, covering all central organizations, institutions, and local authorities. The environment plan acts as an instruction for the coming development and master plans and determines land uses' general decisions. Primary areas and basic principles in the legal structure of the Environment Plan are:

- to direct the sub-scale plans and the following local development plans;
- to define the general laws for the development and protection of the natural environment, historical, and cultural wealth of the country;
- to project drinking water values and produce strategies for sustainable ecological decisions;
- to determine the land use decision based on regional plans and development plans regarding the ecology, hydrological risks, geology of the natural resources, population projection, and sustainable use of the sources;
- to make sure land use continuity and ecosystem integrity in terms of plan decision;
- to prevent pollution before it occurs;
- to assign the policies for the production zones to guarantee the ecological integrity and economic decisions;
- to prepare the Environment Plan by the competent authorities and the relevant administration;
- to carry out the coordination with other relevant administrations by the competent authority;
- to participate the experts from different professions and relevant institutions at the planning process;
- to have a standard database and make maximum use of technology and use field studies using the data, satellite imagery, or aerial photographs.

Later in this chapter, the Environment Plans of five regions in Tukey are evaluated according to the plan regulations defined for water resources.

5.3.5 Development plans (İmar planları)

5.3.5.1 Master plans (Nazım İmar Planı)

In line with Regional and Environment plans, Master Plan with the cadastral status of land uses is prepared at a scale of 1/25000 or 1/5000. The Master Plan and

Implementation Plan follow the Environment planning and are under the authority of the municipalities. The Master Plan provides a basis of the Implementation Plan and includes three written, oral, and drawn layout documents according to the site's characteristics and situation.

The Master Plan scopes for the zoning land are to determine the general usage forms, main region types, future population densities of the regions, density of the structures, the development directions, sizes and principles of various settlement areas transportation systems, and solution of problems. In the preparation of Master Plans, data is obtained from related institutions and organizations within the planning area's scope. No detailed decisions must be taken for the Implementation Plan in terms of the decision level and content. The zoning plans' construction stages may be determined regarding the social and technical infrastructure allocated to the public in the master zoning plans. Some of the subjects covering by Master Plan are:

- Administrative boundaries, geological, geomorphological, hydrological, and hydrogeological structure;
- Spatial development trends and potentials of settlement areas;
- Climate characteristics;
- Ecological structure (ecosystem types, presence of flora and fauna), soil quality and agricultural land use, vegetation;
- Protected areas, sensitive areas (national and nature park, wetlands, nature monuments, natural protection area, wildlife protection area, species, drinking water basins protection areas, and so on);
- Forest areas, pasture, highland, and winter areas;
- Cultural and tourism development zones, and tourism centers;
- General landscape elements and microform analysis;
- Demographic structure and characteristics of the population (age, gender, work, education, marital status);
- Social and economic structure;
- Primary transportation system (highway, railway, seaway, airline, terminal, station, port, and airport);
- Sectoral structure (agriculture, industry, services, transportation, energy, mining, housing, etc.);
- Solid waste storage, recovery, and disposal facilities, drinking water, and wastewater treatment plants, wastewater discharges;

- Natural disaster hazards and urban risks, if any, risk management and avoidance plans;
- Existing land use, construction status, and ownership structure;
- Environmental problems, environment plan decisions, and current development plans (Dede, 2016).

It has emerged after Development Plan, Regional Plans, Regional Spatial Strategy Plan, and Environment Plan. Plan Construction Process covers:

- Determining the area to plan,
- Collection of plan data,
- Analysis and synthesis of studies,
- Making plan decisions,
- Drawing the plan and preparing the report,
- Discussion and approval of the Ministry.

After all stages, the master plan is approved, and a 1/1000 scale Implementation Plan is prepared. A 1/1000 scale implementation plan cannot be made without a Master Plan of 1/5000 scale of a region. Therefore, first, the Master Development Plan comes out, then the Implementation Zoning Plan.

5.3.5.2 Implementation Plans (Uygulama İmar Planları)

The Implementation Plan is applied in smaller-scale areas than the Master Plan and the zoning plans. Although the Master Plan is created on a larger scale than the Implementation Plan, it forms the Implementation Plan basis. In this respect, the Master Plan and Implementation Plan are complementary parts. The relevant municipalities prepare all development plans, whether the Implementation Plan and the Master Plan. The Implementation Plan is a 1/1000 scale plan designed to determine the future's social, cultural, and economic settlement patterns.

It can be made in one step or stages. However, the boundaries of the stages must be shown in the Master Plan. Following the building conditions, it includes some zoning plan features like the number of floors, floor areas, housing height, building distances, and block structure. The Implementation Plan can make life easier for those who have difficulty using public spaces, such as the disabled, the elderly, and children. Individual happiness is in priority in the Implementation Plan and the Master Plan (Dede. 2016).

5.4 Restructuring of water and watershed management

5.4.1 Central Structure

Water and water basin management consists of two main structures, central and local. Under the central structuring, two management boards are located:

- The Water Management Coordination Board, which is responsible for providing coordination among the sectors,
- The Basin Management Central Board is responsible for preparing basin management plans, following up the applied implementations, and inter-agency coordination in each 25 water basins.

5.4.1.1 Water Management Coordination Board

The Prime Ministry (2012/7) published the board formation in the official gazette dated 20/03/2012, numbered 28239. It aims to good water management, water conservation and sustainability, the balance of water conservation and use, and the coordination and cooperation of all relevant ministries, institutions, and organizations to act within a common framework (Url-2). The primary duties of the board are:

- To do measures required for understanding integrated management of the water resources,
- To ensure inter-sectoral coordination and acceleration of investments for effective water management,
- To develop strategies, plans, and policies to achieve the national and international targets,
- To inform the implementation issues to the public organizations in the basin plans,
- To ensure coordination with the upper organization.

Institutions and organizations involved in the board are :

- Ministry of Agriculture and Forestry,
- Ministry of Environment and Urbanisation,
- Ministry of the Interior,
- Ministry of Foreign Affairs,
- Ministry of Health,
- Ministry of Industry and Technology,
- Ministry of Energy and Natural Resources,

- Ministry of Culture and Tourism
- Presidency of Strategy and Budget,
- General Directorate of Water Management,
- State Hydraulic Works,
- Turkish State Meteorological Service,
- General Directorate Combating desertification and erosion,
- Turkish Water Institute.

5.4.1.2 Basin Management Central Board

The Ministry of Agriculture and Forestry was published its regulation in the official gazette dated 18.01.2019, numbered 30659. The Basin Management Central Board has been established to discuss the issues addressed by the Basin Management Committees and cover the decisions on the issues that are not resolved in the Water Management Coordination Board at the basin scale (Url-3). The board's responsibilities are:

- To follow inter-institutional practices in the preparation and implementation of basin preparation plans,
- To bring the national level problems related to water management to the schedule taking decisions for their solution and following up the applications,
- To notify the relevant institutions of the decisions made,
- To follow the developments within the scope of the National Basin Management Strategy and ensure coordination,
- To coordinate the drinking water utility of the basin protection plan to be made and to follow the development,
- To submit the basin management plans to the Water Management Coordination Board.

Institutions and organizations involved in the board are: Ministry of Industry and Technology, Ministry of Environment and Urbanization, Ministry of the Interior, Ministry of Foreign Affairs, , Ministry of Culture and Tourism, The Ministry of Energy and Natural Resources, General Manager Ministry of Health, Ministry of Transport and Infrastructure or the general managers of the relevant units, State Hydraulic Works, General Directorate of Water Management, General Directorate Combating Desertification and Erosion, General Directorate of Nature Protection and National Parks, General Directorate of Meteorology, General Directorate of Forestry, General Directorate of Agricultural Reform, Agricultural Research and Policy General

Directorat, General Directorate of Food, Agriculture and Livestock Ministry of Fisheries, Turkey president of Water Institute, and Head of Disaster and Emergency Management.

5.4.2 Local Structure

The formation of local structure was published in the official gazette dated 18/01/2019, numbered 30659 by the Ministry of Agriculture and Forestry (within the scope of "Havza Yönetimi Merkez Kurulu, Havza Yönetim Heyetleri ve İl Su Yönetimi Koordinasyon Kurullarının Teşekkülü, Görevleri, Çalışma Usul ve Esaslarına Dair Tebliğ"), (Url-4). The board includes the Basin Management Board and the Provincial Water Management Coordination Board.

5.4.2.1. Basin Management Board

The Basin Management Board is a board established separately for each basin to carry out studies on evaluating the implementation of plans at the basin scale. The Basin Management Committees are chaired by a Coordinator Governor determined by the Ministry. The Coordinator Governor is determined for each 25 water basins covering all the basin provinces in Turkey. The Coordinator Governor of Marmara Basin in Istanbul is the Governor for other regions in the basin, including Edirne, Kırklareli, Kocaeli, Çanakkale, Bursa, Tekirdağ, Yalova, Balıkesir, and Kırklareli. The head of the Istanbul Metropolitan Municipality and the General Manager of the Istanbul Water And Sewerage Administration (ISKI: İstanbul Su ve Kanalizasyon İdaresi) are natural members of the Istanbul Basin Management Board. The members of the Basin Management Committees, chaired by the Coordinator Governor, consist of the following persons:

1) Governors of other provinces in the basin,
2) Metropolitan mayors of cities and general managers of water and sewerage administration,
3) Provincial mayors of non-metropolitan provinces,
4) General secretaries of the special provincial administration,
5) General Directorate of Social Aids,
6) General directorate's representative of State Hydraulic Works (DSI),
7) Representative of Turkey Water Institute in transboundary basins,
8) Regional director of DSI as the province coordinator,

9) Representatives of other DSI Regional Directorates in the basin,

10) Ministry directors of the provinces included in the basin,

11) Provincial Directors of Environment and Urbanization,

12) Provincial Directors of Industry and Technology,

13) ILBANK representative,

13) Representatives of organized industrial zones, universities, non-governmental organizations, irrigation unions, with a maximum of two representatives each.

The head of the Basin Management Board may invite the central or provincial representatives of the relevant institutions to the board meetings. The duties of the Basin Management Committees are:

a) To contribute to the studies related to the basin-scale management plans prepared by the Ministry, monitor the plan implementation, and inform the relevant institutions about the decisions taken by the Committee,

b) To follow up the studies for the protection of drinking water resources and to ensure the implementation of the prepared water basin protection plans,

c) To evaluate the work performed by Provincial Water Management Coordination Boards and related institutions and report to the Basin Management Central Board,

d) To ensure public access to information, take their views and active participation in the process of preparing and updating basin-scale management plans,

e) To monitor and report the implementation of the basin management plans within the framework of the determinant principles and follow-up the basin management plans,

f) To work on solving problems related to water management at the basin scale.

Basin Management Board convenes at least once a year. Basin Management Committees may decide to establish sub-commissions and working groups to work on the issues that fall under their job description.

5.4.2.2. Provincial Water Management Coordination Board

The Governorships establish provincial Water Management Coordination Boards. The Mayor of Istanbul Metropolitan and the General Manager of Istanbul Water and Sewerage Administration (ISKI) are natural members of the Istanbul Provincial Water Management Coordination Board, which convenes under an appointed chairmanship Deputy Governor.

Provincial Water Management Coordination Committees consist of the following persons:

1) Metropolitan mayor and general manager of water and sewerage administration in metropolitan cities, 2) Provincial mayors, 3) General Secretary of the particular provincial administration, 4) The highest level representative of the Ministry of Energy and Natural Resources in the province, 5) The highest level representative of the Ministry of Transport and Infrastructure in the province, 6) The highest level representative of the General Directorate of State Hydraulic Works in the province, 7) The highest level representative of the General Directorate of Turkish State Meteorological Service, 8) The highest level representative of the General Directorate of Highways in the region, 9) Development Agency's highest level representative in the province, 10) The highest level representative of ILBANK A.Ş. in the province, 11) Ministry Provincial Directorate, 12) Provincial Directorate of Environment and Urbanization, 13) Provincial Directorate of Industry and Technology, 14) Provincial Directorate of Health, 15) Provincial Manager of Disaster and Emergency, 16) Maximum two representatives from universities and irrigation unions determined by the the board.

The duties of the Provincial Water Management Coordination Board are:

- To provide the necessary contributions for the basin-scale management plans to be prepared by the Ministry,
- To implement the required measures within the framework of the relevant legislation and institutions to prevent the loss of life and property from floods that may occur within the province's boundaries.

Provincial Water Management Coordination Boards convene at least once a year, within the first six months. Institutions/organizations and experts who are not members of the board may participate in the sub-commissions and working groups.

5.5 Water Resources Protection Plan of Turkey

On 17/October/2012, the regulation on “the Protection of Watersheds and Preparation of Management Plans” was passed by the Ministry of Agriculture and Forestry in Turkey. River basin management plans are under the Ministry of Agriculture and Forestry’s primary responsibility. The Ministry established a river basin coordination commission in 2013 to manage water resources in Turkey.

According to this instruction, the conservation and protection of surface and groundwater, their ecological, chemical, and physical quality, and the water quantity have been in priority (Öztürk, 2016). This regulation aims to provide plans for water protection and water usage of water basins and smaller water bodies such as dams and lakes and prepare integrated watershed management for surface water and soil sources.

First of all, the General Directory of Water Management has characterized 25 hydrological river basins according to their geographies and their priorities in Turkey. Based on this regulation, preparing the river basin protection plans have been started. Finally, the watershed protection and management plan for the 25 hydrological river basins were prepared. The adoptive regulations have developed policies for the cooperative management of water in Turkey. In each river basin, there is a River Basin Authority for managing the water demand and supply. The National Basin Strategy was completed in 2014, and River Basin Protection Action Plans have been completed for each river basin. The principles and regulations of the legal structure of the Protection Plan are:

- To provide conservation planning for potable water sources, conduct environmentally inter-basin water transfer, protect the water resources quality and quantity, prohibit the deterioration of the water having the good condition, protect the aquatic habitats and species, and determine the typology for surface water bodies;
- To define protection areas on the maps, monitor and maintain reference conditions, and plan for the natural mineral and geothermal water resources in the Basin Management Plans;
- To discover solutions for hotspots, protect water-dependent ecosystems, make a balance of conservation- use, preserve water required for the ecosystems, and ensure land use continuity and ecosystem integrity in terms of plan decision;
- To manage overflowing, doughtiness, flood, and control the climate change effects in water resource;
- To address non-point source pollution and prevent sewage sludge;
- To prepare accident management plans, control accidental pollution, and collect wastewater and deliver to a treatment plant;

- To evaluate irrigation water, use of the methods based on productivity in irrigation, encourage the efficient use of water by irrigation water tariffs, and encourage the re-use of rainwater and treated domestic wastewater in irrigation;
- To designate good water to tourism, trade, mining, recreation, transportation, and other water needs, not discharge domestic, urban, industrial, and energy wastewater to the receiving environment;
- To allow public access to information, obtain their opinions and active participation, and increase the life quality of the residents in the water basin;
- To detect authorized administration for the maintenance of sustainable water use, recognize the measures related to monitoring and control, and detect governorship by the Ministry if the watershed covers more provinces;
- To create a participatory approach in the management plans by the Ministry, lead necessary plans with EU member countries in transboundary basins, and recognize the responsibilities among participants to enhance the administrative capacity;
- To find the water allocation principles regarding basin water budget and priorities, and analyze the water usage cost in the basin based on economic trends;
- To take complementary management plans, classify water bodies into the artificial, natural, or substantial categories, determine the water quality standards and use an effective monitoring system and efficient water technologies;
- To integrate the management plan into the Ministry's central database and all kinds of programs and strategies, review the reports and update it at least every six years, observe the virtual water balance based on production and consumption.

In the Basin Protection Action Plans, the water amount, water pollution, agricultural activities, economic, industry, urbanization in the water basins, threats posed by these activities, and the urgent preventions have been considered. In this term, water basins' general situations and their environmental structures through land activities were

defined. The water resources potential, water quality categorization, and pollution load were evaluated and estimated. The urban waste water planning was performed; the environmental problems were evaluated; and the necessary solutions and works were determined (Kimençe et al, 2016). In Basin Protection Action Plans, 15 actions were defined:

Action 1 Urban wastewater management.

Action 2 Industrial wastewater management.

Action 3 Solid waste management.

Action 4 Non-point source pollution management and control.

Action 5 Planting, flood, and erosion control.

Action 6 Sewage sludge control.

Action 7 Preparation of Basin Conservation Planning in potable water.

Action 8 Overflowing management.

Action 9 Drought management.

Action 10 Monitoring, inventory, and water information system studies.

Action 11 Water investment.

Action 12 Reuse of the treated wastewater.

Action 13 Control of the climate change effects on water resources.

Action 14 Sectoral allocation plans.

Action 15 Solutions suggested for hotspots (Turkey Ministry of Agriculture and Forestry, 2013).

For comprehensive management of the water basins in Turkey, “Water Management Coordination Committee” was created with the president’s confirmation in 2012. This includes all individuals and stakeholders in the water basins and from the related institutions and local managers. These Regional Water Management Commission get together three times a year and report the Water Basin Management Committees' results. This committee has the following rights:

1. Survey the implementation of water basin management;

2. Survey the management plans of drought and overflowing.

3. Send report to its higher commission;

4. Register the results and solutions achieved from monitoring and tracking;

5. Follow the conservation activities of the used and potable water;

6. Intervene the public to update and prepare the management plan of droughts, overflowing, and water basins (Kimençe et al., 2016).

Therefore, the Protection Action Plans of 25 river basins in Turkey are prepared. In these plans, according to the Water Directive Framework, it is suggested Benefit-Cost Analysis in which the following steps should be followed:

- Each alternative's cost should be determined. If the cost is spread over the years, a cash flow table is created for each alternative. The price should be calculated annually using the discount rate (discount rate);
- The negative effect of the measures on other targets should be investigated, and the cost required to eliminate such effects should be calculated.
- The most appropriate alternatives should be selected as cost (Figure 5.2).

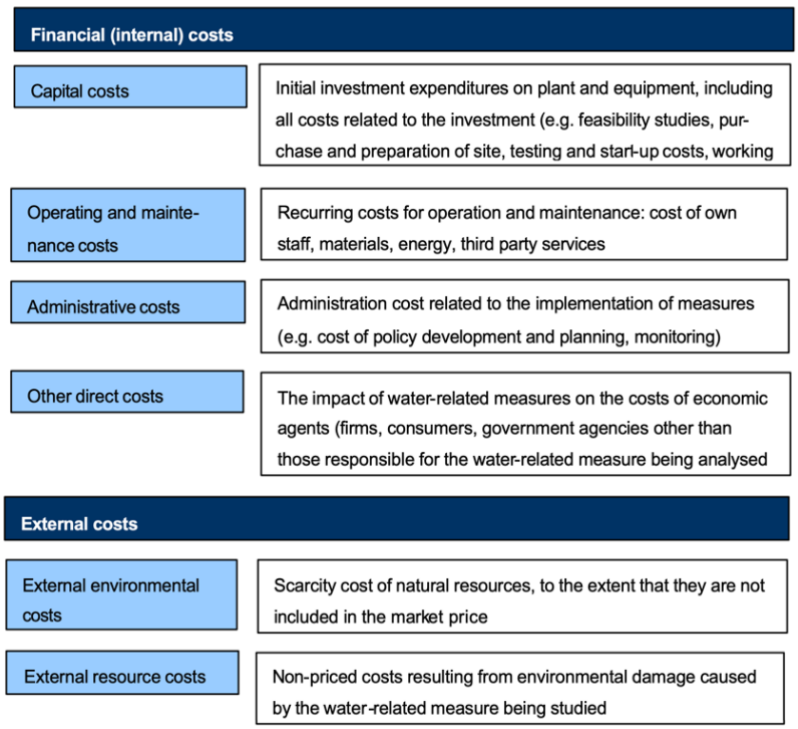

Figure 5.2 : The cost categories that should be considered in the planning process **(**Ministry of Agriculture and Forestry).

5.5.1 Drinking water resources protection plan

Turkey has adopted a basin-based water management approach and initiated water management plans for drinking water resources. Following the provision of "Conservation and Development of Water Resources, the Ministry of Agriculture and Forestry has performed studies related to developing the short, medium, and long-term policies for the protection and sustainable use of drinking water resources. Many drinking water protections researched are conducted in basins, where there is a water quality problem. Although these plans are not realized at the river basin scale, they can serve as a model for the implementation of an integrated and holistic planning approach in water-related planning activities (Çiçek et al., 2015).

For providing the protection plans of drinking water resources such as dams and lakes at first, the general characterizations such as ecological, socio-economic, physical structures, and current land use of the water bodies have been determined. Then, the pollution sources are evaluated, and a new program for water quality monitoring is initiated. Monitoring stations for the water quality are positioned in the reservoir to determine the water quality. In the third step, using a mathematical model of water quality, the alternatives and scenarios are developed for a basin protection plan, and the expected effects of different water quality options are calculated. Ultimately, a protection plan of the water body covering land-use proposals is prepared. Furthermore, based on the prepared protection plan, the special regulations and protection zones are defined in each specific dam-lake (Çiçek et al., 2015), (Figure 5.3).

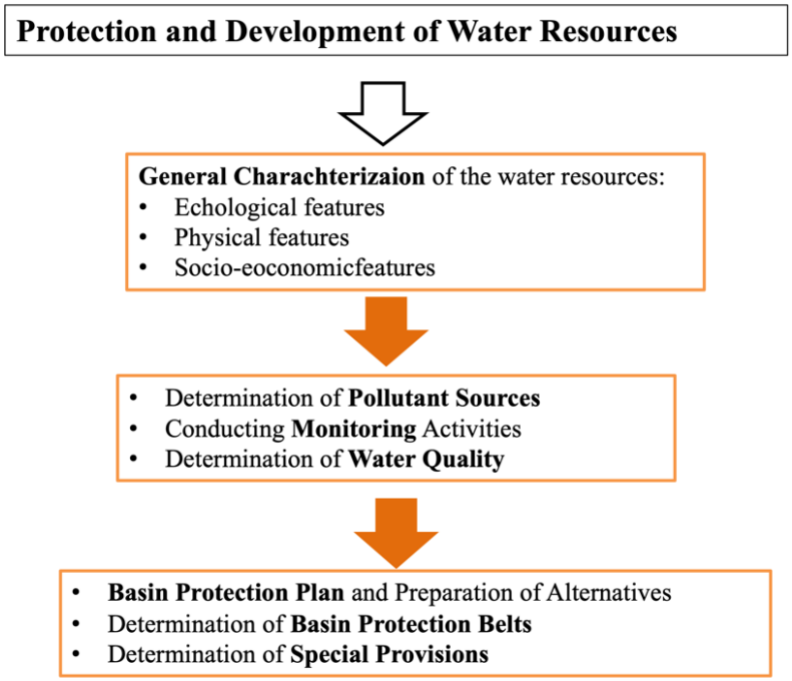

Figure 5.3 : Process of preparing drinking water resources protection plan by Ministry of Agriculture and Forestry.

The projects of drinking water protection plans are being performed under the Ministry of Agriculture and Forestry's approval and control. Considering overall water quality and quantity, related risks, and the required level of water resource protection, four different protection zones (absolute 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 regulations (Figure 5.4). These general provisions and protection zones are in force for all drinking water reservoirs and lakes until special requirements are made for each drinking water source and its basin. In some cases, primarily when the dam-lake is located in the metropolitan boundaries, they are prepared by research institutions like Tubitak and then approved by the Ministry (Şahin, 2016).

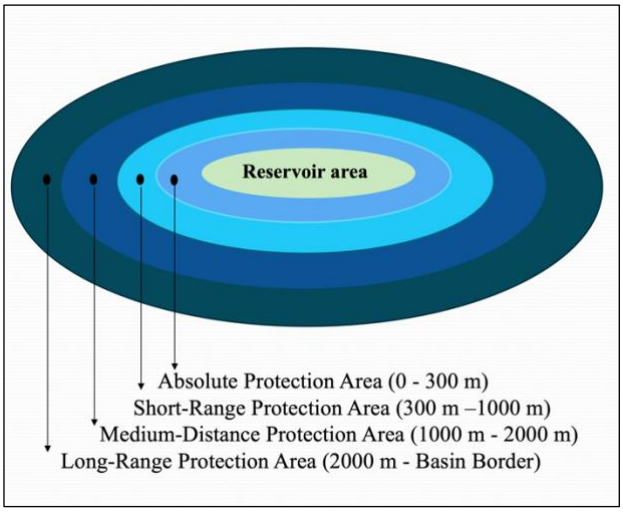

Figure 5.4 : Protection zones determined in Water Pollution Control Regulation.

In this way, the protection plans, including the protection zones, special regulations, and strategies for each water resource like dams and lakes, are prepared. So far, the specific regulations of the Atatürk Dam Lake, Egirdir Lake, Lake Beyşehir , Gördes Dam Lake, Karacaören 1 and 2 Dam Lake, Kartalkaya Dam Lake Basin Protection Plan, Kazandere and Pabuçdere Dam Lake, Mamasın Dam Lake, Porsuk Dam Lake, Büyükçekmece Dam Lake Basin Protection Plan, Elmalı 1-2 Dam Basin Protection Plan, Gökçe Dam Lake Basin, and Kurtdere, Çamlıdere Dam and Gerede Isikli Regulator Basins, Gönen Dam Lake and Kumköy Regulator are prepared and available through the Agriculture and Forestry Ministry/ General Directorate of Water Management. In the following text, five protection plans prepared for drinking water resources, which the Ministry recently performed, are evaluated in terms of their covered strategies and regulations.

5.5.1.1 Evaluation of drinking water resources protection plan and Environment Plans in terms of sustainability concept

Among the national and regional plans in Turkey, the Environment Plan has contained a specific position for water resources. It includes planning regulations and strategies for the water basins and other water bodies located in the regions. In this part, it evaluates the Environment Plan and Water Basin Protection Plan in terms of the regulations and principles covered in those plans.

1. Environment Plan (Çevre Düzeni Planı): it was passed on November 11, 2008, and prepared based on the "Law on Organization and Duties of the Ministry of

Environment and Forestry" dated 1/5/2003 and "the Environmental Law" dated 28/8/1983 (Url-1).

2. Drinking Water Basin Protection Plan (İçme Su Havza Koruma Planı): it was based on the regulation on "the Protection of Watersheds and Preparation of Management Plans" published in the Official Gazette dated 17/10/2012 (Url-4).

In this research, the plan's evaluation aims to understand the content, strategies, provisions, and management requirements considered for the water resources. In the assessment, the identified regulations and principles are categorized based on the sustainability dimensions.

The review of both plans' legal structures show that most of the goals and principles have focused on the water basin management and ecological issues. The scopes are too limited in the physical, economic, and social environment. As Table 5.3 shows, there is no explicit content on the infrastructure and land uses like commercial, industrial, agricultural, and recreational activities. The economic scopes are limited to agricultural production with concentration on new methods in irrigation and agriculture. Tourism and energy production are completely ignored in both plans. About the social area, the only scope is to get the public access to the documents and plans, and they don't consider any special rights to the residents. Similarly, there is no content about the analysis of the people's preferences and perceptions.

5.3 : Categorization of the scopes, objectives, and strategies mentioned in legal structure of the Environment Plan and Protection Plan in terms of Sustainability Dimensions.

Sustainability factors		Environment Plan	Protection Plan
Ecological Dimension	Water sources	Projection drinking water values; Determining strategies for ecological and ecosystem decisions.	Conservation plansprepa preparation in potable water resources; Sustainable development of water resources; Protection of quality and quantity of water resource; Prevention of the deterioration of the good water condition; Environmental objectives for inter-basin water transfer; Optimum use of water resource according to ecosystem process; Protection of aquatic habitats and species; Determination of the typology for surface water bodies.
	Other natural sources (soil, forest,..)	Based on development plans and regional plans, providing rational use of water resource.	Defining protection areas on the map; Monitoring and maintaining reference conditions.
	Ecosystem	Ensuring land use continuity and ecosystem integrity in terms of plan decision; Not disrupting the ecological balance.	Solutions for hotspots; Balance of conservation- use; Protection of water-dependent ecosystems; Preserving water required for the ecosystem.
	Natural hazards	Providing strategies for environmental problems.	Overflowing and flood management;Drought management; Control of the climate change effects in the water resource; Determining the possibility of floods and droughts due to climate change.
	Pollution and environmental health	Preventing pollution before it occurs; Determining land use decisions for a healthy environment.	Non-point source pollution management; Controlling sewage sludge; Preparing accident management plans to control accidental pollution; Collection of wastewater and delivery to a treatment plant; No discharge of industrial and energy wastewater to the receiving environment;
	Transportation and logistic		Good water allocation to trade, tourism, recreation, mining, transportation, and other water needs.
Physical Dimension	Historical values	Determining the general policies for the protection and development of the cultural, historical, and natural environment;	
	Land uses	Determining the decisions for settlement and land use in accordance with the country regional plan; Determining population projection considering the sustainable use of natural resources; Considering ecological, geological and hydrological risks on land use decision.	Basin plans providing based on the conservation and use of natural mineral and geothermal water resources.

Table 5.3 (continued) : Categorization of the scopes, objectives, and strategies mentioned in legal structure of the Environment Plan and Protection Plan in terms of Sustainability Dimensions.

Sustainability factors		Environment Plan	Protection Plan
Economic dimension	Agriculture	Determining strategies and policies for the protected areas to make sure integrity of ecological decisions.	Analysis of irrigation water; Encouraging the efficient use of water by irrigation water tariffs; Using methods based on productivity in irrigation; Encouraging the re-use of treated domestic wastewater and rainwater; Sectoral allocation plans preparation.
Social dimension	Social right	Making the plans public.	Public access to information to obtain their opinions and participation; The increase of life quality of the residents in the water basin.
	Institutional structure	Preparing environment plan by the competent authorities and the relevant administration.	Determination of authorized administration for the maintenance of sustainable water use; Detection of the measures as to monitoring, control, and re-use drainage waters by the opinion of the Ministry of Food, Agriculture and Livestock; Determination of governorship by the Ministry if the watershed covers more provinces; Publishment of watershed management plans by the Ministry and updated at the latest every six years.
	Participation and engagement	Conducting participation of experts from different professions in the plan; Conducting participation of relevant institutions to the planning; Coordination with the Ministry of National Defense; Providing effective participation through survey application, meeting, and internet environment.	Participatory approach in watershed management plans by the Ministry; Necessary plans with EU member countries in transboundary basins; Division of the responsibilities among participants to enhance the administrative capacity.
Water management	Finance	Making the amendments of the plan investments by the Ministry of Public Works and Settlement and approved by Ministry of Environment and Forestry.	Address of general cost of water services in accordance with the polluter and user-pays principle; Determination of water allocation principles considering basin budget and priorities; Analysis to cover the water usage cost considering economic trends;
	Management	Taking development plan and regional plans as basis in the Environment Plan; Leading sub-scale plans in compliance with the environment plan; Going back in planning process and having feedback process; Having a standard database; Making maximum use of technology; Using the data, satellite imagery or aerial photographs in field studies.	Provide of complementary plans to the management plans; Classification of water bodies into the artificial, natural or substantial ones; Determination of environmental quality standards; Provide of an effective monitoring system; Integration of the management plan to all kinds of plans and into the central database of the Ministry; Review of the characterization reports at least every six years; Observation of the virtual water balance based on production and consumption; Use of efficient water technologies.

The plans structures and strategies

In this research, five cases of drinking water resources in Turkey are selected to evaluate the plans' implementation structures. The main reasons for choosing these areas are the availability of the Environment Plans and the Water Resource Protection Plans of the selected regions and their importance in supplying Turkey's current water need (Figure 5.5).

Figure 5.5 : Location of the selected drinking water resources in Turkey.

The selected water reservoirs are:

1. The reservoir of Atatürk Dam is positioned in the center of Anatolia, extending over an area of 817 km^2. With a water amount of 48.7 km^3, it is Turkey's biggest human-made dam using for energy production and irrigation purposes.

2. Dam Basin of Melen over the Melen Stream was established in the south of the Black Sea that flows between Sakarya and Düzce. The dam lake has a 100 m width, with 110.46 meters maximum water level. It was planned to supply 75% of drinking water needs by providing 77 million cubic meters of potable water in Istanbul.

3. Büyükçekmece Basin, is located in the European part of Istanbul in the Southwest, close to the Marmara Sea. It has a 2 km width, 7 km length, and 28.47 km^2 surface area as a freshwater reservoir. The basin, which is mainly swamp and shallow (6 meters in the deepest area) is fed by Karasu Stream. The dam has separated Büyükçekmece Basin from the Marmara Sea. Recently, the lake has been at risk due to pollution generated from human settlements and industrial zones (Figure 5.6).

4. Elmalı Dam- Lake has been one of the water resources that meet drinking water needs to Istanbul on the Asian part. The total lake area, total watershed area, and the lake volume are respectively 1.1 km^2, 83.4 km^2, and 9.6 hm^3 (Kaya, 2008). Due to the basin location, Elmali Dams are surrounded by forest areas. The second dam over the Göksu River flowing into the Bosphorus was generated to supply drinking water. The

reservoir is fed by 11 rivers carrying huge pollution loads into the water basin and has posed ecological problems (Uyguner, 2009). Furthermore, rapid construction and leakage trigger water pollution (Figure 5.7).

5. Gördes Dam-Lake located in Manisa Province, was completed in 2004 by Turkish State Hydraulic Works (DSİ) on the Gördes River. The primary purpose has been to supply water for drinking and irrigation. At first, it could not store the water because of the leaching, but currently, its issue was solved. The dam's storage capacity is 448.46 hm^3, which is planned to supply water for the annual average of 59.00 hm^3 of the domestic uses in the Izmir Metropolitan Region and the irrigation of 14,809 hectares areas in the surrounding plains.

Figure 5.6 : Pictures taken from the Büyükçekmece Basin showing the lake and its surrounding land uses |(Istanbul, 2019).

Figure 5.7 : Pictures taken from the Elmali Dam-lake showing the lake and its surrounding land uses |(Istanbul, 2019).

The regulations and provisions defined in the two plans are particular for each dam lake and water basin. However, it tries to figure out which planning strategies and principles are generally taken into consideration through the planning process of the water reservoirs in Turkey. The Environment Plans of each region include the plan explanation reports and the plan principles reported and documented by the official website of the Ministry of Environment and Urbanization (Url-5).

Figure 5.8 shows the Environment Plans of the region in which the dam-lakes are located, and figure 5.9 shows the Protection Plans related to each water resource. In water resource protection plans, the areas are zoned into four groups:

- Absolute Protection Areas (0 - 300),
- Short Conservation Area (300 m -1000 m),
- Mid-Range Conservation Area (1000 m - 2000 m),
- Long-Range Conservation Area (2000 m - Basin Borders).

The various land uses, including settlement, agriculture, industry, and mining, are restricted based on the protection level. In this way, the two plan's regulations are evaluated and compared. The specific regulations defined in each Protection Plans and Environment Plans of water resources are categorized based on four sustainability dimensions of Ecological, Physical, and Socio-Economic factors and their included sub-factors. Therefore, several Tables have been provided in which the related management and planning regulations are summarized. In the appendix part A, the plans' regulations of:

- Gördes Dam-lake in Tables A1, A.2, A.3,;
- Atatürk dam-lake in Tables A.4, A.5, A.6, A.7;
- Elmalı Dam-lakes in Tables A.8, A.9, A.10, A.11,;
- Büyükçekmec Basin in Tables A.12, A.1, A.14, A.15, A.16,;
- Melen dam-lakes in Tables of A.17, A.18, A.19, A.20, A.21, are categorized.

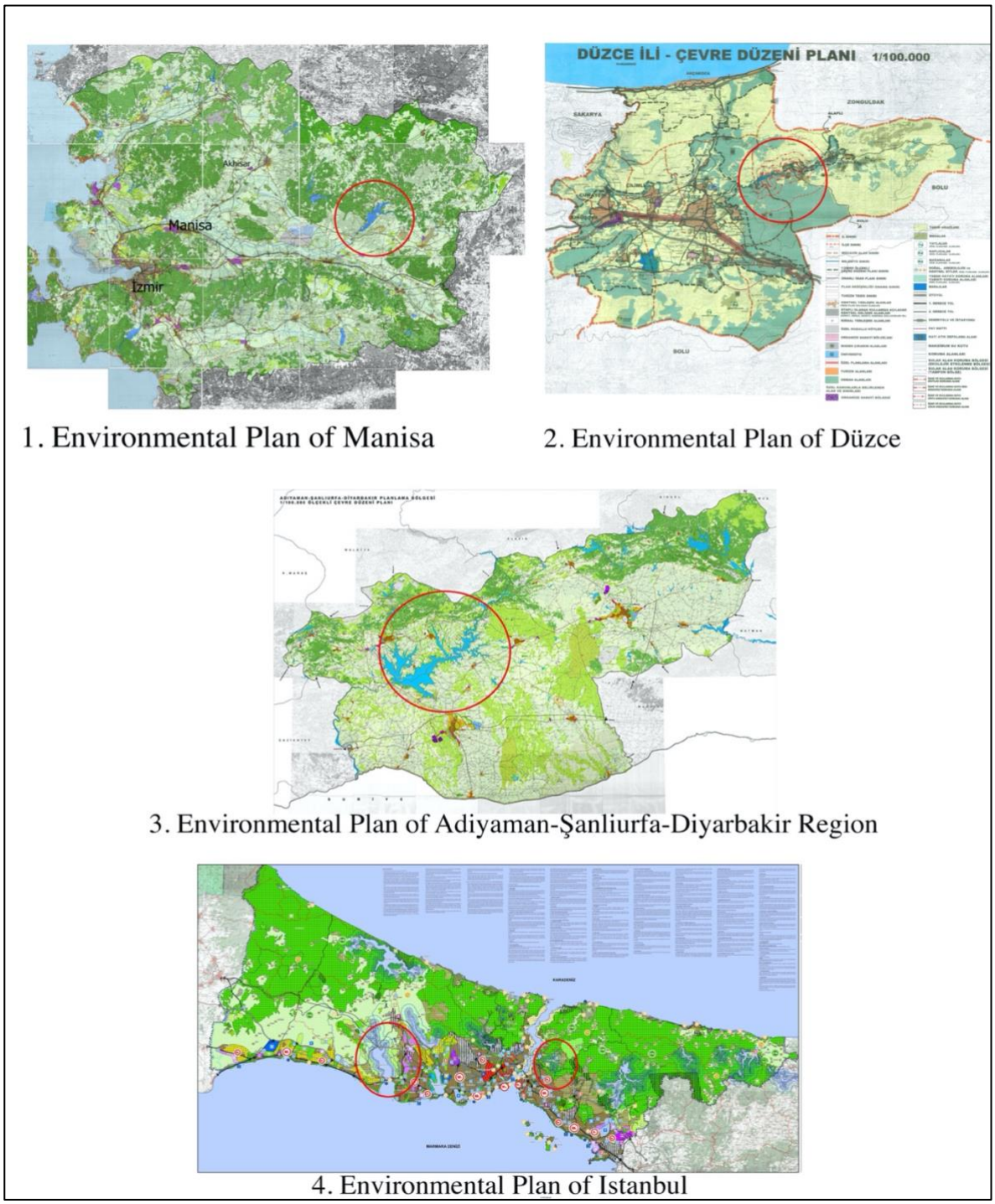

Figure 5.8 : Environment Plans of the selected regions including dam-lakes (Url-5): 1) Manisa Region including the Gördes Dam-lake, 2) Düzce Region including the Melen Basin, 3) Adiyaman-Şanliurfa-Diyarbakir Region including the Atatürk Dam-lake, 4) Istanbul including the Elmalı lake in Asian part and Büyükçekmece Baisn in European part, prepared by Environment and Urbanism Ministry.

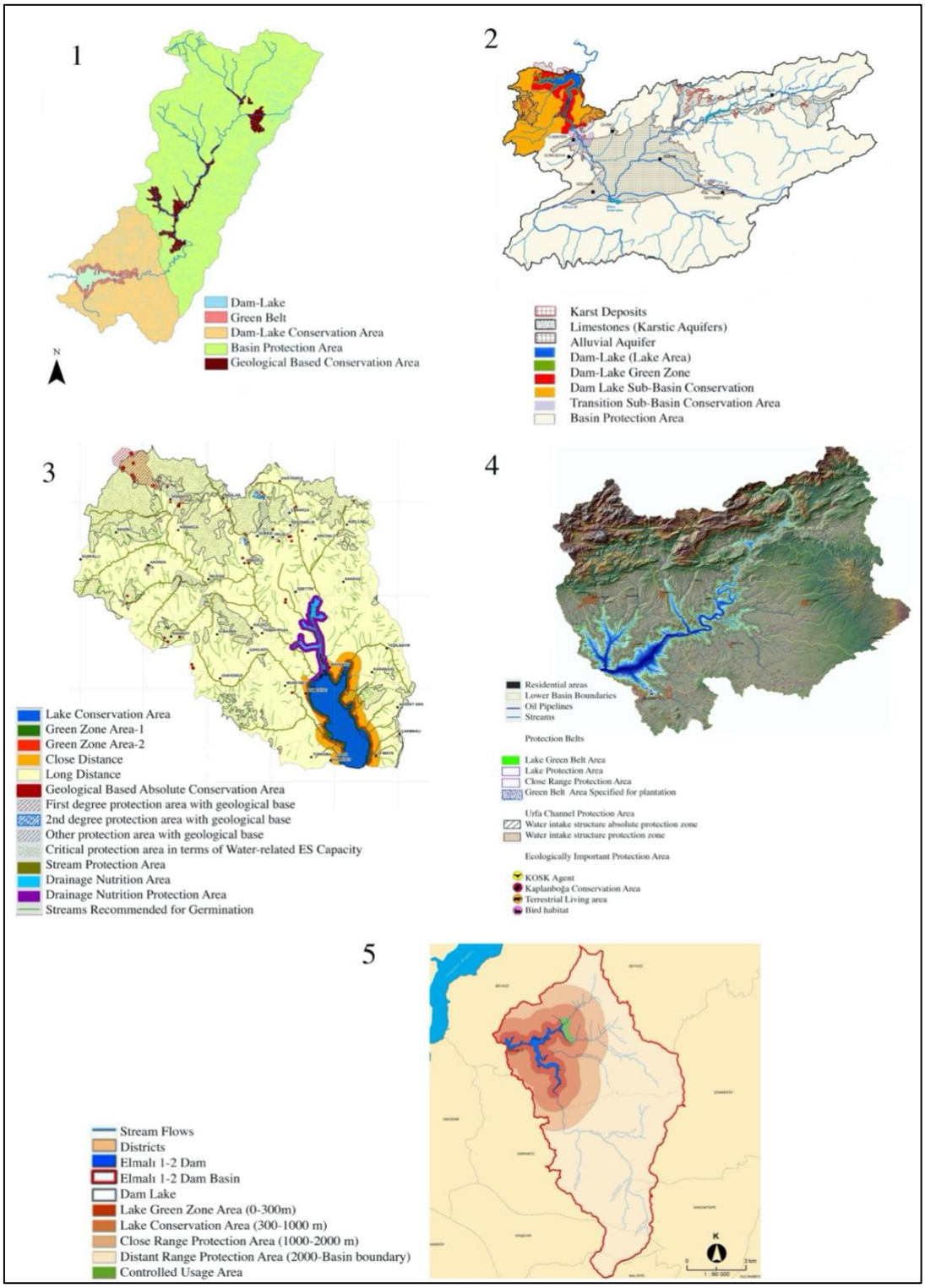

Figure 5.9 : Protection Plans of the water reserviors prepared by Turkey Ministry of Agriculture and Forestry (Url-6): 1) Gördes Dam -lake, 2) Melen Dam-Lake, 3) Büyükçekmece Basin, 4) Ataturk Dam-Lake Elmalı Lake-Dams.

By comparing the plans' implementation structures, significant knowledge on some aspects of Turkey's water resources planning could have been identified. According to Table 5.4, the two plans have covered each other in some areas, but, in some other aspects, they don't offer any planning regulations and principles. According to the sustainability dimensions, the evaluations of the two plans of Protection Plan and Environment Plan could show the following results.

- **Ecological dimension**

The Environment Plans legislate the rules on protecting the natural sources (surface water, groundwater, soil, forest, air, biological diversity, animal habitats, woods, and species) in the wetlands and controlling natural disasters like flood, drought, earthquake, and climate change effect. They consider some targets on natural disaster management such as earthquake and flood management with no provisions on the climate change issue. However, in the Protection Plans, there are restrictions and regulations defined for each water protection zone against excessive use of groundwater and natural sources, stream channel change, forest and lake activities, reservoir scaffolding, and navigating in the lake water area. In the Protection Plans, there are no principles for environmental issues like climate change and natural disasters. The Protection Plans of the dam-lakes pays more attention to controlling ecological pollution and measuring the wastewater discharge. It consists of strict restrictions on discharging solid pollution and wastewater in the close-range protected areas and the basin green belts.

- **Physical dimension**

According to the plans' evaluation, the principles of utilities and water infrastructure in the water regions are about supplying the waste management utilities and the public services' technical and social infrastructures. In the Environment Plans, regulations related to transportation are limited to protect the existing roads and prevent new construction of roads in the water region. However, in the Protection Plans of the studied water bodies, several matters are mentioned on the existent roads. They include prevention of roadsides erosion, generation of the temporary storage for dangerous wastes caused by traffic accidents, the establishment of accumulation walls to prohibit waste from reaching the water, the road surface covering with the previous materials, and generation of an emergency response plan following vehicle accidents. In both

plans, cultural and historical properties are regulated to be protected, not be allowed for selling, or any other activities in the zones determined as the treasury. The sub-plans will provide more details on their protection.

In the Environment Plans, the land use-related regulations highlight the previous zoning plans and development plans. They are restricted to keeping the existent settlement zones in the basin, not planning for new development in the basin protected zones, and analyzing the settlement populations in the water basin. In the Water Resource Protection Plan, land -use-related regulations determine limitations against functions like new construction, new mining, new agriculture, livestock activities, cemetery on settlement areas, animal grazing, new urban activities like housing, trade, services, industry. The is an exception for day-to-day recreational functions, including picnic utilities in line with ecosystem protection in these plans. More information on the plan's regulations is relegated to the sub-scale planning efforts. As to the commercial use of the area, there are not determined specific laws in both plans.

- **Economic dimension**

The water resource economic dimensions' principles underline the human actions that respect ecological values in the water areas. They emphasize the application of renewable natural energy sources, organic agriculture, biotechnical methods, eco-tourism activities in agriculture, environmental farming techniques in crop production, controlled grazing, and rehabilitation of the expired mining areas, and a holistic planning approach in mining and quarry. Economic activities such as mining, industry, fuel services, and commerce are mainly forbidden and seriously monitored through the limitations described in both plans content, particularly in the Protection Plans. However, some exceptions are seen in the plans that permit industrial functions in the water regions' long-distance protected zones without posing waste pollution in the human and natural environments.

- **Social dimension**

The social dimension and its relevant sub-criteria are mainly underestimated in the plans. Social rights in both plans have covered a few strategies such as taking advantage of the public interest in the land use plans and creating a balanced distribution of the technical and social infrastructure (e.g., safety, security, education, health, municipal service, regional park). There are no brilliant principles on

evaluating sanitation and public health in the plans. Analyses of the attitudes and life patterns of the population living on the site have not been carried out.

Table 5.4 : The final comparison related to the implementation structure of two plans (Environment Plan and Basin Protection Plan) according to the specific regulations defined for each five selected water resources.

Plans		Ecological dimension					Physical dimension								Economic dimension				Social dimension		
		W.	O.	Ec.	En. Pr.	E. H.	Inf.	Tr.	H.	Land Uses and Density					Ag.	In.	T.	E.	S. R.	P. H.	B.
										S. A.	Ag. A.	In. Ar.	Com. A.	R. A.							
Atatürk	En. P.	■	■	■	■	■	■	■	■	■	■				■	■	■	■			
	Pro. P.		■	■		■	■	■	■	■	■			■	■	■	■		■		
Elmalı	En. P.	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■		
	Pro. P.	■	■	■		■	■	■		■		■		■	■	■	■	■	■		
Büyükçe şmece	En. P.	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■		
	Pro. P.	■	■	■		■	■	■	■	■	■	■		■	■	■		■	■		
Melen	En. P.	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
	Pro. P.	■	■	■		■	■	■	■	■	■	■		■	■	■	■		■	■	
Gördes	En. P.	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■		
	Pro. P.	■	■	■		■	■	■	■	■	■	■		■	■	■	■	■		■	

En. P.: Environment Plan, Pro. P.: Protection Plan, W.: Water resource, O.: Other natural sources, Ec.: Ecosystem and biodiversity, En. Pr.: Environmental Problems, E.H: Environmental Health, Inf.: Infrastructure and utilities, Tr.: Transportation and logistics, H.: Historical values, S. A: Settlement Areas, Ag. A.: Agricultural Areas, In. Ar.: Industrial Areas, Com. A.: Commercial Areas, R. A.: Recreational Areas, Ag.: Agriculture, aquaculture, & husbandry, In.: Industry and mining, T.: Tourism development, E., Energy and fuel services, S.R.: Social Right, P.H.: Public Health, B., Behavior and attitudes.

5.2 Main Achievements and Challenges Recognized in Water Resource Management of Turkey

Turkey could achieve several significant achievements in some aspects of water resource management and protection, which are:

- Turkey could achieve improvement in water management approaches over the last years. There are significant infrastructure deficiencies, especially in the Eastern provinces, in terms of potable water source utilization, the water network connection to residences, and wastewater treatment services. Currently, 55% of the total municipal population lacks drinking water services and water treatment plants. Pollution from marine vessels in coastal areas, and domestic and industrial waste, due to human activities such as aquaculture and tourism has caused pressure on water resources. Within this framework, studies for eliminating the factors that pose deterioration in river ecosystems, especially land-based pollutants, are carried out. Thanks to the measures taken to reduce waste at source, the amount of solid waste per capita has remained virtually unchanged since 1994, despite emerging various consumption patterns and economic growth. In addition, the ratio of the population receiving waste disposal service to the total population was only 5 % in 1994, while this ratio increased to 58 % in 2011 (Turkey Ministry of Development, 2014).
- According to the latest data in 2012, over 6 million hectares (5.6 million hectares of land and 0.4 million hectares of marine) are converted into protected areas in Turkey (Turkey Ministry of Development, 2014). The academic projects and studies could help the ecosystem services of the water basins are determined. For example, a survey of the Omerli drinking water basin determined 30 ecosystem services related to the forest, urban green area, agricultural, surface water, shrubbery, and pasture. Another study of the Melen Basin, showed that the basin has 50.1% high ecosystem services capacity and 45,64% moderate ecosystem services capacity (Tezer et al., 2018).
- Inter-basin water transfer projects have been an effective engineering method that will ensure water availability to water-scared places (Zhou et al., 2017). In

Turkey, several inter-basin projects have been begun to provide drinking water from the sea or basin into another basin located in the cities over the last years. Currently, 45% of water requirements in Istanbul are met by inter-basin water transfers, which is projected to meet 70% of water demands. One of the great inter-basin projects is the Melen Project, which will provide drinking water by a transfer line to Istanbul.

- In Turkey, the number of wastewater management and treatment plants remarkably increased over the last years, and various projects on disaster management have been studied. To handle Turkey's possible climate crises, three main strategies have been introduced: treatment plants number increase, water pollution monitoring in the basins, and knowledge improvement on disaster management. It is expected that climate change will have effects on water basins in Turkey:
  - Air temperature will be warmer 2-3 C in 30 years,
  - The snow precipitation will be replaced with moderate rainfall, and water flows will decrease,
  - In the potable water resources and lakes, the toxic will increase.
  - Consequently, the water quality will reduce, and the number of treatment plants will not be enough.
  - Due to climate change, the water supply systems will get into trouble, and the flows in the water basin will reduce. The reduction of water potential will negatively affect the ecosystem services, agriculture, industry, and potable water resources.
  - Natural disasters like drought, fire, overflowing will happen in the future years.
- In Turkey, to ensure sustainable agricultural production, 30 agricultural basins have been determined considering the climatic conditions, soil structure, and topographic characteristics of the regions. Suitable product patterns are defined in these basins to ensure more efficient use of agricultural supports and biological diversity (Turkey Ministry of Development, 2014). In Büyükçekmece, pressurized irrigation systems have been introduced in

irrigated areas, and in Gördes dam-lake, switching to pressurized irrigation systems in two years was mentioned. In the plan regulations of Melen Basin, organic agriculture was suggested in the existing agricultural areas through farmers' training and integrated ecosystem services.

Through the studies, they are recognized some main challenges and issues in the water resources management in Turkey, which are:

- There is no relevant national Law on "Water," which has led to low priority, legitimacy, and a small legal basis following less governmental supports in Turkey. It has been discussed for a long time about Water Law regulation, but it is still continuous.The primary legislation on water management in Turkey came into force in 1926 named "Water Act." Although since 1926, the perspectives on water management has changed dramatically, the law content has not undergone a comprehensive modification to date. The goals defined in the national development plan have put low priority on water and water resources. Thus the issue of water resource protection did not get considerable support to be implemented.
- In Turkey, water allocation between different regions and competing users has been an issue. Water footprint per capita is 1,977 m3 / year in Turkey (the average world amount: 1.385 m3). According to the National Strategy of Regional Development (2014), regarding investments in drinking water networks, the ratio of people benefiting from the drinking water within the municipal boundaries has increased from 88 percent in 1994 to 99 % in 2010. Turkey also consumes 139.6 Milyrad cubic meters in the year for various production sectors (64% green water footprint) in which 89% of water footprint goes mainly for the production of cotton and wheat in agriculture, as exported goods (7% for the domestic use and 4% for the industry) (Pegram et al., 2014). Thus, studies and planning for water allocation should become an essential issue in Turkey's water management system.
- The water management system of Turkey differs from European countries. Implementation of the IWRM has been a challenging task due to:

- using municipal units (province/district) instead of the ecological border of the water basin in the management process;
- the highly fragmented structure of water management and its centralized system;
- not having the democratic participation of various parties in decision-making processes;
- inadequacy of institutional capacity;
- not having valid control of discharges; and not using an effective water-related tariff (Yilmaz, 2014).

- In Turkey, the Water Basin Protection Plan and the Environment Plan don't complete each other in some aspects. The Protection Plan as a sub-plan doesn't go further in supplying strategies and planning regulations. Even though they cover some overlapping goals and provisions, however, over some aspects, they don't fill up each other's gap. Therefore, it will take a long way to catch the sustainability goals if serious related modifications are not performed in that planning system. The evaluation of water resource plans' implication structure could also prove a huge fragmentation between spatial planning and water basin management.
- As the other responsible for the water resource management, municipalities are not aware enough of social and ecological values related to the drinking water resources. However, in some cases, they could act well due to directly connecting to the areas and understanding the resident's problems. The more municipalities are informed about the sustainable management planning approach; the better water resources are protected. They need to organize training programs, regular meetings, and close cooperation with the rresponsible ministers like Ministry of Agriculture and Forestry.
- There are no specific budget and encouragement plans to support the people residing in the water basins while implementing the program. They need to be persuaded by encouragement programs to limit their activities, which cause ecological issues and pollutes the water resources. For example, husbandry

restriction to a specific number of cattle regulated in the plan needs offering governmental support or affiliating other business chances to the residents.

- Low capacity building and insufficient technical knowledge have limited monitoring, controlling measures, and treatment technologies. Due to their high expenses, the lack of appropriate recycling technologies has caused limitations on treatment methods and nutrient recycling in Turkey's water management systems. In Turkey's drinking water resources plans, the protection provisions emphasize that the stormwater channels should be separated from the wastewater channel. There are various restrictions on discharging wastewater into the treatment plans. However, there is no more detail on stormwater management or nutrient and waste recycling.
- There is no defined framework for stakeholders and water users' participation in Turkey's water resource planning. Close communication with local stakeholders has been organized in the planning processes to get their expectations and concerns, analyze the socio-economic conditions affected by the plan's decisions, and provide new income sources for supporting local people whose activities are restricted by the plan decisions. However, public participation is just limited to some discussion with the local users on the region. Besides, there is no practical participation of various experts in the decision-making process on the social studies, economy, and regional planning of water resources. After the proposed plans for the water resources are announced, the university academics are invited to get their comments on the final step of planning. While the central regulations and strategies have already been decided and finalized.

6. METHOD

Watershed planning and management contain multiple scopes, elements, and issues that lead to difficult decisions making. Water resource planning and management need a holistic framework considering all items defined in the sustainability concept, which can conduct protection watershed plans. A suitable decision-making model can help evaluate the alternatives proposed for water resource management.

This research aims to define an evaluation model for water resource management plans based on the sustainability principles through understanding the inter-relationship among the sustainability indicators and factors and their importance. First, the main criteria and indicators of Sustainable Water Resource Planning (SWRP) are recognized through the literature studies, and a hierarchy of sustainability factors are achieved. They are then valued through a quantitative method of decision-making like the Analytical Hierarchy Process (AHP), which is used for this research.

In this work, the Analytical Hierarchy Process (AHP) as a multi-criteria decision-making method is used to understand the interrelationships among sustainability factors and consider a numerical value for SWRP criterion. With the AHP method, the primary factors and sub-factors of water resources planning in terms of sustainability principles are ranked. Pairwise comparisons are made for the criteria that are later turned into quantitative numbers. The main objectives of using the AHP method in this research are as follows:

- Prioritizing and ranking the primary factors and sub-factors of water resources planning in terms of the sustainability principle,
- Weighing the subjective factors in social and ecological dimensions by considering quantitive values.
- Defining different perspectives of experts toward sustainability principles in water resource management and planning.

In general, the method applied in this research contains four main steps, as Figure 6.1 shows:

- Determining a hierarchy of criteria (factors and sub-factors) determined in water resources sustainability;
- Ranking the criteria by a questionnaire;
- Prioritizing the criteria using the AHP method;
- Creating a discussion over the results by a Focus Group Meeting.

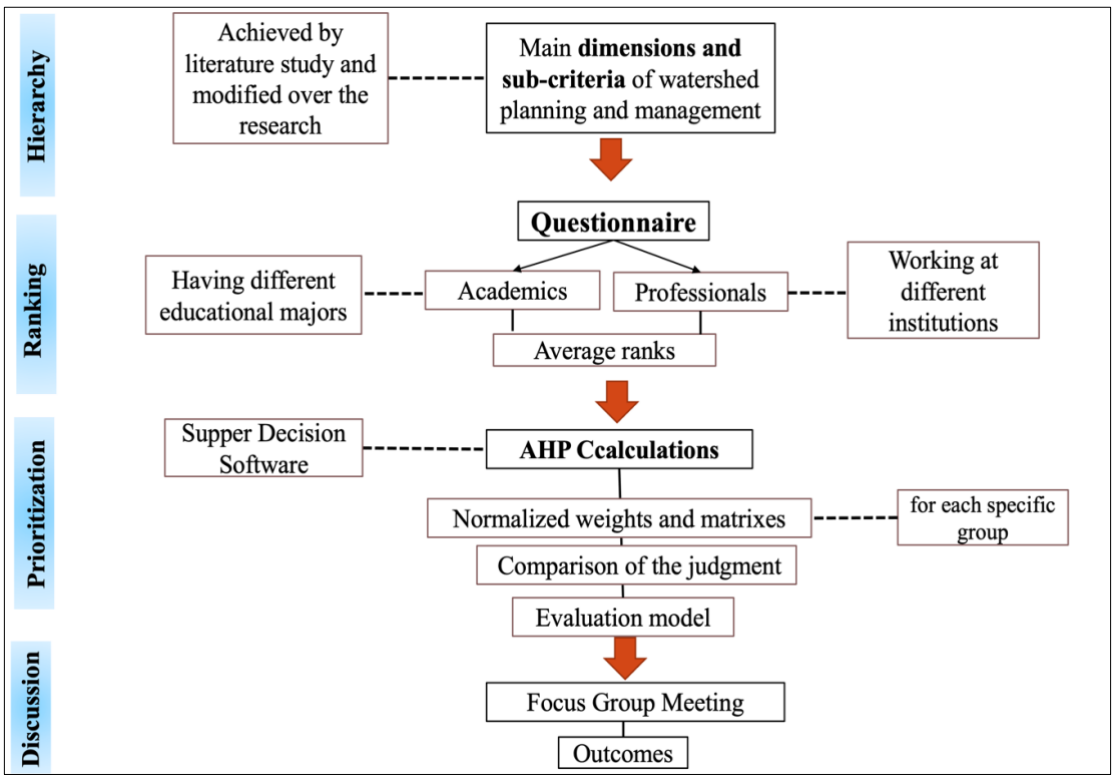

Figure 6.1 :A schematic diagram of the research method.

6.1 Determinig a Hierarchial Structure

It is necessary to reduce a complex issue into sub-problems or break it down as a hierarchy to handle a complicated decision-making problem. Decomposing a matter into a hierarchy of sub-factors can make its evaluation easy. Therefore, all relevant factors and sub-factors impacting the water resource sustainability are organized into a hierarchy (Bhushan and Rai, 2014).

This work trying to produce a brilliant structure for sustainability-oriented planning of the water resource determines the essential factors and sub-factors of a sustainable water resource. Considering four main areas in the water resource sustainable planning (physical, environmental, ecological, and economic dimensions), this article provides

the relevant sub-factors applied in any sustainable management of the basins (Figure 6.2).

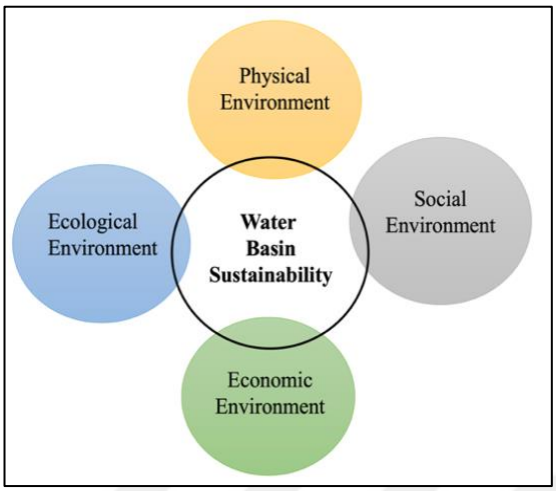

Figure 6.2 : Main factors of sustainability in water resource planning.

The four main dimensions/ environments of the sustainable water resource are:

- Ecological environment: the water resource consumption should be managed in a way that maintains the critical life-support systems, without compromising the use of future generations of the same sources (Jønch-Clausen and Fugl, 2001). The leading variables of environmental sustainability clarified in this work are water resources (Ouyang, 2012), other natural sources such as air, sand, soil, and forest, environmental issues including climate change (Räsänen et al., 2017) and natural disasters, ecosystem and biodiversity (Arthington et al., 2009), and ecological health.
- Built environment: this area is composed of a series of requirements for applying the relevant technology and physical sciences in the water resource management plans to correlate the competing interests of different types of land use. Sustainability of the built environment means protecting human sources and technology for a long-time (Yang et al., 2016). This category involves sub-factors of infrastructure reliability and capacity, logistics and transportation, cultural and historical values, and land use and density.
- Social environment: socio-economic development and population growth continuously increase water demands and exacerbate the water-related pressure and shortage risks (Zhou et al., 2017). Therefore, accessibility to

drinkable water is one of the primary social dimensions of watershed sustainability. All people's right to have access to adequate water quantity and quality to protect human well-being must be universally recognized (Shen et al., 2011). This dimension includes regulations that support better living conditions and social changes by understanding what people need from the areas. In this work, the social values and rights, public health, and public attitudes and behavior (the preference and perception of the populations living in the basin) are defined as the primary social sub-factors in the SWMP.

- Economic environment: this planning dimension intends to maximize the economic benefits gained from the whole basin area and ensure that these costs and benefits are equitably distributed. The plan must identify an equitable budget, risk-sharing policies, and enhanced risk management approaches (Cox, 1987). Agriculture, husbandry, and aquaculture development (as primary economic sources); energy production and tourism; industrial and mining development; and commerce have been identified as essential sources for economic enhancement in the entire water region (Tønch-Clausen and Fugl, 2001; Shen et al., 2011).

This research has provided 21 sub-factors under four main areas of a the sustainable water resources or basin plans (Figure 6.3). The hierarchy structure is thought to have three main criteria and sub criteria (Figure 6.4).

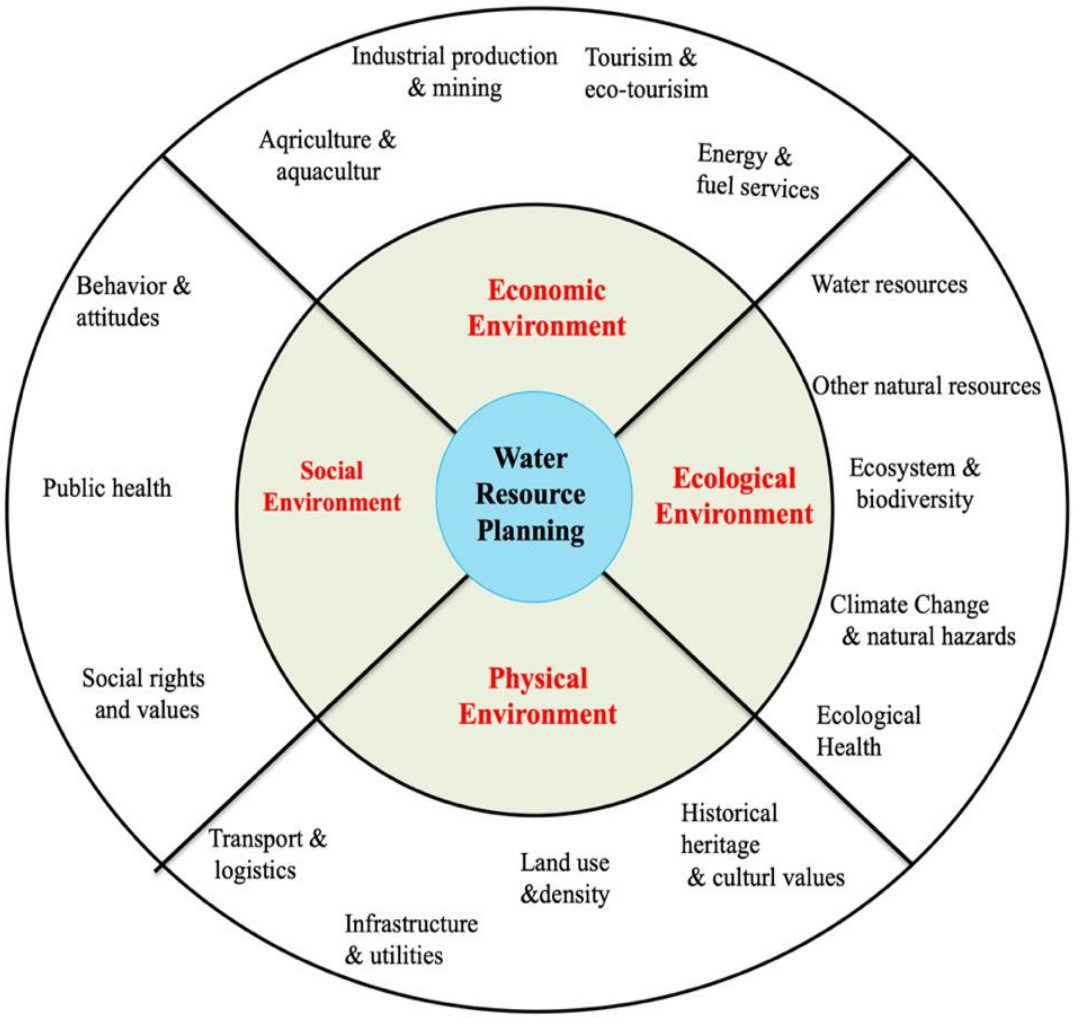

Figure 6.3 : Sustainability framework of the water resources, including necessary planning criteria and sub-criteria.

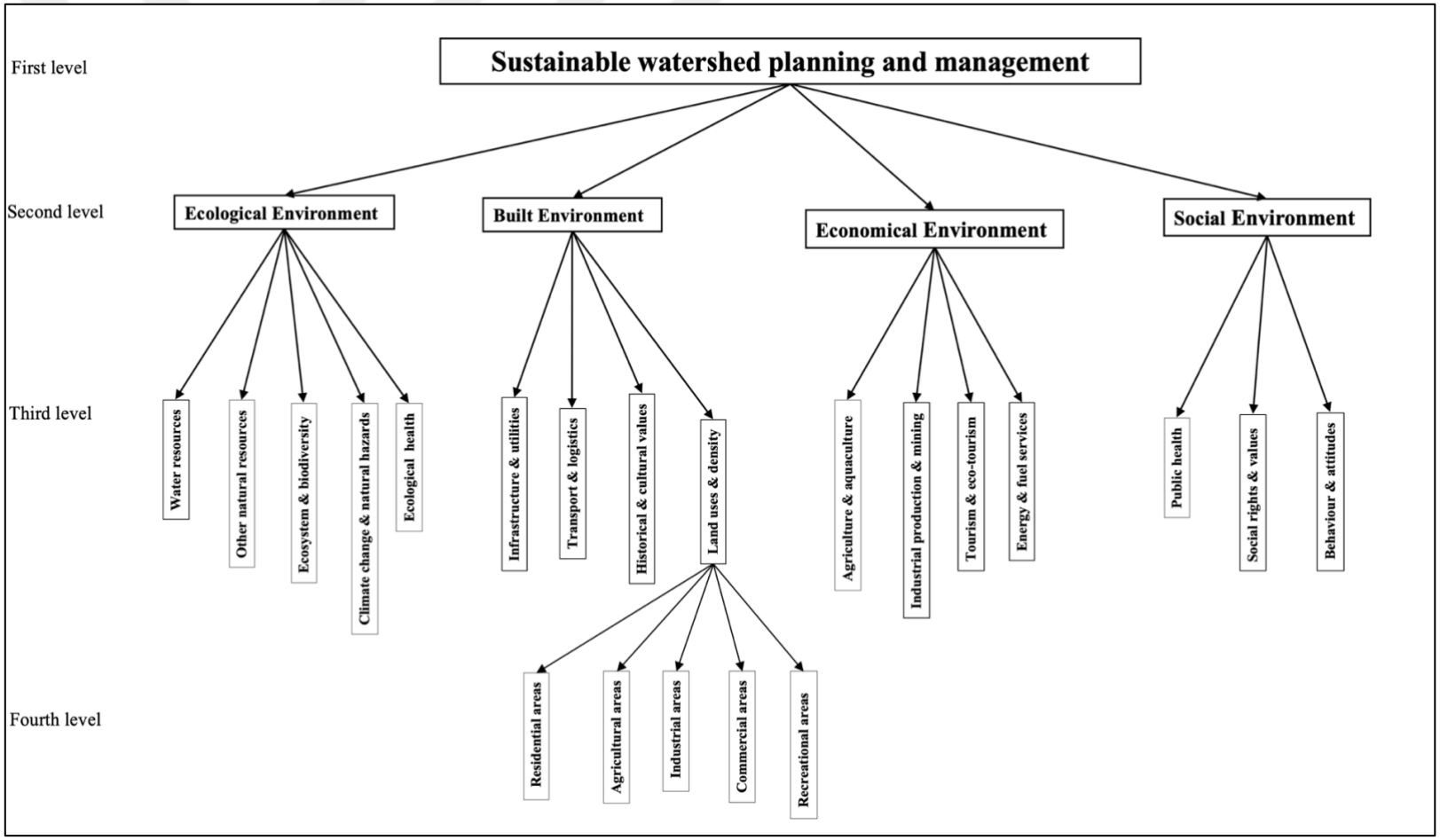

Figure 6.4: The hierarchical structure of the planning/management factors and sub-factors of a sustainable watershed.

6. 2 Ranking the Criteria through a Questionnaire

The planning factors and sub-factors of the water resources were evaluated by experts who have knowledge or experience on the subject through a questionnaire. According to the AHP structure, a questionnaire was prepared to ask for a pair-comparison of the determinant planning criteria. As water resource management planning is a specific field of knowledge, a limited number of experts have been chosen for answering the questionnaire in this research. The responders have been categorized into two groups:

- Academicians, including university professors, professor assistants, and Ph.D. holders in the related areas of water resources like watershed management and planning, natural resource and environmental engineering, and so on;
- Professionals who are working practically in one of the water-related institutions in Turkey like the Ministry of Ministry of Agriculture and Forestry, the State Hydraulic Works (DSI), and Istanbul Water and Sewerage Administration (ISKI).

Members of experts were asked for the pairwise comparison of the main criteria and their related sub-factors (Figure 6.5). Experts can rate the comparison as equal, slightly strong, strong, very strong, and extremely strong. The scale ranges from one to nine, where one implies that the two elements are the same or are equally important. On the other hand, number nine means that one factor is extremely more important than the other in a pairwise matrix. The questionnaire was prepared through Google E-forms, sent by email to the persons for getting the answers.

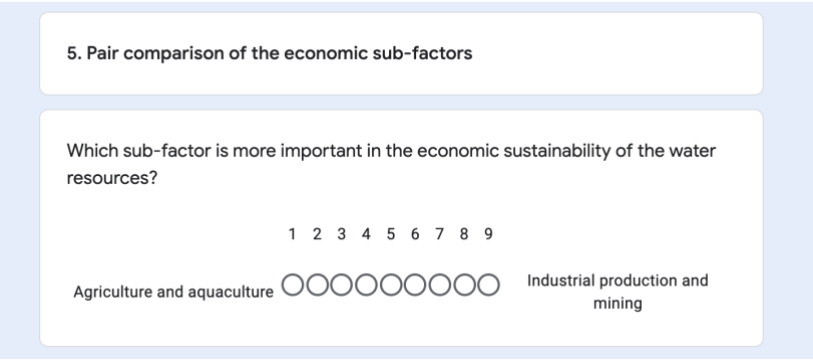

Figure 6.5 : An example of the questions asked from the experts about the importance of the water resource sustainability criteria.

The online questionnaire form was sent to the selected individuals including 20 persons of the academicians (university teachers) and 17 individuals of professionals who are working in one of the State Hydraulic Works (DSI), Istanbul Water and Sewerage Administration (ISKI), Ministry of Agriculture and Forestry (TOB). Table 6.2 shows the personal information summary of the responders. In the next chapter, the questionnaire results are analyzed and calculated to get the criteria priorities according to the AHP method.

Table 6.1: The information of the persons who have answered the quationaire.

Persons	Number	Ages	Working institutions and departments			Degree Level
Academics	21 (9 female, 12 males)	60% : 30-45 30%: 45-60 10%: 45-60	University	Urban and Regional Planning	4 persons	Mostly Ph.D.
				Landscape Architecture	7 persons	
				Forestry Engineering	7 persons	
				Environmental Engineering	2 persons	
Proessionals	17 (9 females, 8 males)	70% : 30-45 30%: 46-60	Institutions	Ministry of Agriculture and Forestry (TOB)	7 persons	bachelor degree: 65% master degree: 50% (Civil Engineering, Urban Planning, Environmental Engineering)
				State Hydraulic Works (DSI)	4 persons	
				Istanbul Water and Sewerage Administration (ISKI)	6 persons	

Finally, the ranking of the factors and sub-factors were obtained by the questionnaire. As it was mentioned in the Thesis Hypothesis, large different perspectives might emerge between academics having science, and professionals having experiences in the area. It was also supposed that the judgments on prioritizations might be different among academics influenced by the knowledge taken through education or teaching. Similarly, the professionals working at different institutions may be influenced by the

institution's regulations, scopes, and operational targets in their choices. Therefore, in the evaluations of the answers:

- The academics' choices were evaluated and compared based on their academic knowledge;
- The professionals' choices were evaluated and compared based on their working places;
- The choices of two groups: professionals and academics, were compared together.

6.3 Prioriotizing the Criteria

The pairwise comparisons of the factors and variables in three levels of hierarchy structure were organized into square matrixes based on the AHM method. By calculating the principal eigenvalue of the matrixes and normalizing the answers, the partial importance of the different criteria (the value weights) is achieved. As explained in the second chapter (Integrated Assessment), the eigenvector is caught by multiplying the entries together in each matrix row and then taking the nth root of that product. In this research, an online software program named “Super Decision” was applied to do the AHP calculations.

“Super Decision” program is appropriately organized for AHP implementation founded by Saaty (1926-2017) to calculate the numbers and produce the matrixes. The software was developed by the AHP creator team (Thomas L. Saaty) in 1996 to help persons make more rational decisions. This program has allowed us to enter the choices and judgments, get results, and the products' sensitivity rate, proving the validity of the answers. Therefore, the average of the questioners' answers was entered into the software to get the final weights and normalized values. In this way, the comparison matrixes and diagrams with an acceptable consistency rate were achieved. The consistency rate, according to Saaty should not be more than 0.1.

“Super Decision” program involves continuous steps:

- At the first step, the hierarchy structure should be defined. In this research, four levels of related factors and sub-factors were entered into the program (Figure 6.6);

- In the second phase, the questionnaire should be completed (Figure 6.7). The average amount of the pairwise comparison already obtained through the questionnaire was entered into the program questionnaire. Simultaneously, the program shows the prioritization results, the related matrix, numbers, and so on (Figure 6.8). This part has been separately performed for each group of the answers to make the later comparison possible.
- In the third step, it evaluates the alternatives based on the obtained weights. This part was not applied to this research.

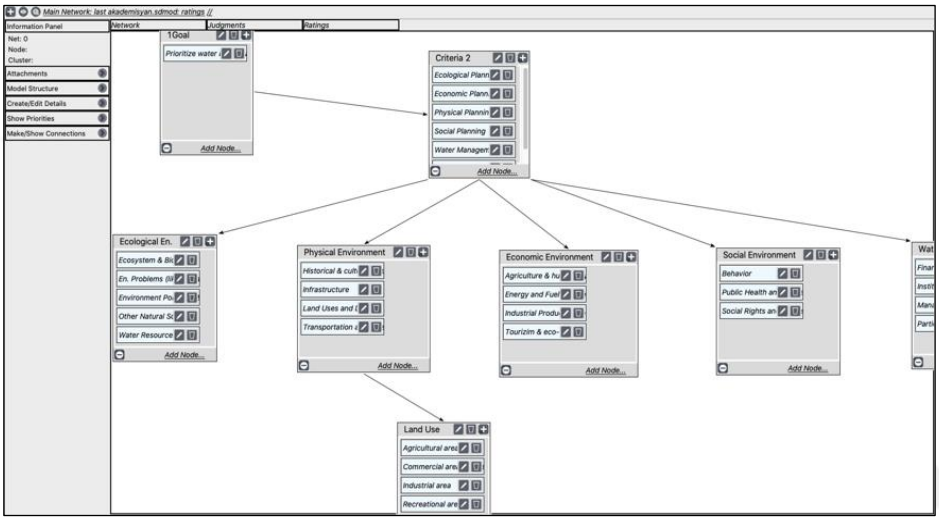

Figure 6.6 : Definig the hierarchical structure in “Super Decision” Program.

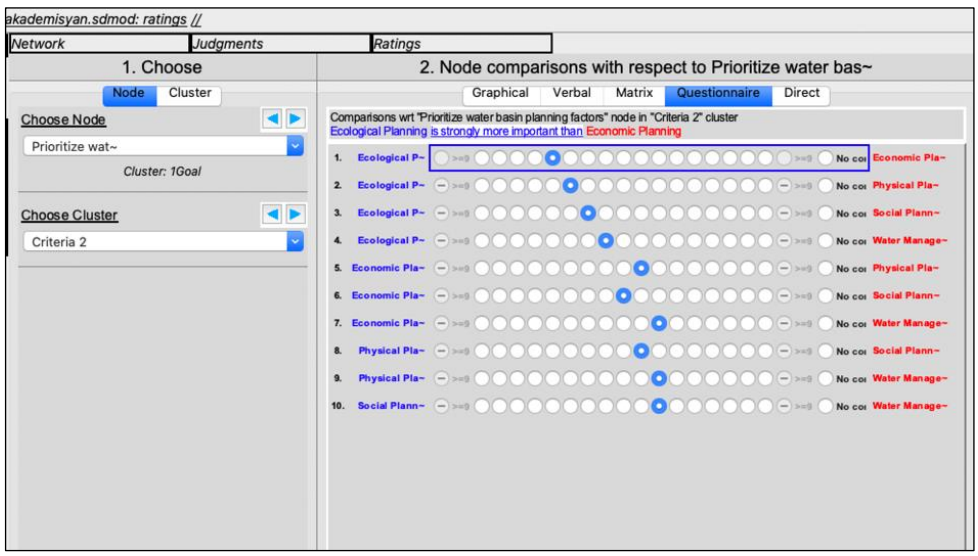

Figure 6.7 : Putting the average amount of the rankings into the questionnaire defined at the “Super Decision” program.

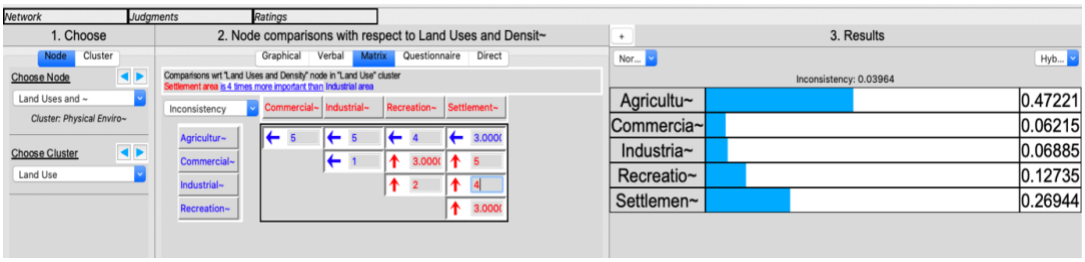

Figure 6.8 : "Super Decision" program provides comparison matrixes, factors prioritization, and numerical values for each criterion.

After getting the prioritization and weights of each factor and sub-factors through the Super Decision program, the Excel program was used to categorize the answers. In this way, for each criterion, a quantitive number showing its value was achieved. The numerical values were inserted into the Excel program to provide comparisons. In this way, the answers of various groups of professionals and experts could have been compared and showed as brilliant diagrams.

6.4 Creating Focus Group Meeting

After analyzing the results achieved from the questionnaires on prioritizing the factors, a meeting was designed to discuss the obtained outcomes. In this way, 12 professors were invited to participate in an online meeting. They have been chosen based on their educational majors and their researches on the Turkey water resources. The meeting was held by the professors from majors of Urban and Regional Planning, Landscape Architecture, Forestry Engineering, Environmental Engineering. In the meeting:

- First, through a presentation, the research and the obtained results are explained to the professors in 30 minutes.
- In the second step, the professors were asked to express their comments about the obtained results, especially different viewpoints over factors prioritization among various responders. Around 10 minutes was given to each professor to explain their words that were recorded and registered.

6.4.1 Questionnaire after meeting

After the meeting, the professors who participated in the meeting were asked to fill out the online questionnaire. The professors should have stated their opinions for 11

questions about water resources, watershed management systems, and solutions for the problems in the water resource area in Turkey. The questions ask:

- to point the current problems relating to water basins in Turkey;
- to write the reasons for the problems marked in the last question;
- to evaluate functions of the authorized institutions dealing with water resources management in Turkey;
  - Positive functions
  - Weak points
- to suggest solutions for:
  - for protection of the ecological environment of water resources ;
  - for prevention of environmental pollution in water resources
  - for the increase of the water amount in the basins and water demand management,
  - for stakeholder and community engagement in the watershed planning andmanagement;
  - for the improvement of the relationship between land use and water resources;
  - for the economic problems related to water basins;
  - for the improvement of the social life in water basins;
  - for the water resources management and implementation problems.

In this way, the questions were answered by the professors who participated in the meeting. By analyzing those statements and categorizing them into the thesis findings, general summary of the Turkey water resource situation and possible suggestions have been provided in the last chapter of the conclusion.

This research provided a good case for benefiting the AHP to evaluate the sustainability dimensions in water resources areas. It utilizes the AHP method to clarify the challenges and conflicting areas which may occur in water basin management and planning. In most previous research, weighing the variables through the AHP method has been mostly performed by a group of experts who have science or experience on the issue. However, the large differences among the individuals' judgments are rarely explained in terms of their effects on the proposed decision-making model. In most of the cases, the answers' mean is considered for the model creation. To get an agreement among groups of experts with various expertise, the

judgments are synthesized into a single one by geometric mean to achieve a general priority for each criterion. Thus, a wide range of interviews with various groups of experts has been performed to get a consensus over the drivers' values and the alternatives. What makes this research unique is an attempt to analyzing the effects of large different viewpoints among respondents over ranking the determinant variables in watershed planning.

7. RESULTS

7.1 Sustainability Framework

According to what is explained in the method, the primary factors and sub-factors of water resource sustainability were determined through literature studies and reviewed during the thesis progress. Figure 7.1 shows the primary factors and sub-factors that have been considered in the planning and management of a sustainable watershed or a water resource.

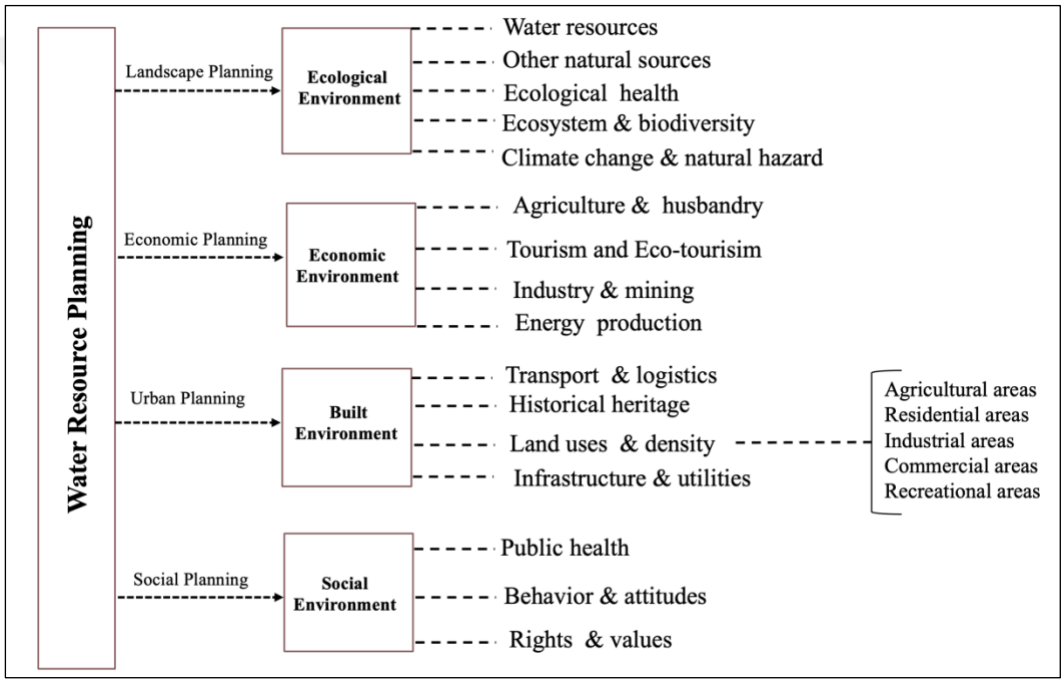

Figure 7.1 : The sub-factors determined under each sustainability dimension considered in planning and managing the water resources.

These primary factors and sub-factors were finalized after discussion meetings with the academics over the thesis program. Each sub-factor acts as a title for a group of issues that should be considered in water resource planning and management. The sub-factors with their included elements and indicators are clarified in the following tables (Table 7.1, Table 7.2, Table 7.3, and Table 7.4).

Table 7.1: Definition of the sub-factors under the ecological dimension based on the sustainability principle.

Main Factors	Sub-factors	The relevant elements, indicators, and scopes covered under each category
Ecological Environment	Water systems	• Water quality and water quantity, • Pressure over the water resources, • Water flows (minimum and maximum water flows), • Streams and lakes assessment.
	Other Natural Sources	• Land and water management integration, • Soil protection and sediment control, • Arranging the relations between plant-soil-water, • Forestry protection and production.
	Ecosystem & Biodiversity	• Various ecosystem functions and services, • Water ecosystems protection, • Fauna and flora, and biodiversity production and protection, • Wildlife, and animal habitat protection.
	Climate Change & Natural Hazards	• Environmental hazard control and monitoring, • Control of erosion, landslide, flood, and overflowing, • Projection of droughts, temperature, rainfall, and sea level, • Decrease of the derivers of droughts, • Climate robustness (rainfall, runoff, temperature, humidity), • Reduction of the effect of climate change on the water basins, • Anticipation of the possible effects of climate change on water basins over time
	Ecological Health	• Prevention of the groundwater and surface water pollution, • Stormwater management, • Pollution recycling, • Solid waste monitoring, reduction, and recycling.

Table 7.2 : Definition of the sub-factors under the physical/built environment based on the sustainability principle.

Main Factors	Sub-factors		The relevant elements, indicators, and scopes covered under each category
Physical Environment	Infrastructure & utilities		• Water services, water pipes, public facilities, wastewater utilities; • Infrastructure adequacy and rehabilitation and sanitation infrastructure to the residents; • Operational cost and technological development; • Adaptability of the water infrastructure to climate change.
	Transportation & logistics		• Transportation corridors, including highways, railways, ports, harbors, shipyards, airports, etc.; • Managing transport demand and car traffic demand; • Providing efficient access to goods and services for all inhabitants; • Organizing logistical services (water, ice, oil supply, ship maintenance, and repair).
	Historical & cultural values		• The spiritual relationships, language, songlines, stories, sacred places, customary use, plants and animals associated with water, recreational or commercial activities, archaeology, historical dimension, areas declared as world heritage sites, attractive landscapes and scenic beauty, places of religious importance, monuments of national/state/local level importance; • Recognizing the relationship of culture and traditions with their ancestral lands, water, sites; • Preserving cultural and spiritual values, multi-arched architecture, water canals, and underground cisterns;
	Land Uses & Density	Residential area	• Construction in the riparian area, rural development, and their environmental impacts; • Protecting the land, countryside, and environment while helping rural communities; • Promoting social security, welfare, the living standard, the peace, and stability.
		Commercial area	• Office buildings, medical centers, hotels, malls, retail stores, warehouses, and garages, medical school, laboratories, workshops, training institutions, hospital, and fuel station; • Environmental effect of commerce on water basin; • Increase of the community well-fare, economy, and employment in the water basin.
		Industrial area	• Increase of the energy, material efficiency, and recycling rate; • Reduction of water and land uses, soil pollution, and virgin material extraction; • Meeting the industrialization demands.
		Agricultural area	• Sustaining agricultural land; sustainable irrigation for agriculture; • Development of a more effective production environment; • Control of the pest invasion and its adverse impacts on health, safety, wildlife, and the environment;
		Recreational area	• Creation of green spaces systems within and among communities; • Preservation of wilderness areas, wildlife habitats, and biodiversity of area.

Table 7.3 : Definition of the sub-factors under the economic dimension based on the sustainability principle.

Main Factors	Sub-factors	The relevant elements, indicators, and scopes covered under each category
Economic Environment	Agriculture & Aquaculture	• Agriculture net benefit, agricultural employment, agriculture production efficiency, fishing capacity, and husbandry; • Development of agriculture and aquaculture per-capita gross domestic product; • Minimization of environmental impacts and increase of farm quality, fishing, husbandry; • Conservation and enhancement of the resource base; • Improvement of the economic situation of the rural community; • Providing job and work opportunity; • Efficient use of land, green source,and water in the basin.
	Industrial Production and Mining	• Tourism, recreation, shipping, and boating; • Preservation of wilderness areas, wildlife habitats, and biodiversity of the area; • Minimization of the negative construction impacts on river systems during exploration and industry; • Providing jobs and benefits to the community residing in the water basin; • Sustainable mining involving financially viable, environmentally sound, and socially responsible; • Ensuring that the fiscal regime is stable over time; • Decrease of the industry demand for groundwater and river; • Responding to the industrial development in the river basin.
	Tourism & eco-tourism	• Providing job chances; • Improving the finance and economic condition and improving the resident's livelihood; • Developing tourism and ecotourism chance on the water basin; • Recreational angling; • Providing food for rural and urban communities.
	Energy production & fuel services	• Producing electric power • Producing hydropower or hydraulic power from moving water used for irrigation, by operation of various machines, such as watermills, textile machines, sawmills, dock cranes, and domestic lifts; • Providing services for the community; • Improving the financial condition and the resident livelihood; • Developing tourism and ecotourism chance on the water basin.

Table 7.4 : Definition of the sub-factors under the social dimension based on the sustainability principle**.**

Main Factors	Sub-factors	The relevant elements, indictors, and scopes covered under each category.
Social Environment	Social Rights and values	• Income security for workers; • Affordable access to health care, family, basic goods, services, and opportunities necessary to survive and thrive; • Social security for health, education, food, water, housing, a healthy environment, and culture. • Education opportunity; • Participation in decision making; • Acceptance and awareness of water basin planning.
	Public health	• Improvement of well-being and sanitation; • Access to the safe water; • Enhancement of the life quality;
	Behavior & attitudes	• Analyses of the residents' behavior perception, preferences, life and consumption pattern, and the users' trend about the water use and pollution; • Satisfaction of the current users' needs and expectations of the water basin; • Planning based on the real social challenges of the inhabitants; • Considering all various ages, races, and genes in the basin management; • Sustaining the water use in the reservoir by leading the users to a correct habit and behavior.

7.2. Criteria Prioritization

The research main goal has been to provide an evaluation model for watershed or water resource management plans based on sustainability principles. Following the goal, the first step recognized in this research has been preparing a hierarchy of the primary factors in planning a sustainable watershed. Therefore, in this research, the hierarchy model of planning factors and sub-factors are designed. As Figure 6.4 in the chapter of method shows, it has four levels: the first level is the goal, and the other three levels contain the sustainability planning factors and subfactors.

As was explained in the methodology, these factors and subfactors were evaluated through the AHP method to understand their relationship and define the range of their importance in water resource planning. The answers were obtained from various groups of academicians and professionals through a questionnaire and then categorized. The obtained data from the questionnaire was calculated according to the AHP method to get the numerical weights of the criteria importance.

In this chapter, the results of criteria prioritizations and comparisons are explained and analyzed.

The AHP analyses show the differences and similarities among various groups of persons who did factors prioritization. To understand the effect of the various education, disciplines, and institutional policies on the responders' choices, the answers were analyzed separately. Among the groups of academics, four categories according to their academic areas are recognized, and among the professions, three groups according to the institutions where they work are recognized. Therefore, first, the similarity and differences among these categories are evaluated to check how much they have parallel opinions on the factors prioritization. Then the answers of two primary groups of academics and professions are analyzed.

In this way, the weights and prioritization of the following sustainability criteria are achieved.

- the main sustainability dimensions
- the ecological sub-factors
- the physical/built environment sub-factors
- the economic sub-factors
- the social sub-factors
- the land-use subfactors

7.2.1 Prioritization by the academics

In the evaluation of the academics' answers (20 persons), according to Table 7.5, it was recognized they had got their degrees in one of the four majors, including Landscape Architecture, Forestry Engineering, Urban Planning, and Environmental Engineering. To understand the effect of their field studies on giving the planning factors importance, their answers are categorized and evaluated separately. The results showed interesting similarities and differences among the groups'preferences.

Table 7.5: Academics' categorization based on their educational majors in the factors evaluation.

Responder	Ages	Major	Number
Academics	60% : 30-45 30%: 45-60 10%: 45-60	Landscape Architecture	7
		Forestry Engineering	7
		Urban Planning	4
		Environmental Engineering	2

As Figure 7.2 shows:

- In prioritizing the primary dimension, according to the academics'choices, the more importance has been considered for the Ecological Environment by the professors of Landscape Architecture; for the Economic Environment by the professors of Environmental Engineering; for the Social Environment by professors of Urban Planning; and for the Physical Environment by the professors of Forestry Engineering. The main dimensions' average prioritization from the most important to the least one is Ecological Environment, Social Environment, Physical Environment, and the Economic Environment. The current differences in the choices seem partially logical regarding the academic areas and courses taken by the professors.

In prioritizing the ecological sub-factors, according to the academics' choices, more importance has been considered for Water resources by the professors of Environmental Engineering; for Ecosystem and biodiversity by the professors of Landscape Architecture; and for Climate Change and natural disasters, and Ecological health by professors of Forestry Engineering and Urban Planning. Landscape architects having knowledge and experiences on the Ecological environment expectedly chose the Ecological systems and biodiversity as the first prominent subfactor. Urban planners and Forestry engineers more dealing with environmental problems and pollution seem to have logical choices. The average prioritization of the Ecological sub-factors from the most important to the least one is Ecosystem and biodiversity, Water resources, Other natural resources, Climate changes and natural disasters, and Ecological health.

- In prioritizing the Social sub-factors, according to the academics' choices, more importance has been considered first for Public health, second for Social rights and values, and then for Behaviors and attitudes. However, the professors of Environmental Engineering put more importance on Social rights and the professors of Foresty Engineering put more weight on Behaviors and attitudes than other groups.
- In prioritizing the Economic sub-factors, for all groups, the most important factors (more or less) respectively are Agriculture and aquaculture, Tourism and eco-tourism, Industrial production, and Energy production as the last one. The small difference is the more importance considered for Tourism and eco-tourism by the professors of Urban Planning. It may be because of the urban planners' knowledge of the economic effects of tourism taken by spatial and local planning activities.
- In prioritizing the Physical sub-factors, there are small differences among groups' judgments. However, the more importance goes for Land use, Infrastructure and utility, Historical values, and Transport and logistics. Professors of Urban Planning put more weight on Historical and cultural values, and professors of Environmental Engineering put more weight on Infrastructure and utilities.
- In prioritizing the Land-use sub-factors, the primary land uses are recognized the Agricultural and Residential areas and then the Recreational, Commercial, and Industrial areas. Among the answers, the professors of Environmental

Engineering consider more value for the Residential areas. The professors of Urban Planning consider more importance on the Recreational areas than the other groups.

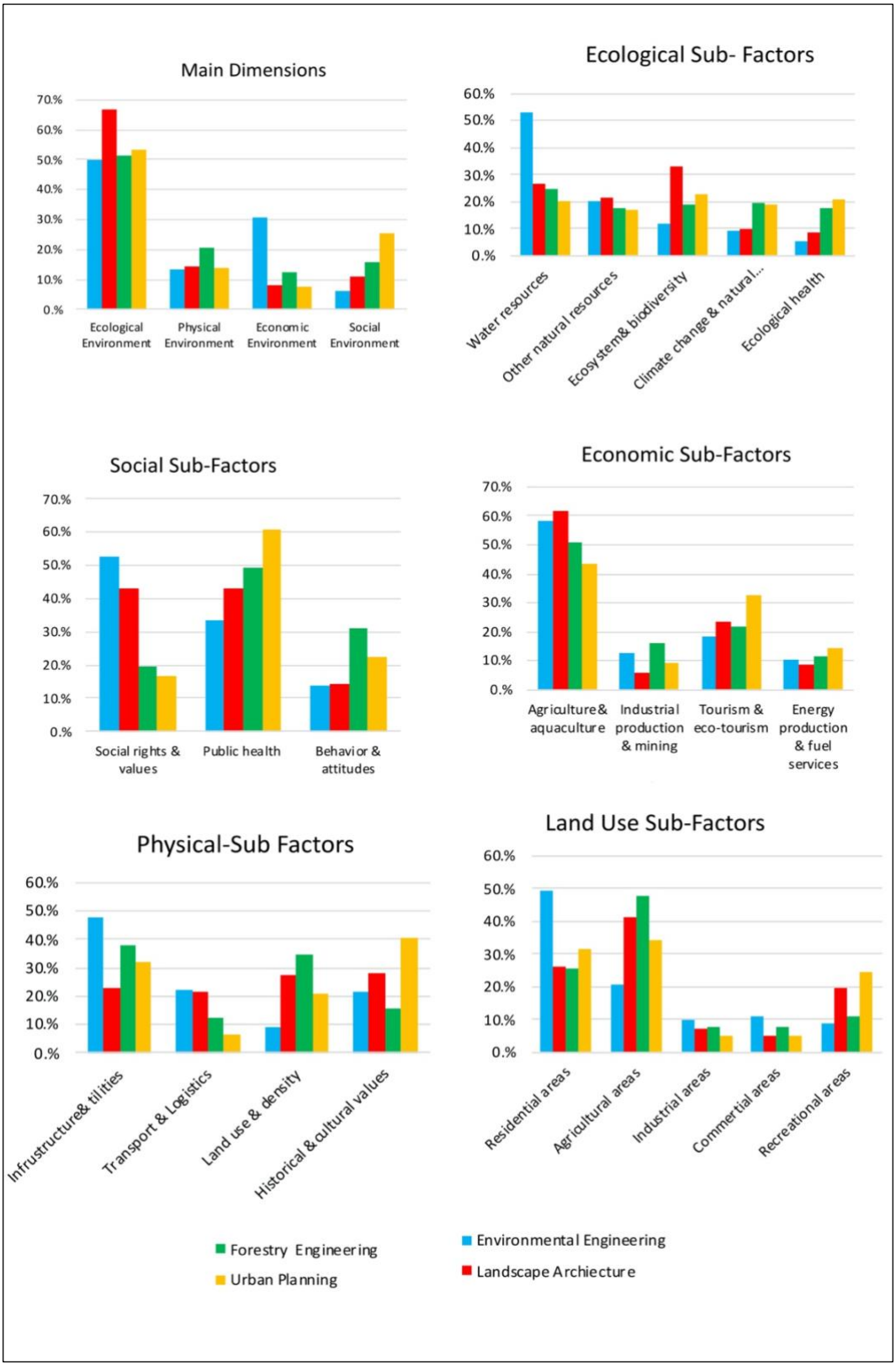

Figure 7.2 : The academics' prioritizations of the planning factors in sustainable water resources.

7.2.2 Prioritization by the professionals

According to Table 7.6, the professionals who did the factor prioritization have been working at one of the three institutions:

- Turkey Ministry of Agriculture and Forestry (Tarim ve Orman Bakanliği: TOB),
- The General Directorate of the State Hydraulic Works (DSI: Devlet Su İşleri Genel Müdürlüğü),
- The Istanbul Water and Sewerage Administration (İstanbul Su ve Kanalizasyon İdaresi: İSKİ).

Each of those institutions has its specific instruction, scopes, economic targets, and operational framework to protect and manage the water resources, which may affect the workers' perspectives.

- The Ministry of Agriculture and Forestry (*Tarım ve Orman Bakanlığı*) is a government ministry which is responsible for forestry and agriculture-related affairs in Turkey. The duties of the Ministry are to research on the development of agriculture, animal production, and aquaculture production; to ensure the protection of the forest, soil, water resources, and biodiversity; to work towards raising the awareness of the farmer; to conduct studies to determine general policies for agriculture and animal husbandry; and to protect nature, national parks, natural parks, and wetlands.
- The State Hydraulic Works (DSI: Devlet Su İşleri), as a state agency and a legal entity with a supplementary budget, is organized under the Ministry of Environment and Forestry. It is responsible for utilizing, planning, managing all water resources in Turkey. The DSI aims to develop water and land resources in Turkey, covering a wide range of interrelated functions. Its functions include irrigation, hydroelectric power generation, domestic and industrial water supplies for large cities, recreation, and research on water-related planning, design, and construction materials.
- İSKİ is an independent, public, and legal entity affiliated with Istanbul Metropolitan Municipality. Its establishment aims to carry out the Istanbul Metropolitan Municipality's water and sewerage services and establish all facilities required for this purpose. The duties of İSKİ are to provide drinking water utility and industrial water needs, distribute water to those in need,

remove wastewater from settlements and transport them to the discharge place, prevent the pollution of the sea, lake, river shores, groundwater, and so on.

In the evaluation, the professional's judgments (17 persons)are categorized based on their working places to understand the institutional structures' possible effect on their perspective (Table 7.6.). The results show their different and similar aspects of prioritizing the sustainability factors for watershed planning and management.

Table 7.6 : Professionals' categorization based on their educational degrees in the evaluation of the questionnaire.

Responder	Ages	Place of Working	Number
Professionals	70% : 30-45 30%: 46-60	Turkish Ministry of Agriculture and Forestry (TOB)	7
		The State Hydraulic Works (DSI)	4
		Istanbul Water and Sewerage Administration (ISKI)	6

As Figure 7.3 shows the professionals' choices on the importance of the sustainability factors:

- In evaluating the main dimensions by the professionals, with small differences, they put the weight from the most to the least one for the Ecological, Social, Economic, Physical Environment. Professionals working at TOB have put more weight on the importance of the Ecological Environment. It is maybe due to the TOB projects on natural resource protection.
- In evaluating the Ecological subfactors, the professionals from three institutions have considered partially similar prioritizations on the factors. First, the Water resources, followed by Ecological health, Climate change and natural disasters, Ecosystem and biodiversity, and finally, Other natural resources are ranked as ecological sub-factors in water resource planning. The professionals working at DSI have put more weight on the Water systems following the institution's target on water resource protection.
- In evaluating the Economic subfactors, professionals from all institutions have similar opinions on the items' importance. In their view, the first weight goes for Agricultural production, second for

Tourism, followed by Energy production, and Industrial production as the least important one.

- In evaluating the Social subfactors, the professionals with small differences have selected Public health as the most important social sub-factor, then Social rights and values, and Behavior and attitudes as the last one. The professionals working at DSI seem that have more importance on the Behaviors and attitudes of the people living in the water areas. As a state institution responsible for planning and managing all water in Turkey, DSI has performed related social studies in water resource planning.
- In the evaluation of the Physical subfactors, there are noticeable differences among the professionals working at DSI and others. Persons working at DSI put more weight on the Land use and Historical value. However, professionals working at TOB and ISKI put more weight and value on the Infrusturtue and utilities as physical sub-factors. The professionals working at TOB following the institutional aims on the agriculture production, the same as the professionals working at ISKI as a municipal executive unite, has more prioritization on the Infrusturtue and utilities.
- In evaluating the Land-use subfactors, the professionals have chosen Agricultural areas, Residential areas, Recreational areas, Commercial areas, and Industrial areas, respectively, as the most critical uses considered in the planning and management of water resources.

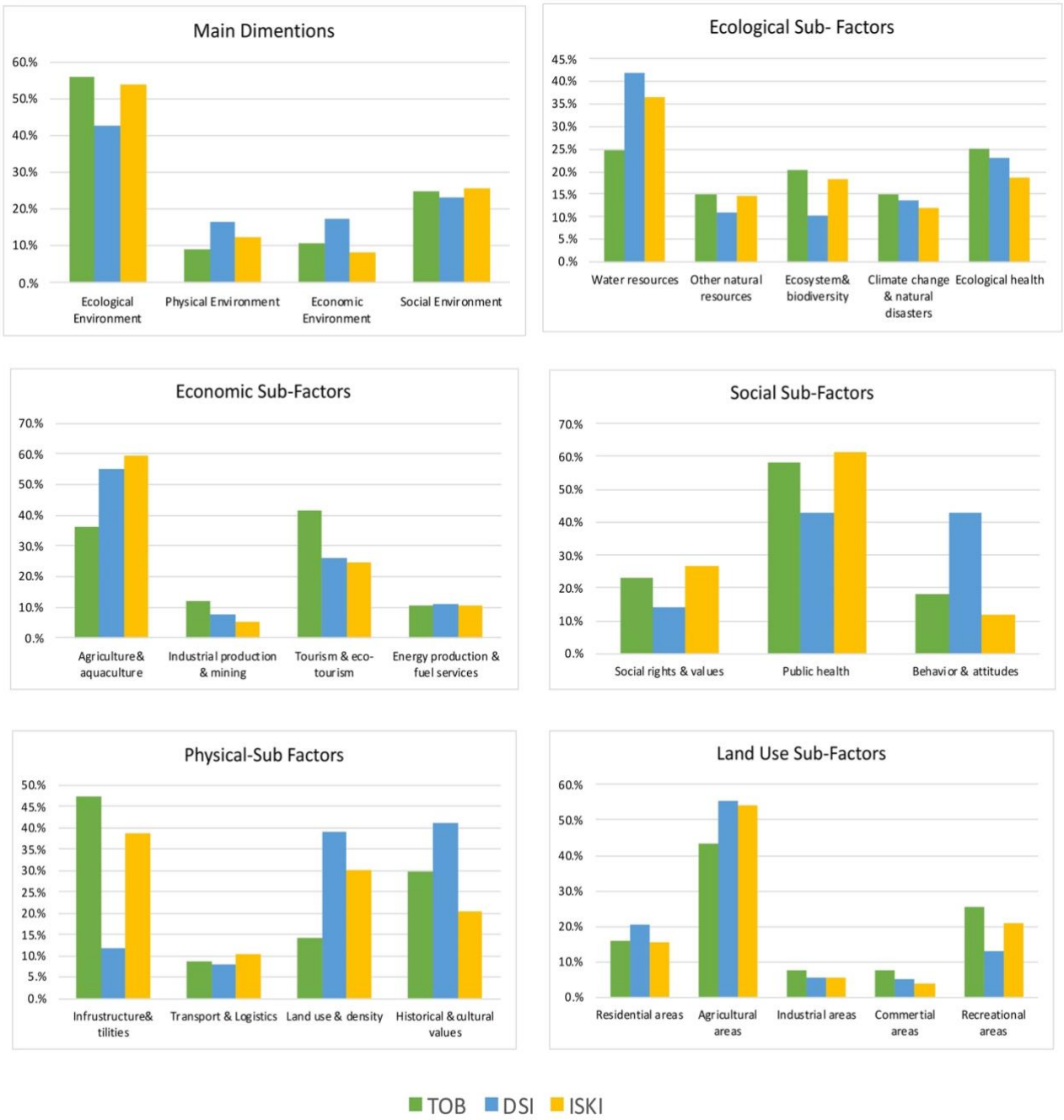

Figure 7.3 : The professionals' prioritization of the planning factors in sustainable water:resources. TOB: Turkey Ministry of Agriculture and Forestry, DSI: The General Directorate of State Hydraulic Works, ISKI: Istanbul Water and Sewerage Administration.

7.2.3 Comparing academics and professionals' prioritization

After evaluating the criteria weights and prioritization based on the responders' knowledge and working experiences, it tries to understand the different choices among two main groups of professionals and academics. In this part, the judgments of the two groups are analyzed and compared to each other. The average amounts of the data obtained from the two groups (academics and professionals) were compared. The normalized weights are determined in Table 7.7, which shows the quantitative values caught for each criterion by the two groups of participants.

Table 7.7 : The normalized weights and values in two categories of responders (academics and professionals) achieved by the AHP method.

Sustainability Environments	Weights		Sub-Factors	Weights	
	Academicians	Professionals		Academicians	Professionals
Ecological environment	0.4179	0.347	Water resources	0.22	0.349
			Other natural resources	0.215	0.142
			Ecosystem and biodiversity	0.275	0.086
			Environmental problems	0.200	0.167
			Environmental pollution	0.090	0.257
Physical environment	0.1018	0.0516	Infrastructure and utilities	0.223	0.385
			Transportation and logistic	0.114	0.0873
			Land uses and density	0.514	0.1423
			Historical and cultural values	0.149	0.385
Economic environment	0.0837	0.107	Agriculture and aquaculture	0.578	0.528
			Industrial production and mining	0.112	0.081
			Tourism and eco-tourism	0.213	0.299
			Energy and fuel services	0.097	0.091
Social environment	0.124	0.1382	Social rights and values	0.311	0.249
			Public health	0.493	0.594
			Behavior and life pattern	0.196	0.157
Total	1	1		1	1

7.2.3.1 Weight of the sustainability dimensions

The results could identify noticeable similarities and differences in comparing two groups' viewpoints toward the main dimensions of watershed sustainability. In weighing and prioritizing four primary factors considered for the SWMP, the Ecological environment has got the most important based on the opinion of two groups (around 55%). The academics and the professionals considered the Social environment (19-22%) the second important factor. The academics chose the least value for the Economic environment (12%), but for the professionals, the Physical environment has the least value (7%) among the others. The fragmentation among the watershed

management process and other disciplines like urban planning may cause that different opinions. (Figure 7.4).

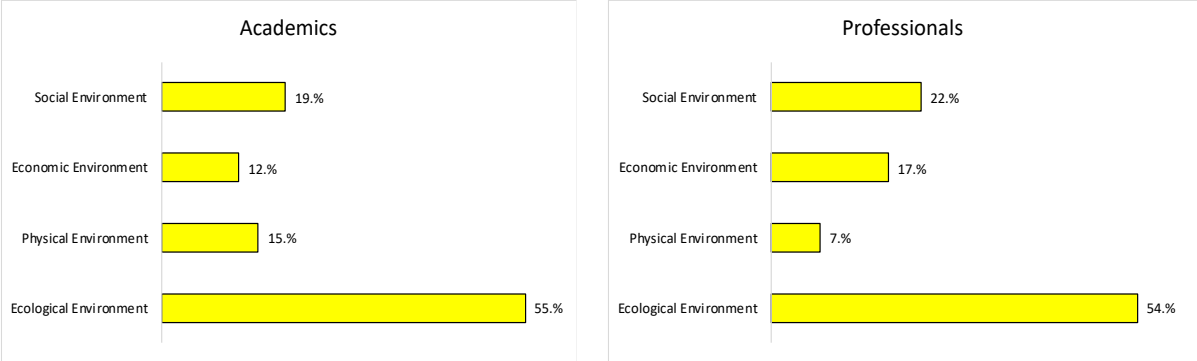

Figure 7.4 : Comparison of the weights in prioritizing the primary dimensions considered for the SWRP.

7.2.3.2 Weight of the ecological sub-factors

In weighing the ecological sub-factors, there is a clear difference between the two groups' choices. The academics put the most weight on the Ecosystem functions and biodiversity (28%). They also prioritized the sub-factor of Water systems and water resources with the same value as the Other natural resources. According to the professional's opinions, Water resources (35%) and then Environmental health (26%) are the most critical criterion under the category of Ecological environment in SWMP. The professionals may have more logical choices regarding water quality problems and environmental pollutions in Turkey's water basins. However, it may also prove that professionals have less information on the importance of ecosystem functions and ecological cycles in the water areas (Figure 7.5).

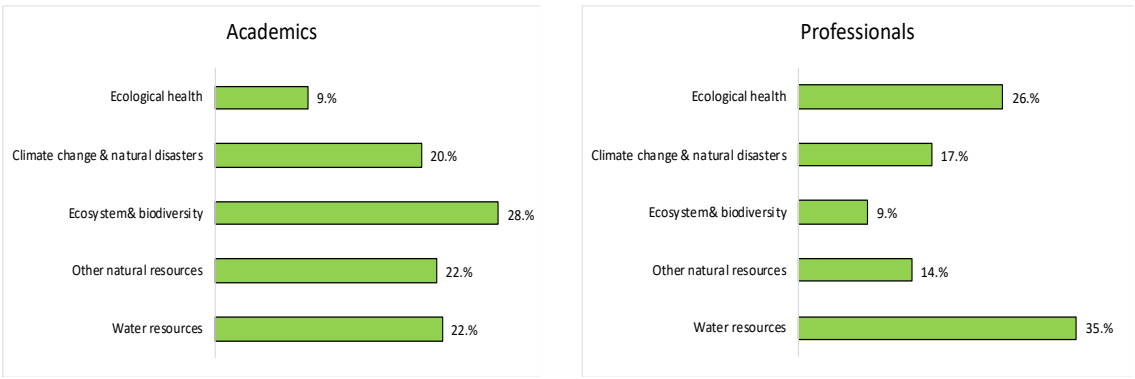

Figure 7.5: Comparison of the weights in prioritizing the Ecological sub-factors considered for the SWRP.

7.2.3.3 Weight of the physical sub-factors

Regarding the physical sub-factors' importance, the academics gave the highest value to Land uses and density (51%). In contrast, the professionals thought that the most value should be determined for Historical values and infrastructure (38%). Transport was selected as the least important priority by both groups. The critical contradiction between the two groups' choices is over Land uses and density, which was valued 14% by the professionals. Regarding the different impacts of the land uses on the water quality and watershed environment, land use assessment has been recognized as a substantially critical act to academics (Figure 7.6).

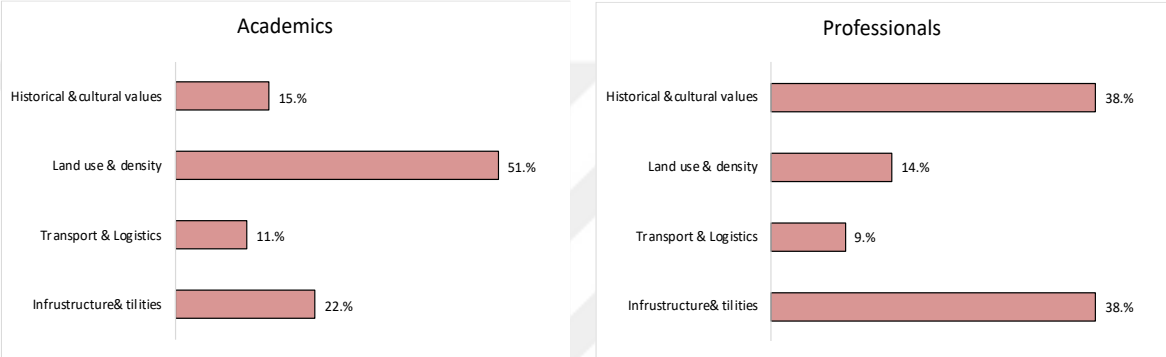

Figure 7.6 : Comparison of the weights in prioritizing the Physical Sub-factors considered for the SWRP.

7.2.3.4 Weight of the economic sub-factors

In valuating the sub-factors of the economy, two groups regarded similar choices for the prioritization. Agriculture and aquaculture development as the first important priority (55%) followed by Tourism development (21-30%), then Industrial and mining, and finally Energy production as the least important criterion have been ranked. The comparisons show that the professionals have put a little more weight (30%) on the tourism sector than the academicians (21%). The research may be due to the professionals' knowledge and experience about the positive effect of tourism activities in the economy of the water areas in Turkey (Figure 7.7).

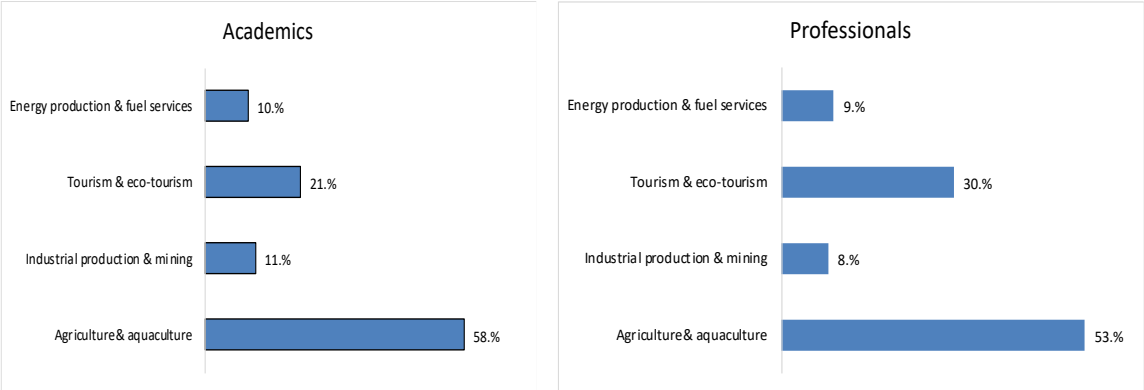

Figure 7.7 : Comparison of the weights in prioritizing the Economic sub-factors considered for the SWRP.

7.2.3.5 Weight of the social sub-factors

In weighing the social factors, the highest values according to the groups' answers were given to Public health (50–60%), then to Social rights and values (25–31%), and finally to Behavior and attitudes (16%–20%). These choices seem reliable regarding the right of public access to safe, clean water and sewage utilities. Even though the public behavior as a criterion has been achieved the least value, it does not mean this dimension can be ignored in the watershed planning and management approach (Figure 7.8).

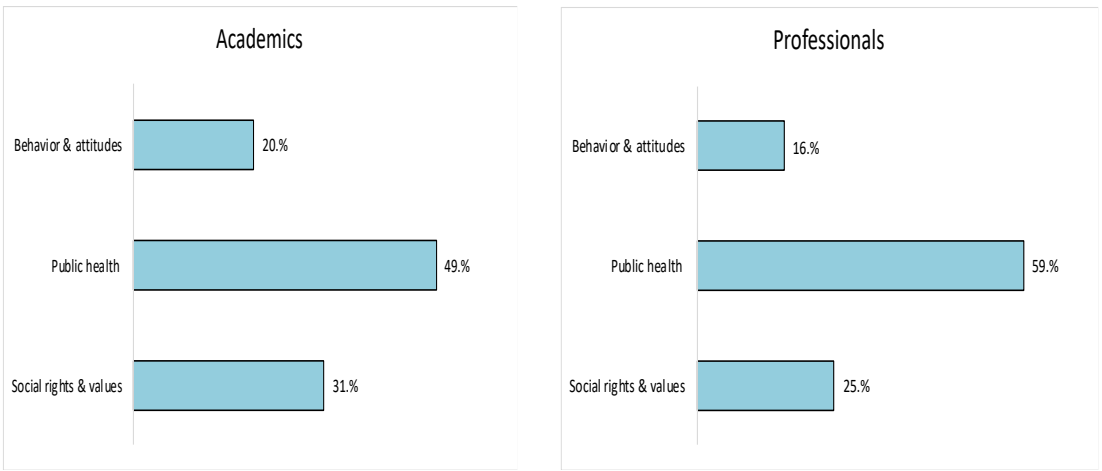

Figure 7.8 : Comparison of the weights in prioritizing the Social Sub-factors considered for the SWRP.

7.2.3.6 Weight of land-use sub-factors

In weighing the land use sub-factors as the fourth level of the sustainability hierarchy, the two groups agreed on the prioritization. As Figure 7.10 shows, the most important value was given to Agricultural areas (47-48%), followed by Residential areas, Recreational areas, and finally, Commercial and Industrial areas (6-7%). This choice looks acceptable as agriculture is the main water-using sector and residential areas are an undeniable land used in any water basins. Watershed planning regulations mostly restrict the commercial and industrial areas due to their negative impacts on the water area. Recreational uses are partially allowed in some watershed areas according to their distance from the water bodies (Figure 7.9).

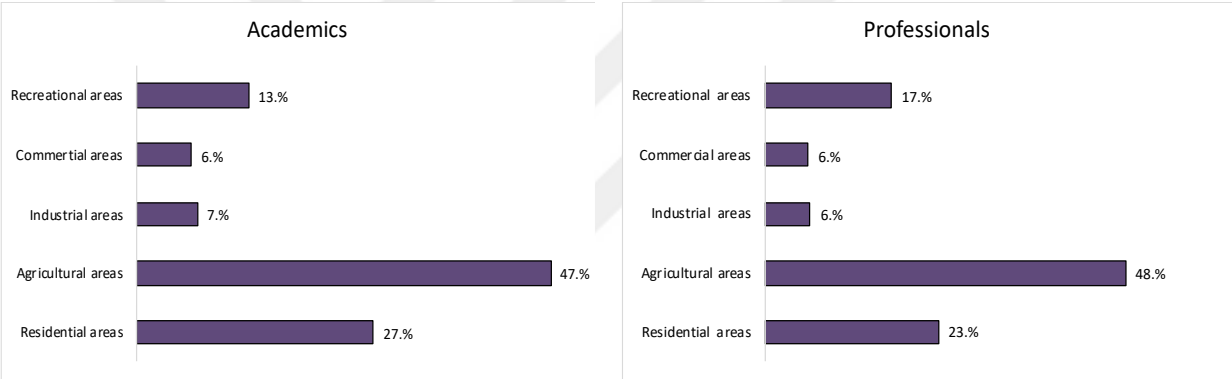

Figure 7.9 : Comparison of the weights in prioritizing the Land-use sub-factors considered for the SWRP.

The results showed different preferences on some aspects of water resources sustainability among experts, especially in weighing the main dimensions and ecological and physical sub-factors. The professionals considered low values on the physical planning, watershed ecosystem function, land uses effect, management technique, and other natural sources (except water) in the SWMP. Two groups have agreement on valuing sub-criteria of economic and social dimensions and Land Uses (Figure 7.10). The professionals having less information on the ecosystem function, land uses affect, social and economic requirements, and so on will not provide a sustainable water resource management and plan.

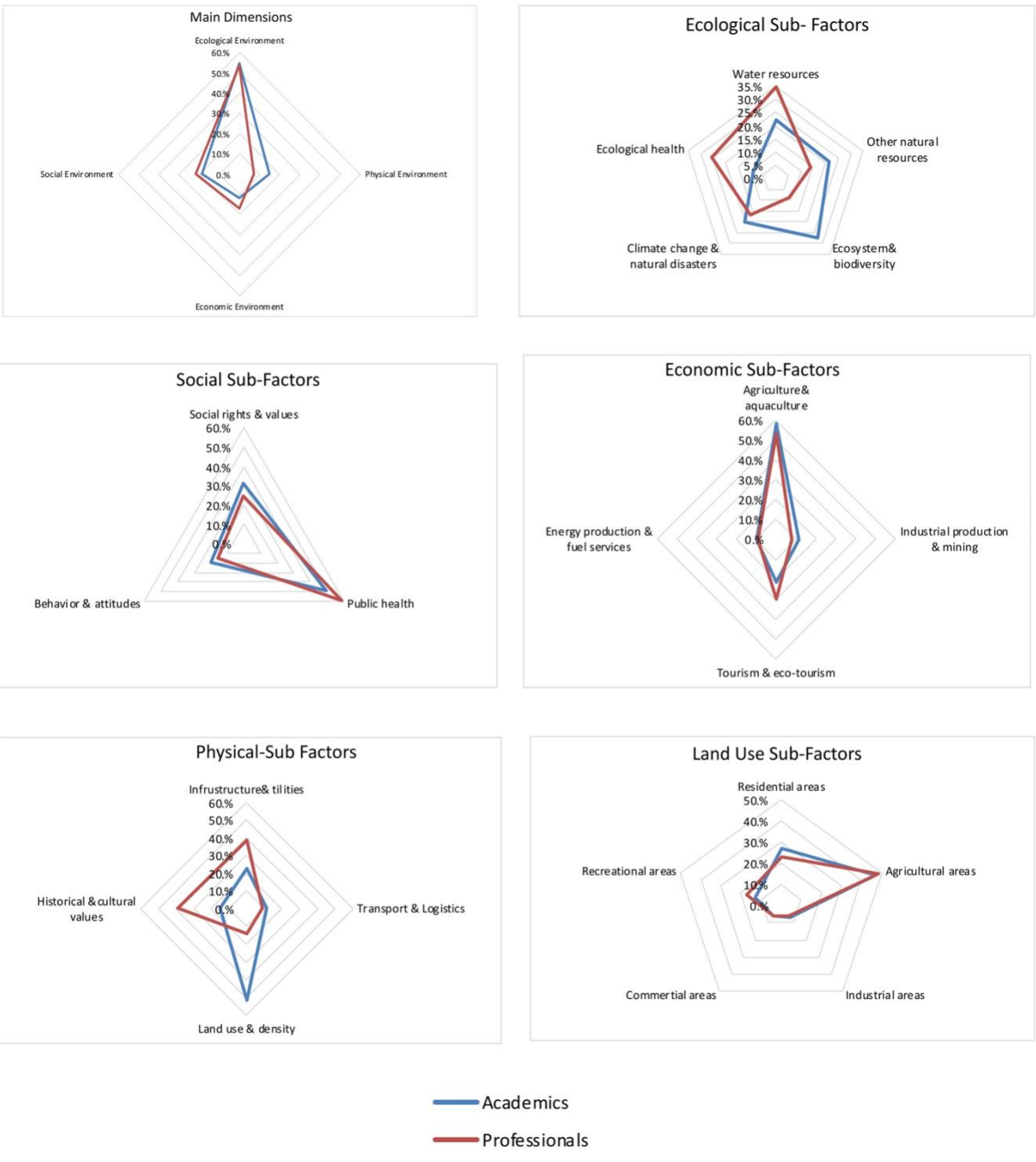

Figure 7.10 : Comparative diagrams of the two groups' answers in prioritizing the sustainability criteria of watershed planning and management.

In comparing various academics groups' choices, the existing differences in the factors prioritization can be rooted in their knowledge areas. The academics knowing Landscape Architecture have put more importance on Ecological environment and Ecosystem and biodiversity, which shows their information on the ecological science. The academics with the science of Environmental Engineering have put more attention on the importance of the Economic environment, Water resource itself, Water infrastructure and utilities, and Residential uses on the water basins. The academics with the degree of Urban Planning have given more weight to the social environment, Public health, Tourism, Recreational uses, Historical values, and Climate change management, as they have conducted various research and projects in those areas. The academics with the degree of Forestry Engineering have had attention on the Land uses and density, Physical and Ecological environments.

Various groups of professionals, who are working at one of the TOB, DSI, ISKI, have had more similar viewpoints. However, in some areas, they showed small differences: the professionals working at DSI seem that have more importance on the factor of Economic Environment, Behaviors and attitudes of the people, Land uses, Water resources, and Historical and cultural heritages. The professionals from TOB following the institution's goal about agriculture and crop production put more weight on Tourism and ecotourism. The workers at the ISKI pay more attention to the Facilities and utilities, influenced by their institution procedures.

There are critical differences in comparing the two groups of academics and professionals' choices in weighting ecological and physical sub-factors. In general, academics have considered the global issues important on the water resource sustainability. They have a more holistic view based on their knowledge of climate change, ecosystem, biodiversity, and land use effect. While the professionals focusing on solutions for the problems like water pollution have been affected by the institutional perspective. They considered factors, such as ecosystem functions, infrastructure, land-use impacts, and other natural sources, as less critical for sustainable water resource planning and management. However, the correlation is understandable among the two groups' choices on weighing main dimensions and sub-criteria of economy, society, and land-uses with small differences.

7.4 Increase of the Agreements

The water resource planning process is associated with different sustainability elements, including ecology, society, economy, and built structures. It has caused the water basin or water resource planning to become much more complicated and need a comprehensive, dynamic, and cooperative approach. This research could identify primary contradictions among decision-makers and knowledge holders over prioritizing sustainability factors related to the water resources. The mentioned contradiction may lead to a holistic approach of watershed management, or in contrast, it may lead to difficulties in decision making. Anyway, it is necessary that the diverse views among stakeholders, managers, experts, and the water users are identified and conducted toward protecting water resources. Identifying the areas of conflict can discover the critical challenges that may appear during the decision-making process, management programming, and implementation efforts.

Experts and professionals' different opinions should be harmonized to determine any evaluation model for water resource management plans. Professionals won't be able to prepare a sustainable watershed plan when they don’t have appropriate information about land-use impacts, ecosystem cycles, economic and social requirements, and so on. Similarly, academics with various viewpoints on the planning items cannot agree on a specific evaluation structure for the water resources. This issue can be mitigated through some techniques and strategies:

- The policy should require cooperation between two groups of academics and professions in watershed-related projects. Their participation should become normal and regular in the water resources projects and programs. The involving various groups of stakeholders, water users, managers, and experts is a crucial element in decision-making for water resources protection and planning. Cooperation among different government institutions, local agencies, and public organizations should also be defined and created from the first step of the planning process. The contradiction between public users and stakeholders, professionals and academics, and regional planners and local managers, or even among different groups of experts like land-use planners, landscape architects, environmentalists, economists, and water managers can appear at

all stages of the planning process. If it is not conducted, it will have adverse impacts on the plans implementation and sustainability goals over a long time.

- Organized meetings, introductory programs, and educational workshops that create conversation among various groups of decision-makers, knowledge holders, and public users are needed. These programs can be considered at each step of water resource planning, including scope determination and prioritization, challenge and problem clarification, management strategies identification, solutions offering, source allocation, and so on. At the end of the conversation meetings, the participants will most likely achieve more harmonized opinions and suggest comprehensive solutions.
- Academics and practitioners need to have a common language in their participatory programs and projects. The academics should present practical strategies in the meetings and let the professionals understand the approaches with simple language and technique. It will be associated with more successful results and strengthen the relationship.
- Institutional coordination is needed as there is sometimes fragmentation among actors, institutions, ministries, and other related sectors regarding their policies, regulations, and instructions. Managing water resources has a complicated structure in Turkey that has led to different scopes, approaches, and processes in water basin planning and management.

The results proved that there are different perspectives among experts and academics on some aspects of watershed sustainability. According to the results, the evaluation model for water resource sustainability plans is suggested in Figure 7.11. In this proposed model, criteria in one specific color show two groups' similar choices on the criteria importance level. However, the criteria in two colors show the conflicting opinions of the groups on their prioritization. For instance, Public health, as the social sub-factor showed in one color (purple), has been selected as a strongly important criterion by both groups. Environmental health as the ecological sub-factor depicted in two colors shows that it has been chosen as a very important sub-factor from one group and slightly important from the other group (Figure 7.11).

The evaluation model suggested in this research is a flexible model that is open to future changes. This model can be modified by adding and removing its elements and

become more holistic over time. As people and their knowledge alter; nature and climate change; and the watersheds and their challenges alter over time, the watershed plans' evaluation model can not be stable.

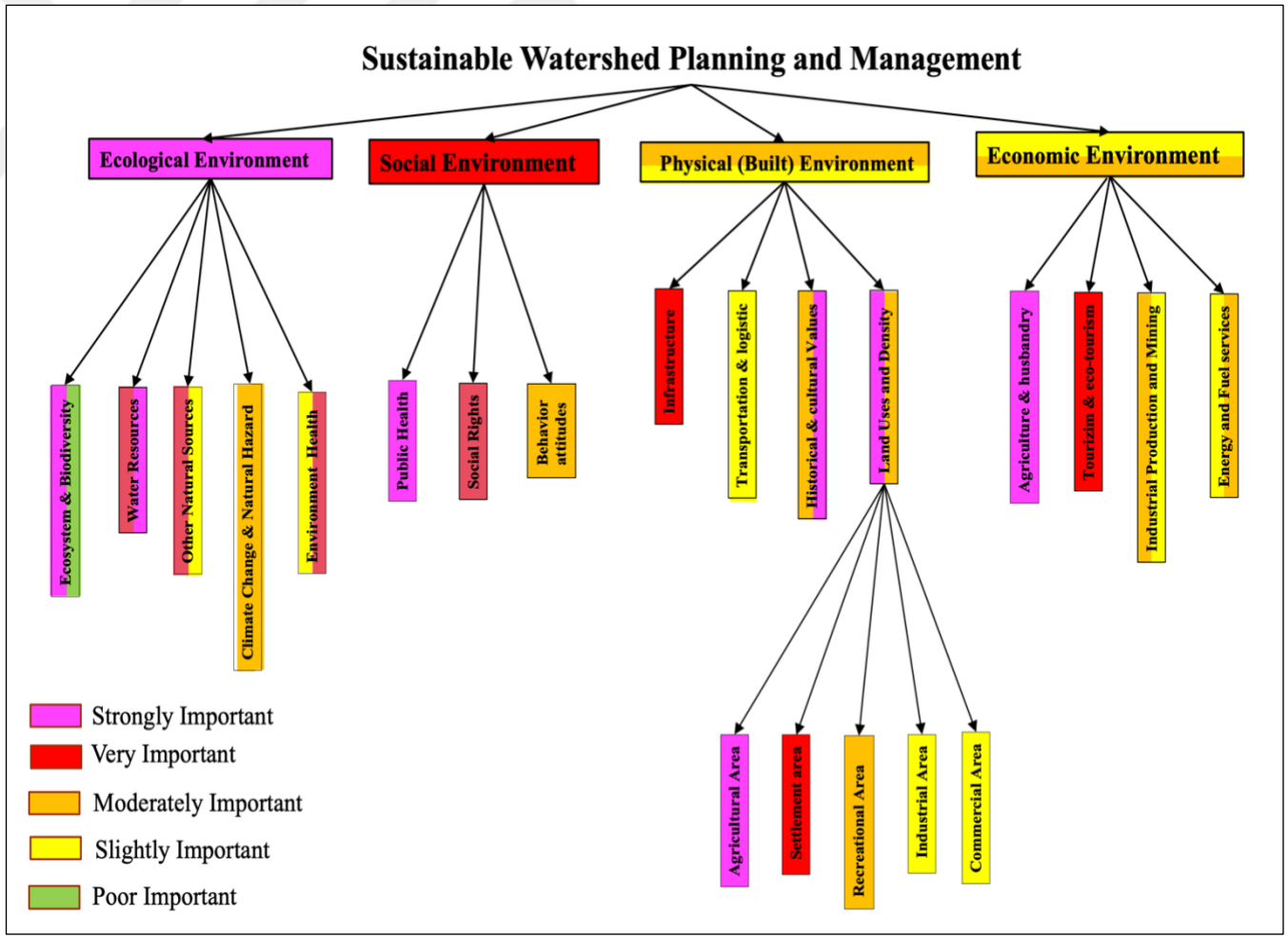

Figure 7.11 : The evaluation model suggested in the research for sustainable water resource plans.

8. CONCLUSION

Regarding the importance of the water resources in ecosystem stability and human development and increasing diverse ecological issues related to the watersheds, evaluating the water resource management plans seems essential.

Considering sustainable water management approaches like integrated water resource management, four central dimensions (ecological environment, built environment, social environment, economic environment) have been recognized in the holistic water management approach.

Water resource plans need to respond to all sustainability dimensions, even though specific strategies and solutions should also be considered for each watershed's current issues.

Considering new planning and management approaches emerging in under-developing countries like Turkey, it seems necessary that the water-related plans are assessed in terms of covering various dimensions of social, economic, ecological, and physical aspects. Water resource planning approaches aiming at water basin protection mainly focus on the environmental aspects and management. However, they should also respond to the residents' economic needs, protect their cultural and social values, and sustain their lifestyle.

According to the previous experiences, three main strategies can contribute to creating a holistic water resource plan:

- Public and water user participation in the water resource planning process can help with social and economic evaluation in the area. The plan's implementation challenges won't appear, and the residents as the main stakeholders will support the plan.
- Comprehensive information on the related issues is necessary for the protection, management, or planning process over the decision-making process. As an inter-disciplinary process, water resource planning and management require integrating various disciplines, particularly water management, spatial planning, urban designing, and landscape architecture (Figure 8.1).Through appropriate policies and regional regulations, the existing

fragmentation among various disciplines can reduce that lead to much more practical results.

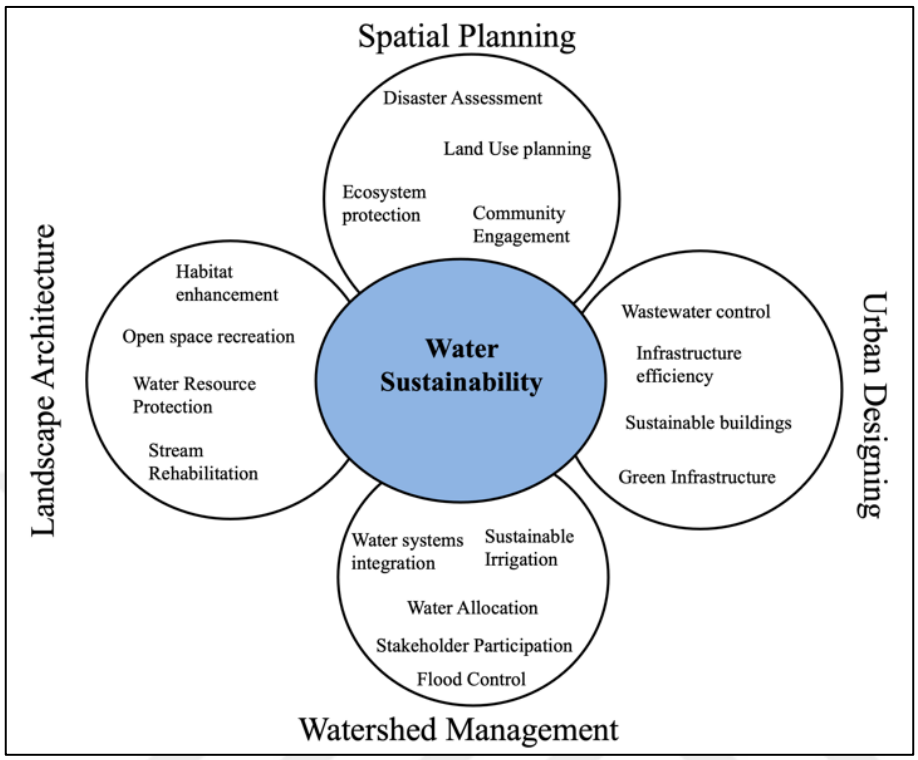

Figure 8.1: Water and water resource sustainability requires various disciplines integration.

- Water sustainability as a scope should be regarded in national policy, regional and provincial plans, developmental and economic plans, spatial and zoning plans, local and sub-scale plans, by covering various strategies and techniques for water-saving and water resource protection. Each sub-plan should go one step further in the issue by providing practical strategies and techniques for water resource protection at different scales.

This thesis shows some contradiction among knowledge holders and decision-makers in some aspects of prioritizing water resource sustainability factors, which may lead to failure to achieve sustainability objectives.

Knowledge holders decide based on their academic information related to the issue, and the practitioners are affected by the institutional targets and their working experience.

It seems that before taking any serious steps toward watershed planning, the gaps among the perspectives of target groups should be identified and conducted.

Determining the contradicting views can help understand the primary challenges that will appear during the management, planning, and implementation efforts.

They are various ways to parallelize the conflicting opinions, like through discussion meetings among stakeholders. However, the different viewpoints can be regarded as a strong aspect of a holistic and flexible model.

The evaluation model for watershed plans suggested in this research should be changeable over time by adding or changing its elements. It should let the different preferences have a position in the evaluation structure of the watershed proposed plans. As the ecology, society, economy, and environment change over time, the suggested model should also be modified over time.

8.1 Situation of the Water Resources in Turkey

Evaluation of the drinking water resources and water basins in Turkey has resulted in general information. Here, it summarizes the water resources situation, their main challenges, and proposed suggestions for the problems mitigations in Turkey. The findings are based on the research results and the experts' discussion during the thesis progress.

8.1.1 Water resources main issues

According to the experts' opinions and the analysis of the results, the current problems related to water basins in Turkey (from the most to the least critical ones) are:

- Wrong and inappropriate land uses that have caused the watershed's ecosystem degradation,
- Water pollution,
- Environmental pollution,
- Insufficient water infrastructure,
- Soil erosion in the basin,
- Illegal water uses,
- Tree cutting in the water areas,
- Unsuitable agricultural uses,
- Changing the morphology of streams,
- Wrong decisions about dam constructions.

Seven main causes for the mentioned problems related to the water resources have been recognized (from the most to the least important ones):

- Land use planning and water resources management is not integrated;
- Management system in existing water resources is inappropriate;
- There is not institutional coordination;
- National policies and laws related to water resources in Turkey are not supportive enough;
- There is insufficient participation of society and stakeholders in the planning and management process;
- Technology and knowledge on water treatment and recycling are not enough (low capacity building);
- Finally, there are implementation problems due to insufficient funding, supportive programs, and encouragement.

8.1.2 Water Resources Management System

The functions of the authorized water institutions like the Ministry of Environment and Agriculture (Water Management Directorate), Water canalization institution (e.g., ISKI), the State Hydraulic Works (DSI) in Turkey, can be assessed considering the research findings.

Evaluation of Turkey's water management system has shown several good aspects in some areas and some weak points in other areas.

The existing management systems in Turkey have positive functions and achievements like:

- The watershed-based studies and researches are open to cooperation with the academic sectors.
- The analysis processes and data collection are in harmony with EU processes in water resources management. The authorized institutions like DSI and Water Management Directorate function and follow the European WFD in the last ten years.
- Basin management plans have achieved the potential to provide an intersection between national-level policies and local level planning practices.
- Authorized institutions are carrying out noticeable studies. Thanks to these studies performed in recent years, the water quality, water basin potential, and issues could be analyzed multi-dimensionally in Turkey.

- With the help of different projects, the initiatives to change the traditional perspective of water resource management have been achieved by improving the institutional capacity.
- In recent years, the legislative arrangements are critical gains in terms of creating a basis for implementation in the practice of basin management plans.
- Specialized disciplines and expertise are developed in the area of water planning and management.

The weak points and drawbacks of the water resource management system in Turkey are as follows:

- The authorized institutions concentrate more on the currents problems like pollution discharge in the water basin related activities. They have focused on the wastewater treatment and disposal facilities rather than controlling the pollution sources. Being far from the globally ecological aspects and working under political decisions has caused these problems.
- There is a large lack of coordination and communication between ministries and their internal organizations with lower-scale planning actors such as municipalities in the management processes related to the water resources. This situation has led to multiple procedures, authorities, and regulations in water-related areas that make the basin integrated management difficult. The mismatch between decisions made at the upper and lower scale plans renders the holistic practices.
- The current water resource management and planning in Turkey have a dispersed structure. There are still ongoing changes in the authorities and responsibilities.

8.2 Improving Water Resources Management

In this research, some suggestions for improving the situation and solving the problems associated with Turkey's water resources have been achieved.

The suggested strategies and regulations are categorized under seven scopes of water resource management and planning.

8.2.1 Suggestions for the ecological issues and environmental protection

- The society should be informed about the water resources' environmental issues through engagement and cooperation in the water management and improvement programs;
- The ecological conditions should be taken into account in the plans' regulations and the legal framework of the water resource;
- Regarding the land use's effect on the water and environment quality, proper land-use plans for each water area by the experts are needed. In Turkey, in the newly conducted water management projects, the integration of spatial planning and watershed management has been taken into attention;
- The multi-faceted benefits of ecosystems should be explained in a more understandable and tangible way for all stakeholders. In Turkey, over the last years, great researches on the basin ecosystem service have been obtained. They identify the current basin status, basin natural resources, endangered ecosystems, ecological capacity, and so on. All managers and stakeholders should know about the ecosystem services of the water basin they are involved;
- Management policies should be determined by considering the ecological cycles as a whole. For example, water basins should not only focus on drinking water supply or energy production. The effect of policies (harm, benefit, trade-off, etc.) developed under different thematic titles (water, forest, pasture, etc.) should be evaluated;
- Scientific, administrative, social, and legal regulations should be integrated into ecological requirements.

8.2.2 Mitigating the water and environmental pollution

- Public awareness should be raised about the effect of their actions on water pollution and the importance of environmental health;
- Related sanctions, supervision, control, regulation, and measurements should be applied over the planning process and after plan implementation in the water basins;
- The pollution sources in the areas should be identified. In this respect, the sources causing pollution should be transformed into an ecologically sound structure. In Turkey, during the basin assessment, the water quality is measured

at some specific stations; however, the pollutions' primary sources are not discoverd;

- Parallel approaches can be followed for the protection of the ecological environment. Land use should be planned correctly; infrastructure deficiencies should be completed regarding environmental services; sewage discharge system should be repaired; stormwater should be managed;

8.2.3 Increasing the water amount

Increasing the amount of water in any basin depends on the basin's meteorological parameters, physical properties of the basin, and land uses. The basin planners or water managers should focus on the parameters which can be controlled. Also, in urban watersheds, the issue is not increasing the amount of water, but high water quality is needed. This situation should be considered individually for each basin. However, in general, there are some suggestions:

- The land use of the basin should be taken into consideration, and forest areas should be protected. The basin's natural structure, forests, open areas, green belts, and streams channels affecting the water amount should be preserved in the watersheds;
- The water use efficiency should be realized primarily with the protection of the water resources. If there is a shortage of surface and underground water resources, it may be necessary to build physical structures for the basins and manage the process and supervision in cooperation with the related institutions;
- Since Turkey's basins are largely fed by rainfall, the amount of water in the basins is primarily related to rainfall regimes. Climate change policies should come to the fore for making the unstable rainfall regimes more manageable. The destruction, fragmentation, and degradation of basin ecosystems should be minimized, especially in forest areas. Besides, approaches such as ecological design, ecological planning, and focusing on nature-friendly economic sectors should be implemented to mitigate climate change effects;
- Restrictions and regulations regarding water use in agriculture can be introduced. Mobilization can be limited, especially in the public sector. Activities that will prevent the flow of water should be ended.

8.2.4. Managing Water Demand

- Incentives to change users' consumption habits and lifestyle can be practical;
- Loss-leakage rates in water allocation should be reduced;
- Incentives for sectors requiring minimum water needs is a good idea. For instance, incentives for effective management in agricultural product pattern and irrigation activities or a transition to systems that reduce water demand in industrial production can be defined;
- It is necessary to study the water budgets of the basins correctly and to plan their sectoral water usage;
- Application of scientific and technological approaches for water recycling/treatment should be activated.

8.2.5 Engaging stakeholders and community

- Certain institutions and the academic community should be combined on the same platform, and evaluations should be made by discussing how much the views overlap in practice and implementation. New approaches should be created;
- Stakeholder and community participation in watershed planning should be ensured. Community participation in the basin issues should be discussed with its positive and negative aspects;
- Regularly informing different stakeholders about the process and practices is a critical issue in participation. At this point, especially the management units come together in regular periods. Therefore, policies and decisions can be developed holistically;
- Meetings and informative campaigns can be emphasized, starting with primary education. Training and awareness-raising activities, people's participation in the planning decisions should be carried out to comprehend water resources' importance.

8.2.6 Bolstering the relationship between land use and water resources planning

- The critical thing is to maintain the already made that relationship correctly. Water resources are impacted by decisions related to land use and growth management. These decisions influence water demand, affect water supply, and impact water quality. Today, planners are increasingly working with water professionals and challenges into local plans and regulations in the US. Planners play a crucial role in facilitating the implementation of IWRM efforts, which depend on interdisciplinary collaboration between water professionals, planners, engineers, landscape architects, public works professionals, and other related professions.Changes and transformations in the basin land use are the most influential factors. Therefore, water planning should be done considering the land use classification;
- Direct and indirect effects of land use or use changes on water resources should be analyzed and measured by analytical methods. Possible impacts based on future scenarios should also be revealed. The alternative outputs should be considered a parameter included in land use planning development processes;
- It should be mandatory to continue national policies in local plans. Budgets and funding support should be allocated for expropriation; Water, wastewater, and stormwater master planning should be linked to land use planning, using sustainability principles and locally adopted goals.
- Application of usage types and density should be determined and limited in the watershed plans. This regulation in most of the proposed basin plans has been emphasized;
- The issue of water resource management and protection in the administrative planning process should be prioritized. It will be possible by propper water acts and policy in Turkey.

8.2.7 Solving economic and budget problems

- It may be possible to develop an economic resource for the people living in water basins within the principle of sustainability. For example, it is an economic resource for forest villagers to collect and sell non-wood forest

products where they live. Planning such resources in the basins and contributing to the society as financial income can be considered;

- For the creation of alternative funding sources, "polluter pays principle" applications can be developed. Especially in Turkey, it seems much more practical to prevent water pollution;
- An ecosystem services approach should be adopted that needs related analytical researches on the basins ecosystem values;
- Some economic activities may be introduced. For example, recreational activities, eco-tourism, camping with daily use utilities, etc.;
- The holistic approach in management and planning can help the economy in the area. Analysis of the economic situation in each water basin is an essential part of the site assessment. In 2017, the Basin Protection action plan for Kartalkaya dam lake was prepared by the Ministry of Agriculture and Forestry (General Directorate of Water Management) with socio-economic evaluations.

8.2.8 Solving management and implementation problems

- Ecologically based solutions should be applied rather than only mechanical solutions as a requirement for sustainable solutions. The powerful institutions that have a say should be coordinated with the disciples having an ecology understanding;
- Multi-layer and multi-actor planning and management practices need to be developed. Basin management commissions can be considered as a good start at this point. In Turkey, multi-actor management has been applying. For example, the urban water resources are managed by the municipal institutions, and the regional water resources are under the supervision of the upper organization and ministry. However, it may lead to complexity in planning and management approaches;
- The experience and modifications gained in this area should be expanded in all institutions related to water resources management. Besides, under the conditions provided by stakeholders' participation in basin management, basic policies and strategies should be determined, and red lines related to the relevant water source should be defined;

- An effective governance and participation mechanism, parallel applications, basin-based management are needed. Incentives and encourage programs should be defined to the residents living in the water areas for following the rules. In most watershed e planning in Tukey, diverse restrictions on the land and water uses are defined. For example, the farming has been limited in Istanbul water basins without specifying any other economic sources or incentives to be replaced. Thus it has caused issues and challenges over plan implementation.

8.2.9 Improving the social life in water basins

- Social life should be conducted in a way that does not spoil the structure of the water basins. Apart from this, new social areas should be developed and planned for society so that it does not harm the water resources. For example, green places and recreational activities within the city should be increased, with less pressure in the basins;
- Environmentally friendly approaches should be implemented by keeping the construction to a minimum. Much more attention should be paid to the upper basins, and social activities should be distributed all around the area in a controlled manner not to deteriorate the land use;
- Alternative opportunities can be created with different activities such as ecotourism, recreation, etc., that will increase users' interaction with nature;
- Social infrastructure and transportation systems should be strengthened. The migration movement towards the city should be controlled following the water resource protection;
- The socio-ecological models in watershed management can be applied, and the social impact of the activities should be examined besides the ecological impact. It needs various experts' cooperation in the basin plan preparation in Turkey.

The water management systems in Turkey is continuedly under changes and modifications. The responsibilities, related organizations, decision committees, regulatory structures, and management approaches are still unstable. For example, the basin-related management committees, duties, procedures, and principles were restructured in 2012 (Url-1), 2015, (Url-7), and 2019 (Url-2). Through these revisions, new responsibilities and duties are redefined.

This research has evaluated the four water resources action plans available between 2018-2019. However, it may not refer to all planning acts of water resources in Turkey. Some basin protection plans like Kartalkaya basin-dam in Kahramanmaraş (not evaluated in the study) prepared late are much more complete in land use studies and socio-economic analysis.

Furthermore, the basin plan preparation process may differ based on its condition, allocated budget, and other issues. Thus, the survey of a few watershed protection action plans may not cover all aspects and issues as to the water basin planning approach in Turkey. However, these assessments and suggestions can help Turkey toward holistic modifications in water resource development and protection.

8.3 Challenges of the Research

One of the primary challenges during the thesis has been the data collection about the existing management and planning structure in Turkey. The institutional system of water management in Turkey is too complicated. The responsibilities have been shared among various sectors and organizations.

The institutions and authorities are still under change, which has made the water management systems unstable. It was not easy to fully understand the water-related actions, initiatives, and official framework. Therefore, in this research, the finalized documents and reports available through the ministries' websites could have been utilized.

The other issue has been about the connection with the water institutions requiring bureaucratic process. Meeting with the responsible persons has not been an easy task. The meeting time was too limited, and sometimes they were not aware of the management details, and the planning process and the reconnection looked impossible. Therefore, it did not become possible for their invitations into the thesis-related meetings.

8.4 Next Step

The water resources plans proposed for the basin management and protection can be assessed using the sustainability principles. The further steps toward the issue can be evaluating the alternative plans based on the model suggested in this research.

In this way, the model applicability and its drawbacks will be identified. Thus, future studies may lead to developing and completing the model according to new findings and projects.

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APPENDICES

APPENDIX A: Tables
APPENDIX B: Questionaire Form

APPENDIX A: Tables

Table A.1 : The provisions related to *the ecological dimension* defined in the Environment and Protection Plans of Gordes Dam-Lake.

Plans	Water Sources	Other Natural Sources (soil, forest, & air)	Ecosystem function & Biodiversity	Natural hazards & Climate Change	Ecological Health
Environment Plan	-Balanced use of water resources. -Protection of the surrounding environment of the wells in the distances specified by the relevant regulations. -Protection of the dams used for irrigation & drinking water; Protection of water basin, drinking water belts & groundwater resources. -Protection of the surface water exceeding the basin boundary by the relevant administration.	-Protection of the natural characteristics of rocky & stony areas within the borders of this plan. -In all forest areas, the implication following the Forest Law.	-Protection of the sensitive ecology identified by national & international regulation. -Protection of the areas rich in flora & fauna.	-Applying the relevant regulation against floods; Assessment of disaster risk through planning; Not allowance to structures around the river & stream beds until completion of the flood prevention works. -Development of structures against flooding in the plans ;Provide regulations on technical procedures for disposal of wastewaters.	-Pollution prevention & measures in the basin by the relevant administration before the approval of the plan. -The transition of the wastewater to collective treatment systems throughout the integrated projects; Regular collection & storage of solid waste.
Protection Plan	-Protection of groundwater in the basin following the regulations against pollution & degradation.	The implication of erosion reduction methods throughout the basin; Not allowing sand & gravel to be removed from the dam-lake or dry streams within the first 1000 meters of the maximum water elevation; The measure of natural vegetation to prevent soil erosion on the buffer strip of the dam-lake.	Not allowing floor screening in except for sluice & benthic cleaning; Not allowing scaffolding in the reservoir except temporary scaffolding for sports purposes; Requiring a wire fence in some areas of the buffer strip of the water resource.		No discharge of factories blackwater into basin; Harvesting existing in-water plants at regular intervals in the dam-lake; Construction of treatment & sewage system simultaneously; Disposing of solid animal wastes or use them as fertilizer; Rehabilitation of all irregular waste landfills; Not allowance to all types of solid & hazardous wastes to be dumped on the basin; Not dispose of waste waste water in the lake and streams feeding the lake.

Table A.2 : The provisions related to *the physical dimension* defined in the Environment and Protection Plans of Gordes Dam-Lake.

Plans	Infrastructure & Utilities	Transport & logistics	Historical Values	Land Uses				
				Settlment areas	Agricultural areas	Industrial areas	Com. areas	Recreational areas
Environment Plan	-Improvement of the infrastructure for all urban & rural settlements within the drinking water protection zones. -Providing functional distribution of social & technical infrastructure in sub-scale plans.	-Except for the transportation infrastructure processed according to the institutional views, the railway, highway routes, &pier proposed by this plan are schematic. -Protection of the existing transport routes in the dam sites.	-Protection of the archaeological& historical sites. -Preparing zoning plans where protection status is changed.	-Evaluation of the population in the protection areas indicated as settlement areas. -Finalizing the boundaries of the rural settlement units in the sub-scale plans. -Providing sub-scale plans for the graveyards of settlement areas. -Local development plans before the approval date of this plan, are valid. -Not allowing the extensions that may bring density increase after this plan approval.	-Not including greenhouses in the agricultural areas. -Not turning agricultural structures for any other uses.	-The industry's construction conditions in the urban settelments proposed by zoning plans before this plan are valid.		-Including facilities such as shower, WC, eating, drinking, & sports facilities in recreational areas. -Determining construction conditions in the sub-scale plans in line with the relevant regulations. -Arrangement of the areas that are not suitable as recreational areas in sub-scale plans.

Table A.2 (Continued): The provisions related to *the physical dimension* defined in the Environment and Protection Plans of Gordes Dam-Lake.

Plans	Infrastructure & Utilities	Transport & logistics	Historical Values	Land Uses				
				Settlment areas	Agricultural areas	Industrial areas	Com. al areas	Recreational areas
Protection Plan	-No new construction on the buffer strip of the dam-lake except for technical ones. -Taking into account the infrastructure requirements & population projections in the new zoning plans. -Determination of the applications for facilities on the buffer zone of dam-lake in sub-scale plans.	-No new road construction on the Buffer zones. -Carrying out the necessary disinfection procedures to prevent the transport of invasive species to the reservoir. -Preparing an emergency response plan for the contamination caused by accidents. -Collecting surface flow water arising from highways by channels & disposing outside the buffer zone. -Building structures to temporarily store dangerous wastes of traffic accidents &road walls for preventing the wastes of vehicles from reaching the lake. -Measures to prevent soil erosion from slopes & roadsides by planting on the protected areas.	-Not selling treasury land on the buffer zones of the dam-lake. -Preservation of the existing traditional texture through the sub-scale plans.	-If there are no development areas proposed in the Environmental Plan, sub-scale plans will be prepared considering the boundaries related to the settled area & its vicinity. -Meeting the settlement needs following Environmental Plan & population projections in protected areas. -The building of art structures such as bridges & culverts on the river beds.	-No agriculture & livestock activities within the 15-meter belt on the right & left shores. -Allowing registered pastures, barracks & livestock activities in the protected areas. -No new agricultural areas except for organic farming in the dam-lake protection areas.			-Forming pockets for fishing &water sports on the dam-lake buffer zones (no closer than 300 meters to the water intake structure). -Allowance to recreation places that include daily uses for public use on the buffer zones.

Table A.3 : The provisions related to *the economic and social dimension* defined in the Environment and Protection Plans of Gordes Dam-Lake

Plans	Agriculture, husbandry, &aquaculture	Industrial production & mining	Tourisim & eco-tourisim development	Energy & fuel production	Social Right &Values	Public Health	Behavior attitudes
Environment Plan	-Organic agriculture in short distance of protected belt areas. -Aquaculture in line with the regulations of the Fisheries Law, Coast Law, Environment Law, related laws & other applicable legislation.	-No chemical & metallurgical enrichment operations in long-distance protected zones. -Permits for mines that technically don't create pollution. -No quarries, mining enterprises within the basin. -No filling works in wetlands & the surrounding areas.	-Providing sub-scale plans with coastal uses & daily-tourism in a holistic manner. -Protection of traditional architectural texture in the eco-tourism area.	-Protection of energy resource areas within the framework of the Law. -Obtaining permits for renewable energy (wind, solar, geothermal, hydropower) production from the related institution. -Producing structuring decisions in thermal & electrical power plants with no contradiction of this plan principles. -The necessity of energy transmission, renewable energy generation & natural gas storage.	-Social reinforcement such as security, health, education, regional park, municipal service area, slaughterhouse covered by this plan. -Zoning plans for social infrastructure with no environmental impact assessment.		
Protection Plan	-Not allowance to animal breeding facilities & agriculture that do not meet the discharge standards in the basin. -No aquaculture within the streams feeding the reservoir in dam-lake protected zones. -Permission to the controlled grazing to meet the natural needs of the inhabitants in the area. -Allowance to animal husbandry facilities to store wastewater & solid wastes using appropriate methods. -Using animal wastes as agricultural fertilizers after they are processed. -Switching of the pressurized irrigation system at least to surface irrigation methods other than wild irrigation. -Encouraging good agriculture practices in existing agriculture areas in dam-lake protected areas.	-Need for the Ministry's approval for mining activities in areas beyond 1000 meters from the maximum water level of the dam-lake. -No permission for solution mining, chemical enrichment processes. -No allowance to the plants that produce radioactive raw materials. -Recycling of wastewater from mining activities or storing in sealed-floor ponds -No new industrial facilities in the protected areas. -Permission for the industrial facilities which do not produce hazardous wastes .	-No activity in areas below the maximum water level in the dam-lake. -No water vehicles operating with fuel other than safety & research activities in the dam-lake -Forbiddennig discharge of all kinds of wastewater from the fuel-driven vehicles into the lake. -No sportive angling, hunting, water sports & other activities closer than 300 meters to the drinking water intake.	-Fuel stations & other similar activities on existing roads may be permitted if they don't dispose of wastes &waste water in the area. -Bringing existing fuel stations into compliance with the relevant standards within one year after the approval of the Special Regulations in the area. -No new fuel stations, gas filling stations & chemical depots in the protected areas of the dam-lake. -Allowance to filling activities, fuel supply activities on condition that they meet the standards.	Public lands within the basin are subject to restrictions for protected area.		

Table A.4 : The regulations related to *the ecological dimension* defined in the Environment and Protection Plans of Ataturk Dam-Lake.

Plans	Water Sources	Other Natural Sources (soil, forest, & air)	Ecosystem function & Biodiversity	Natural hazards & Climate Change	Ecological Health
Environment Plan	Protecting drinking water& surface water resource; Balanced using of water resources; Protecting the surrounding environment of the wells to protect the groundwater resources.	Applying provisions of the protection in the natural area; Detecting of the river bank by the relevant government based on Coastal Law; Performing construction-use balance in pasture area; Protecting of forest area; Protecting of national parks, nature parks& natural monuments; Modification of national parks, natural parks, wetlands pro. Plan; Doing necessary planning decision against erosion.	Protecting environmental values; Protecting wetlands, lakes, etc., rich in flora and fauna; Protecting habitat & reproduction areas of the endangered plant or animal species.	Developing protective land-use decisions in disaster risk areas.	Pollution prevention & measures in the basin by the relevant administration, before the approval of the plan. -The transition of the wastewater to collective treatment systems throughout the integrated projects; Regular collection & storage of solid waste.
Protection Plan		Taking measures and methods the areas sensitive to the erosion throughout the basin and in dry streams; Protecting of trees and all plant species in the protected area of the lake; In the green belt, not allowing the soil erosion, weed mowing, &grazing.	Considering ecological priority in protection area; Forbidding tree cutting, touristic facilities to preventing ecological disruption; Considering 100-meter wide area around the lake as a green belt area.		Simultaneously constructing treatment & sewage systems; Not permitting the storage and disposal solid & hazardous wastes in the green belt and a close-range protected area; Not allowing excavation residues in the green belt, except the compulsory technical facilities; Removing nitrogen and phosphorus from all the liquid wastes originating from the facilities in close -range protected area; Collecting wastewater of the picnic areas in leak-proof septic tanks; Prohibiting wastewater discharge from livestock to sewerage systems; Carrying out the necessary disinfection procedures for preventing the vehicle transport; Measuring environmental pollution in organized industrial zones; Treating the wastewater to meet the discharge standards in the distant protection area.

Table A.5 : The regulations related to *the physical dimension* defined in the Environment and Protection Plans of Ataturk Dam-Lake.

Plans	Infrastructure & Utilities	Transport & logistics	Historical Values	Land Uses				
				Settlment areas	Agricultural areas	Industrial areas	Commert ial areas	Recreational areas
Environment Plan	-Establishing facilities for waste treatment by local administration. -Determining technical conditions as to structures in the sub-scale plans	-Preserving existing transportation routes remaining in the dam lake, -Determining alternative routes for existing routes, -Sending new routes plans to the ministry to be processed into the database in the digital environment.	-Protecting cultural & natural assets &landscape determined following Law of Cultural & Natural Assets Protection.	- Remaining urban & rural settlement in the reservoir, -Obtaining the opinions of the relevant institution in land use decision making, -Zoning plans in line with the principles of this plan, population & spatial development decision. -Measures to reduce the pressures of urban development in the protection area.	-Protecting of water resource & dams used for irrigation purposes; -Preventing agriculture structure except for facilities for soil protection in the protection area.	-Restricting enrichment operations in the first 3 km distance from protection belts in the long-distance protection area, -Preventing unplanned industrialization that put pressure on fertile agriculture land, -Not doing mining activities in absolute, short and medium-range protection zones of drinking water resources.		

Table A.5 (Continued): The regulations related *to the physical dimension* defined in the Environment and Protection Plans of Ataturk Dam-Lake.

Plans	Infrastructure & Utilities	Transport & logistics	Historical Values	Land Uses				
				Settlment areas	Agricultural areas	Industrial areas	Commercial areas	Recreational areas
Protection Plan	-Completing all the environmental infrastructure proposals for wastewater; -Preventing construction before wastewater infrastructure construction; - Preventing construction of detachable wastewater infrastructure in the green belt area; -Limiting the infrastructure only for soil production & irrigation in the lake green belt area and close range protection area.	-Constructing the transportation ; -related necessities following the zoning plan in the protected area. .	- Preventing any activities in areas registered as the treasury. - Preventing selling treasury land in the lake; - Preventing activity in the areas registered as the treasury.	- Preventing excavation debris & construction materials into the reservoir; - Preventing new asphalt works within the village settlement boundaries in the lake green belt; -Maintaining the modern techniques used in the existing buildings of the green belt; -Not expanding the village through a zoning plan in the green belt; -Applying close-range basin protection legislation for new development area outside the village boundary; -Not changing in the zoning of the green belt areas of the Ataturk Dam-Lake Plan.	-Not allowing livestock in the irrigation area and organized agriculture area. - allowing the livestock activities for the inhabitants need in the green belt and protection area; - Not allowing excavation residues, rubble &construction materials in the protection area.			-Monitoring water sports only for national and international competitions, -No concreting coating & the land cannot be acquired by filling process in the belt area; -No artificial beach in the lake green belt are; -Permitting the children's playgrounds, and pedestrian roads defined in the Coastal Law in the lake green belt area; -Using public useful and removable materials, and day-to-day facilities in the protection area. -Preventing tourism facilities In the protected area.

Table A.6 : The provisions related *to the socio-economic dimensions* defined in the Environment and Protection Plans of Ataturk Dam-Lake.

Plans	Economic Dimension				Social dimention		
	Agriculture, Husbandry, Aquaculture	**Industrial production & mining**	**Tourisim Development**	**Energy & fuel production**	**Social Right Values**	**Public health**	**Behavior**
Environment Plan	-Protecting of irrigation areas, agricultural areas, & agriculture soils having an important share in crop production; -Priority to closed sys. in the new irrigation system; -Using biotechnical methods rather than using pesticides; -doing organic farming practices in the basin; -Selecting plant species with high economic value in agriculture.	-Controlling Environmental impact of existing industries; -Not removing the mines which were determined pollution-free and suitable; -Not polluting during the mining activities in long-distance protection zones.	-Building pier and fishing shelters for fishing & tourism following permissions of the authorized institution; -Complying land-use decisions with the sub-scale plans regarding the Tourism Incentive Law.	-Protecting & using energy resource areas in accordance with the relevant legislation; -Supporting the use of renewable natural energy sources such as wind, solar and geothermal in infrastructure investments, agriculture & tourism sectors			
Protection Plan	-Starting good agricultural practices in the protected areas; -Selecting plant species suitable for agriculture & organic farming; -Obliging use of the wastewater generated by animal husbandry in agriculture; -Using the animal wastes throughout in agriculture according; -Controlling grazing according to the number of animals needed for the population; -Allowing animal husbandry with integrated facilities & composting of animal wastes in the distant protection area.	-Not allowing new industry, enterprises & not increasing production capacity of the existing industrial plants in close range protection area; -Determining only small industries in the environment plan in distant protection areas; -Not mineral enrichment plant by chemical decomposers; -Establishing only new industries that produce domestic wastewater or dry type, with no hazardous waste in distant protection areas; -Determining the possibility of mine exploration, by the relevant committees; -Not allowing new development in places with no implementation plan.	-Allowing ecotourism & water sports within the dam lake based on the appropriate opinion of State Hydraulic Works; -Tourism in close-protected area under specific regulation.		-Nationalization of the land under the elevation of 542,00 meters by the administration; -Discussing the need for the population of the rural settlement.		

Table A.7 : The provisions related to *the ecological dimension* defined in the Environment and Protection Plans of Elmali Dam-Lake.

Plans	Water Sources	Other Natural Sources (soil, forest, & air)	Ecosystem function & Biodiversity	Natural hazards & Climate Change	Ecological Health
Environment Plan	-Measuring to prevent re-use of the groundwater resources by the relevant administration; -Legislation on the protection &control of drinking water basins; -Controlling water collecting & infiltration in water basins; -Preserving rich water resources.	-Avoiding the negative development in the protected area; -Using forests with low carrying capacity just for scientific purposes; -Protecting existing trees & integrity of the tree-free areas with forestry area by afforestation; -Carrying out scientific activities in the field of arboretum based on Forest Law -Protecting pastures in rural areas; - Conducting forestation of cadastral gaps in forests.	-Integrating natural & rural character of the ecological corridors between basins &dams of Istanbul, & the mobility of wildlife; -Keeping low the density of urban buildings in sub-scale plans, where the ecological' corridors reach the urban area; -Using biological resources in a sustainable manner with the balance of conservation & use; -Preserving the geological & geomorphological diversity of the basin; -Preserving biological diversity including endemic species.	-Constructing boundaries of the geological, hydrological, seismicity-induced potential hazard areas & erosion, fire-sensitive areas & areas at risk for natural disasters, primarily earthquakes, by the relevant institution; -Carrying out detailed risk & disaster management studies by the relevant organizations; -Making an emergency transport network associated with disaster management centers, immediately after the emergence of the disaster, to make emergency operations effective, fast and efficient; -Creating green areas, parks, recreation areas, sports areas, etc. which will be used as local evacuation areas & gathering places to reduce disaster damage; -Not allowing fire, explosion & hazardous uses in places with risk of disaster .	-Measuring for irregular storage area where wastewater used or untreated is discharged in sub-scale plans.

Table A.7 (Continued) : The provisions related *to the ecological dimension* defined in the Environment and Protection Plans of Elmali Dam-Lake.

Plans	Water Sources	Other Natural Sources (soil, forest, & air)	Ecosystem function & Biodiversity	Natural hazards & Climate Change	Ecological Health
Environment Plan	-Measuring to prevent re-use of the groundwater resources by the relevant administration; -Legislation on the protection &control of drinking water basins; -Controlling water collecting & infiltration in water basins; -Preserving rich water resources.	-Avoiding the negative development in the protected area; -Using forests with low carrying capacity just for scientific purposes; -Protecting existing trees & integrity of the tree-free areas with forestry area by afforestation; -Carrying out scientific activities in the field of arboretum based on Forest Law -Protecting pastures in rural areas; - Conducting forestation of cadastral gaps in forests.	-Integrating natural & rural character of the ecological corridors between basins &dams of Istanbul, & the mobility of wildlife; -Keeping low the density of urban buildings in sub-scale plans, where the ecological' corridors reach the urban area; -Using biological resources in a sustainable manner with the balance of conservation & use; -Preserving the geological & geomorphological diversity of the basin; -Preserving biological diversity including endemic species.	-Constructing boundaries of the geological, hydrological, seismicity-induced potential hazard areas & erosion, fire-sensitive areas & areas at risk for natural disasters, primarily earthquakes, by the relevant institution; -Carrying out detailed risk & disaster management studies by the relevant organizations; -Making an emergency transport network associated with disaster management centers, immediately after the emergence of the disaster, to make emergency operations effective, fast and efficient; -Creating green areas, parks, recreation areas, sports areas, etc. which will be used as local evacuation areas & gathering places to reduce disaster damage; -Not allowing fire, explosion & hazardous uses in places with risk of disaster .	-Measuring for irregular storage area where wastewater used or untreated is discharged in sub-scale plans.

Table A.8 : The provisions related to *the physical dimension* defined in the Environment and Protection Plans of Elmali Dam-Lake.

Plans	Infrastructure & Utilities	Transport & logistics	Historical Values
Environment Plan	-Using non-permanent units (beach cabins, kiosks, toilets on the beaches; -Determining the locations & capacities of the piers & marinas by the sub-plans; - Not disturbing the marinas provided by restaurants, repair places, & other facilities, as well as daily service facilities nature on the beach; -Providing technical and social infrastructure like education, health, social, cultural, administrative & sports facility areas, parks, playgrounds, electricity, gas, drinking & utility water, sewage, all kinds of transportation in urban and regional scale.	-Showing the strategic long-term transportation projects in the Plan; -Determining the main transportation system of the city within the framework of the Plan's vision, objectives, targets & strategies & sustainability principles; -Evaluating transportation system project not shown in the plan due to scale, in the sub-scale plan following the integrity & principles of the plan. -Taking appropriate measures in the logistic zones, the units that function as recycling wastes causing noise-e pollution & risk to the en. by the relevant institution.	Determining the historical & natural values remained in the short-range protection zone through a sub-scale plan; -Complying the decisions taken by the Regional Conservation Committee for archaeological, historical, mixed sites with the Supreme Council for the Protection of Cultural and Natural Asset; -Sustaining rural settlement, environmental values, and local architectural characteristics within the village settlements.
Protection Plan	-If a part of the existing facility is within the boundaries of the construction area; the remaining part is subject to the protected zone requirements; -Not allowing hard floor in the garden area outside the building area &using permeable surfaces in the lake protection area instead; Connecting discharges from accommodation facilities to the sewage system out of the basin even if the wastewater from these facilities is highly refined in the Remote Distance Protection Area.	- Carrying out the accumulation walls to prevent hazardous wastes from the vehicles carrying wastes to reach the lake in lake protection area & near distance protection area; -Preparing the emergency response plan for the pollution caused by traffic accidents on the road; -Not permitting to the construction of new roads &railways in green belt conserved areas; - Covering the road surface with permeable material that drains rainwater & exchanges the existing stabilized roads with permeable asphalt in the green belt area,& lake protected area; -Taking the necessary measures to prevent the pollution caused by the manufacturing to new road & railway from reaching the drinking water source in lake protection areas; - Constructing retaining walls and culverts to protect the existing road in the lake protection area;-Possibility to expand & modified the existing roads, new highway routes in Remote Distance Protection.	-Not selling treasury land on the buffer zones of the dam-lake. -Preservation of the existing traditional texture through the sub-scale plans.

Table A.9: The provisions related to *the land use dimension* defined in the Environment and Protection Plans of Elmali Dam-Lake.

Plans	Land Uses				
	Settlment areas	**Agricultural areas**	**Industrial areas**	**Commertial areas**	**Recreational areas**
Environment Plan	-No constructing in the basin areas; -Determining uses to be located in the forbidden areas of the basin in the sub-scale plans considering the legislation; -Carrying out detailed analyzes to identify the uses that damage the water cycle in the ground water reserve areas where the settled areas are located; Clarifying the boundaries & usage decisions of the geologically disadvantaged areas in the sub-scale plans according to the opinions of the relevant institution; -Integrating the areas subject to private ownership ecologically with the forest by afforestation, only daily recreation, camping, greenhouse & nursery activities can be performed until expropriation is made.	- Determining principles agricultural activities by the agricultural land use plan by the relevant institutions; -Determining the areas for which land consolidation activities are foreseen during agricultural planning studies; -Creating new agriculture parcels which are more functional in ecological, economic & social aspects -No husbandry in absolute protected area of drinking water basin; -In case there is no land-use plan for agriculture purposes, the maximum precedent for agricultural purposes other than the covered agriculture structures is provided as 0.10; The exact limits of the agricultural boundaries of this Plan will be determined in sub-scale plans.	Not allowing industrial activities in logistics areas.		-Determining habitat park & the daily recreation area located in the sub-scale plans with the cooperation of the relevant institution; -Day-to-day recreational use may be allowed, provided by the relevant institution that protects the forest ecosystem; -In the pasture areas may also include recreational uses within the existing urban fabric by the relevant institution; - Determination rural activities such as vineyards or farmhouses in the sub-scale plans; -Evaluation for recreation areas in subscale plans for the Istanbul's sea tourism, camping area, &sports facilities.
Protection Plan	Using a sealed septic tank for the settlement that cannot benefit from the wastewater treatment plant & collecting domestic wastewater periodically & delivered to the wastewater treatment plant; Not allowing urban function (housing, trade, services, industry, social infrastructure, etc.) except for safety & technical infrastructure in green belt areas; Not allowing a place of the cemetery in the green belt conserved area & lake protected rare; Reducing the existing construction by zoning plans in the controlled region; Gross density in development plans is 30 persons/ha in the controlled region; Designing the garden areas outside the building as permeable surfaces; Not changing repairs & modifications in use of the existing houses; Not establishing a place of residence or training place, hotels in lake protection area; Not exceeding density values given in the protection plan; Gross population density is 50 persons/ha in lake protection area (not included in the military areas & forest areas); Determining gross population density values for the various regions in the Remote Distance Protection & Short Distance Protection Area.	-No agriculture & livestock activities within the 15-meter belt on the right & left shores. -Allowing registered pastures, barracks & livestock activities in the protected areas. -No new agricultural areas except for organic farming in the dam-lake protection areas.	-Not allowing Industrial enterprises in green belt conservation areas.		Not allowing scaffolding within the reservoir in the dam lake. The temporary scaffold with permission from the administration only for sporty purposes; -Collecting wastewater of children's playground, coffee house, buffet, outdoor sports area, by daily facilities in septic tanks & transporting to the nearest treatment plant; -Using public areas for in the green belt areas & controlled area; -Not allowing universities, dormitories, guesthouses, schools, , tourism facilities in the lake pro. area, except for those with boarding qualifications, conference centers, socio-cultural facilities, family health center; -Not increasing in density in the existing built parcels in the lake protection area.

Table A.10 : The provisions related to *the economic dimension* defined in the Environment and Protection Plans of Elmali Dam-Lake.

Plans	Agriculture, husbandry, &aquaculture	Industrial production & mining	Tourisim & eco-tourisim development	Energy & fuel production
Environment Plan	-Applying organic agriculture; -Switching agriculture to organic &good agricultural practices in the basin; -Not allowing aquaculture &breeding in the streams feeding the reservoir; -Not allowing artificial wetland system into river channels; -Doing ecological farming in areas with agricultural quality; -Permitting crop production & controlled grazing in the ecological farming method in drinking water basin areas; -Increasing agricultural productivity in areas where agricultural quality will be preserved according to the agricultural land use plan; -Concentrating on in-field development services; -Performing ecological tourism with agriculture in ecologic agriculture.	-Permitting operation of mines and quarries in compliance with the provisions related to Environmental Sustainability; -Rehabilitating the expired mining areas outside the forest area; -Using appropriate research & extraction techniques in mining facilities in the regions close to the settlement area; -Not causing environmental pollution of storage & industrial buildings with the use of advanced technology in the framework of plan integrity; -Decentralizing storage & industrial buildings within the framework of an action plan for the logistics or industrial areas; -Making mining & quarry areas by a holistic planning approach; -Permitting activities that do not pose a threat to human and environmental health in the free zones; -Including productions whose types are defined in the relevant laws with no threat to human and environmental health in terms of waste.	-Leading tourism & social activity and recreation, in the Marmara Sea, as a result of scientific research; -Doing recreation & tourism areas for the protection of the natural values of Istanbul (Including ecological ecotourism); - Conducting accommodation, eating &drinking activities for ecological tourism in terms of protection of forest & drinking water basin areas.	-Building renewable energy sources (wind, solar, etc.) facilities with environmental interactions into consideration; -Defining all conveyor & conductive lines such as natural gas lines, oil pipelines, power transmission lines in sub-scale plans.
Protection Plan	-Placing the storage of fertilizers construction in agricultural activities to minimize potential pollution to the reservoir, streams, and groundwater; -Covering fertilizer stores and locating at least 30 m to water resources, & at least 100 m away from the river, creek &drainage channels; -Integrating livestock facilities with the poultry farm activities, throughout the basin in the horizontal 5 km after the Dam Lake border; -Not exceeding 1200 maximum number of bovine animals & 800 the number of sheep in over the basin; -Collecting animal wastes in closed sealed lagoons & encouragement to compost the animal wastes with package system to obtain biogas; -Not allowing livestock & grazing in green belt areas & the contorted areas; -Allowing livestock activities & controlled grazing to meet the needs of the inhabitants.	-Not being used ground & surface water for the manufacturing industry; - Continuing existing industrial plants with no wastewater; -Not establishing a new industrial plant and mines in the lake protection area; -Taking dust prevention measures for dust spreading operations such as excavation, filling, material casting, in the basin. Irrigation should be done to prevent the spreading of dust; -Not permitting for mineral exploration facilities, solution mining, mineral enrichment operations using chemical decomposers in the basin; -Not disturbing the water quality in operations mining activities and the land is returned to nature at the end of the activity; -Preventing measures for the siltation caused by the solid wastes of mining; -Not allowing solid waste in the final storage & disposal facilities at the 3 km wide horizontal distance from the border of Close Distance Protected Area.	-Not allowing tourism facilities in green belt areas & in controlled areas; -Not doing new tourism facilities in the Short Distance Protected Area except for environmentally friendly ecotourism facilities.	-Allowing the fuel station and other activities on existing new roads, if the wastewater is connected to the sewerage system in Remote Distance Protection; - Not permitting new service stations, fuel stations, fuel filling stations in basin protection area; -Adapting existing gas stations infrastructure in Remote Distance Protection; -Meeting TSE standards to the wastewater collector line by pre-treatment in the existing fuel stations.

Table A.11 : The provisions related to *the social dimension* defined in the Environment and Protection Plans of Elmali Dam-Lake.

Plans	**Social Planning**		
	Social Right &Values	Public Health	Behvior attitudes
Environment Plan	-Protecting the ecological characteristics of the shores by taking advantage of the public interest in making use of the lakes, sea and river shores & the coastal lanes surrounding these shores.		
Protection Plan	-Balanced distributing of the social & technical infrastructure areas as the basis for the zoning plans to control the population's pressure on the Lake Green Belt Area. -Public lands located in the basin are also subject to restrictions set for protected areas. -Nationalizing all immovable property & private property in the green belt pro. ar. -Allowing the real & legal persons &organizations having permission to establish a hosting or training place as a hotel. to dispose of the wastewater in accordance with the Reg. to the sewer system or to carry it to a suitable discharge point by the vacuum truck.		

Table A.12 : The provisions related to *the ecological dimension* defined in the Environment and Protection Plans of Buyukcekmece Dam-Lake.

Plans	Water Sources	Other Natural Sources (soil, forest, & air)	Ecosystem function & Biodiversity	Natural hazards & Climate Change	Ecological Health
Environment Plan	This part is the same as strategies defined for Environmet Plan of Elmali dam lake, as they both are located in Istanbul.		.		
Protection Plan	-Cleaning the in-water plants available at the lake in such a way as to positively affect the water quality; -Not allowing water transportation on the lake. However, in compulsory cases like security, or for research purposes, the generated waste cannot be discharged to the lake; -Not allowing scaffolding in the reservoir. Only temporary scaffolding is allowed to be removed and installed; - Growing bush-type plants grown in the region or plant species with suitable propagation characteristics to improve the quality of surface water flowing from agricultural land; -Not allowing aquaculture in the streams feeding the reservoir.	-Taking the methods to reduce erosion in the basin; -Protecting trees & all plant species with their natural environment; -Preserving existing forest area in & not allowing the activities that cause shrinking forest areas in the protected zones; -Carrying out silviculture & technical forestry activities in forest management plans in accordance with the relevant principals of the Forest Law.	-Restoring habitats in the green belts with plant species that can grow in the degraded habitats; -Protecting existing forest area in areas with important ecosystem service.		-Protecting Groundwater in the basin under the" Regulation on the Protection of Groundwater Against Contamination & Degradation; -Transfering the wastewater from existing industrial facilities out of the basin; -Even if treated, not allowing direct wastewater discharge to the reservoir; -Revising wastewater treatment system to ensure nitrogen & phosphorus removal, to the disposal of domestic wastewater in the basin; -Not allowing to all kinds of waste, storage, processing & disposal of waste other than excavation waste in the basin; -Allowing excavation wastes, debris, and construction material spill in the basin under the Regulation; -Rorbiddening to discard any kind of waste in the reservoir; -Connecting wastewater from existing structures to the sewage system in the protected area; -Not installing radioactive raw material processing, generating & radioactive waste facilities in the basin; -Discharging the wastewater generated from non-residential buildings & poultry house, barn, warehouses, grain storages, manure and silage pits, be in accordance with the relevant discharge standards in the far-distance protect.

Table A.13 : The provisions related to *the physical dimension* defined in the Environment and Protection Plans of Buyukcekmece Dam-Lake.

Plans	Infrastructure & Utilities	Transport & logistics	Historical Values
Environment Plan	-Using non-permanent units (beach cabins, kiosks, toilets on the beaches; -Determining the locations & capacities of the piers & marinas by the sub-plans; - Not disturbing the marinas provided by restaurants, repair places, & other facilities, as well as daily service facilities nature on the beach; -Providing technical and social infrastructure like education, health, social, cultural, administrative & sports facility areas, parks, playgrounds, electricity, gas, drinking & utility water, sewage, all kinds of transportation on urban and regional scale.	-Showing the strategic long-term transportation projects in the Plan; -Determining the main transportation system of the city within the framework of the Plan's vision, objectives, targets & strategies & sustainability principles; -Evaluating transportation system project not shown in the plan due to scale, in the sub-scale plan following the integrity & principles of the plan. -Taking appropriate measures in the logistic zones, the units that function as recycling wastes causing noise-e pollution & risk to the en. by the relevant institution.	Determining the historical & natural values remained in the short-range protection zone through a sub-scale plan; -Complying the decisions taken by the Regional - Conservation Committee for archaeological, historical, mixed sites with the Supreme Council for the Protection of Cultural and Natural Assets; -Sustaining rural settlement, environmental values, and local architectural characteristics within the village settlements.
Protection Plan	-Maintaining & rebuilding existing structures in protected areas of the basin; -Carrying out environmental infrastructure measures in sub-basin by İSKİ; -Carrying out wastewater infrastructure works before taking the construction licenses.	-Passing surface waters of the highways through the filtration system to the receiving environment; -In the case of existing & new logistics areas, open parking areas, etc., not connecting the surface flow water to the sewer system; -Not allowing new roads in lake protected zone & not allowing new truck park areas, carwash,oil change, etc. activities in the existing logistics; -Making renovation & road expansion works on existing roads in line with the appropriate opinion of the administration; -Taking measures to prevent soil erosion caused by slopes & road edges like afforestation with species suitable for a catchment in lake protection area; -Making plantation and afforestation for filtration along the existing roads & for the control of the contamination of the surface flow by traffic; -Establishing temporary storage of hazardous wastes posed by traffic accidents on roads in accordance with the legislation; -Establishment of net walls in order to prevent hazardous waste reaching the lake from the vehicles; Making an emergency response plan in case of contamination due to accidents in the lake protected area.	-Protecting cultural heritage & local architectural style based on rural sustainability; -Not allowing activities & sales of these lands in the lands registered in the name of the Treasury.

Table A.14 : The provisions related to *the land use dimension* (physical dmension) defined in the Environment and Protection Plans of Buyukcekmece Dam-Lake.

Plans	Land Uses				
	Settlment areas	**Agricultural areas**	**Industrial areas**	**Com.areas**	**Recreational areas**
Environment Plan	No constructing in the basin areas; Determining uses to be located in the forbidden areas of the basin in the sub-scale plans considering the legislation; Carrying out detailed analyzes to identify the uses that damage the water cycle in the ground water reserve areas where the settled areas are located; Clarifying the boundaries & usage decisions of the geologically disadvantaged areas in the sub-scale plans according to the opinions of the relevant institution; Integrating the areas subject to private ownership ecologically with the forest by afforestation, only daily recreation, camping, greenhouse & nursery activities can be performed until expropriation is made.	Determining principles agricultural activities by the agricultural land use plan by the relevant institutions; Determining the areas for which land consolidation activities are foreseen during agricultural planning studies; Creating new agriculture parcels which are more functional in ecological, economic & social aspects; No husbandry in absolute protected area of drinking water basin; In case there is no land-use plan for agriculture purposes, the maximum precedent for agricultural purposes other than the covered agriculture structures is provided as 0.10; The exact limits of the agricultural boundaries of this Plan will be determined in sub-scale plans.	Not allowing industrial activities in logistics areas.		Determining habitat park & the daily recreation area located in the sub-scale plans with the cooperation of the relevant institution; Day-to-day recreational use may be allowed, provided by the relevant institution that protects the forest ecosystem; In the pasture areas may also include recreational uses within the existing urban fabric by the relevant institution; Determination rural activities such as vineyards or farmhouses in the sub-scale plans; Evaluation for recreation areas in subscale plans for the Istanbul's sea tourism, camping area, &sports facilities.
Protection Plan	Encouraging environmentally sensitive settlement design principles to be implemented throughout the basin; Carrying out all kinds of construction in planned areas according to zoning legislation; In the areas where there is no development plan, the construction is not allowed without preparing the zoning plan; Not allowing structures in the lake protection area except for the environmentally required facilities; Not allowing new settlement areas other than the existing settlements in the basin; Not allowing new settlement less than 10.000 m2 except for the areas where the settlement is permitted in the basin;Covering the settlement surface with the permeable material in the protected area.	Carrying out agricultural purposes in agricultural areas, not in residential areas based on the zoning plan; Not exceeding the total covered area in agricultural land from 150 square meters except for absolute agricultural lands, special product lands, planted farmland, and irrigated farmland defined in Land Use Law in short-distance protection; Not allowing animals grazing in the protected area.	Allowing the small industrial site determined in the zoning plan decisions in the remote-distance protected area and transferring the non-domestic wastewater from these industrial sites out of the basin.		Permitting only recreation or day-to-day use in the public areas such as temporary coffee, buffet, outdoor sports areas, green areas, children's playground in short-distance protected area & the lake protected zone; Not exceeding the total area of the closed parts of the permissible structures 100m2 in short-distance protection areas; Forming the porous coating material to leak the rainwater directly to the soil in the children's playground & the walking track; Collecting the wastewater from the Recreational structures in sealed septic tanks & transport to the nearest treatment plant in short-distance protected area; Not allowing activities such as swimming in the lake or angling at a distance of fewer than 300 m in the green belt area. Not fishing in the dam lake; Allowing to just for hobby orchards, children's playground, walking track & day-use facilities.

Table A.15 : The provisions related to *the socio- economic dimension* in the Environment and Plan of Buyukcekmece Dam-Lake.

Plans	Agriculture, husbandry, &aquaculture	Industrial production & mining	Tourisim & eco-tourisim development	Energy & fuel production	Social Right &Values	Public Health	Behvior attitudes
Environment Plan	-Applying organic agriculture; -Switching agriculture to organic &good agricultural practices in the basin; -Not allowing aquaculture &breeding in the streams feeding the reservoir; -Not allowing artificial wetland system into river channels; -Doing ecological farming in areas with agricultural quality; -Permitting crop production & controlled grazing in the ecological farming method in drinking water basin areas; -Increasing agricultural productivity in areas where agricultural quality will be preserved according to the agricultural land use plan; -Concentrating on in-field development services; -Performing ecological tourism with agriculture in ecologic agriculture.	-Permitting operation of mines and quarries in compliance with the provisions related to Environmental Sustainability; -Rehabilitating the expired mining areas outside the forest area; -Using appropriate research & extraction techniques in mining facilities in the regions close to the settlement area; -Not causing environmental pollution of storage & industrial buildings with the use of advanced technology in the framework of plan integrity; -Decentralizing storage & industrial buildings within the framework of an action plan for the logistics or industrial areas; -Making mining & quarry areas by a holistic planning approach; -Permitting activities that do not pose a threat to human and environmental health in the free zones; -Including productions whose types are defined in the relevant laws with no threat to human and environmental health in terms of waste.	-Leading tourism & social activity and recreation, in the Marmara Sea, as a result of scientific research; -Doing recreation & tourism areas for the protection of the natural values of Istanbul (Including ecological ecotourism); - Conducting accommodation, eating &drinking activities for ecological tourism in terms of protection of forest & drinking water basin areas.	-Building renewable energy sources (wind, solar, etc.) facilities with environmental interactions into consideration; -Defining all conveyor & conductive lines such as natural gas lines, oil pipelines, power transmission lines in sub-scale plans.	-Protecting the ecological characteristics of the shores by taking advantage of the public interest in making use of the lakes, sea and river shores & the coastal lanes surrounding these shores.		

Table A.16 : The provisions related to *the socio- economic dimension* in the Protection Plan of Buyukcekmece Dam-Lake.

Plans	Agriculture, husbandry, &aquaculture	Industrial production & mining	Tourisim & eco-tourisim development	Energy production	Social Right &Values	Public Health	Behvior attitudes
Protection Plan	-Using biological control & biotechnical methods instead of the use of pesticides; -Constructing agricultural preparation stations for agricultural purposes by İSKİ in the basin. No permission for the preparation of pesticides other than agricultural preparation stations; -Introducing pressurized irrigation systems in irrigated areas within 5 years; -Giving priority to supporting organic agriculture in the basin in line with the opinions of the Directorate of Agriculture and Forestry -Being mandatory of good agricultural practices; -Encouraging organic farming practice; -Man. of herbal waste originating from the greenhouses in the basin in line with the views of the Provincial Directorate of Agri.& F. & the Provincial Directorate of Environment and Urbanization; -Allowing animal husbandry activities to meet the needs of the inhabitants in short –distance; -Improvement & use of pasture areas in the basin; -Up to 16000 cattle, 36000 sheep & 10000 poultry can be grown in the basin; -No new commercial or integrated scale livestock facilities except for the requirements of existing facilities; -Carrying out all livestock activities in the basin according to Good Agriculture Implementation.		-No new industrial facilities except for the small Indust. Sites determined in the Environment Plan & development plan decisions; -Collecting disposed wastes of industrial & hazardous waste in sewage sys. or in leaky septic tanks to be discharged at regular intervals to treatment systems in the aviation enterprise area, located in the green bond area, & near- distance protection areas; -The recovery of lands damaged by mining activities in the watershed abandoned mining sites, landscaping with appropriate local species in these rehabilitated areas in ISKI management; -No solution mining, chemical and metallurgical enrichment processes in the basin; -Not allowing sand quarry to remove sand & gravel from the streams in the basin; -No mining activities & excavation in the lake protected area in short distance protected area.	-Not permitting fuel and/or gas filling stations in the protected lake & short -distance protection area.		- In the basin, lands belonging to the state, municipalities, public, legal persons, or persons are subject to protected areas.	

Table A.17 : The provisions related to *the ecological dimension* defined in the Environment and Protection Plans of Melen Dam-Lake.

Plans	Water Sources	Other Natural Sources (soil, forest, & air)	Ecosystem function & Biodiversity	Natural hazards & Climate Change	Ecological Health
Environment Plan	-Protecting the water resources used for drinking water and irrigation in agriculture; -No building permission without stream improvement; -No construction, including the road in the vicinity underground water resource (less than 50.00 m).	-Protecting National parks, nture parks, waterfalls, sites, mounds, highlands, lake environments, winter tourism areas, and so on; -Not performing activities in forest areas, except afforestation & cutting activities by the Ministry in Medium Distance Protection Area; -Applying erosion reduction projects in Short- Range Protection Area; -Protecting the areas designated as forest area; -Ranging land following Pasture Law & related regulation.	-Not changing the upper boundary of the slope or cliff if the land is acquired by filling.	-Complying the conditions of flood area boundaries with implementation provisions determined by the Ministry of Energy & Natural Resources, General Directorate of State Hydraulic Works & the relevant Regional Directorate in sub-scale plans; -Not changing the creek banks in Short-Range Protected Area to prevent flooding.	-Not wastewater & waste discharging to all waters, flow &dry streams feeding the drinking water reservoir; -Connecting sewerage network to a wastewater treatment system in an existing settlement in forest area, in Medium, Short, and Absolute Conservation Area; -Not storing liquid & s.waste in Short- Range Protected Area; -Legal & technical arrangements to eliminate solid waste in a way that does not cause water pollution in Medium Distance Protected Area; -Not using trash &debris in Medium Distance Protected Area; -Carrying out liquid & solid waste landfills under the relevant legislation in Medium Distance Protected Area; -Installing the wastewater treatment system for the sewage of tourist facilities, public education & facilities &collective housing settlement -Not direct discharging of domestic & industrial wastewater into stream beds; -Not connecting the sewage pits to drains or streams; -Collecting solid wastes &treatment sludges regularly; -Removing the structures & facilities causing pollution.

Table A.17 (continued) : The provisions related to *the ecological dimension* defined in the Environment and Protection Plans of Melen Dam-Lake.

Plans	Water Sources	Other Natural Sources (soil, forest, & air)	Ecosystem function & Biodiversity	Natural hazards & Climate Change	Ecological Health
Protection Plan	-Not changing of the beds' streams like filling & excavation, concreted except for the basin works carried out considering cadastral boundaries; -Application of filtration strip in 10 meters of the right and left sides of the streams outside the forest area in the areas of the Basin Protected Area having alluvial features; -Not allowing water wells in the protected area.	-Not allowing any activities to reduce forest areas; -Doing silvicultural & technical forestry activities foreseen in forest management plans; -Forest rehabilitating in public land especially, if it is not built for agricultural purposes; -Supporting afforestation of Dam Lake in the area that lost their forest quality; -Maintaining old forests without artificial fertilizers and pesticides in the Green Belt Area; -Preserving forest area & natural vegetation in the Red Area and the Orange Area; -Measures to prevent soil erosion from slopes within one year in the Red Area & within two years in the Orange Area".	-Not scaning the basin except for benthic cleaning in Dam Lake Conservation Area; -Not taking sand & gravel from the dam lake consevation area & similar materials in the Orange Area. -Requiring a wire fence in some areas of the buffer strip of the water resource.		-Not allowing direct discharge of wastewater into the g.w. & the streams; -Measuring the contamination of g.& surface w.r during the activities; -Not allowing solid waste landfill facilities in alluvium environment & areas of limestone sediments; -Not spilling hazardous waste, garbage, excavation residues, rubble material in the stream; -Applying discharge standards for domestic & industry wastewater in the settlement in the basin. -Taking the measures of point & spread pollution with the purpose of prevention of eutrophication. -Creating an artificial wetland to reduce the pollution loads from another basin; -Collecting domestic wastewaters from existing structures in leak-proof septic tanks, in the green belt conservation area and red area; -Not being allowed solid waste storage sites & disposal stations in green belt conservation Area & Red areas; & Rehabilitating the existing irregular storage areas; -Not allowing to store debris in Red and Orange areas; -Collecting the wastewater from the resource structures in leak-proof septic tanks &transported to the nearest wastewater treatment plant in the green belt; -Preventive measuring for the siltation caused by the solid wastes of the mining & to limit the dust formation in the quarrying; -Not using water transport vehicles operated by fuel in the reservoir; -Forbidding discharge any wastewater occurring in the vehicles to be used in the dam lake even after purification.

Table A.18 : The provisions related to *the physical dimension* defined in the Environment and Protection Plans of Melen Dam-Lake.

Plans	Infrastructure & Utilities	Transport & logistics	Historical Values
Environment Plan	-Improving the infrastructure of all urban and rural settlement; -No buildings, except for the compulsory technical facilities for the drinking water project &the sewage system of existing structures In the Absolute Conservation Area; -Establishing facilities for improving agriculture & livestock activities in the rural settlement; -Determining structuring conditions educational facilities, health facilities, public institution ar., transformers & social & technical infrastructure in sub-scale plans in Long Range Protected Area; -Mandatory technical facilities for the drinking water project for the existing structures in Medium Distance Protected Area.	-No constructing even roads in areas within the maximum water elevation; -Meeting the standards given by the relevant administration for the existing or re-opened roads drained to the rivers in the zoning plans of Short- Range Protected Area.	-Protecting all-natural & cultural values that exist in the plan; -Preserving natural, cultural, and historical identities in accordance with the Law by associated regulation.
Protection Plan	-Not allowing new animal breeding & agriculture facilities in the basin which do not meet the discharge standards.; -Not allowing scaffolding within the dam lake Conservation Area The temporary pier can only be installed with the permission of the administration.	-Taking the measures during the trans. of hazardous substances through the highways in the basin, to prevent the contamination of groundwater & surface water in accordance with the emergency action plan; Forming informative roadside signs by the Adm. where the basin boundary intersect with highways; Not creating new impermeable surface & new road construction in Green belt Conservation Area, but maintenance on existing roads; Ensuring that the surface water flowing from the roads passing through Green belt Conservation Area is collect by channel & passed through a filtration strip or into the soil; Storing hazardous wastes as a result of accidents that can reach the lake by the administration. In case of contamination due to accidents, the emergency response plan is prepared within one year; Using lock parquet (hardwood) & stone that drain rainwater as a coating material in the existing road in the Red Area; Leading repair work on existing roads with no effect on water quality and quantity in the Red and Orange Areas & basin protection area; In the Red areas, new roads just as an alternative for the routs under the maximum level of water & for central social areas & agricultural activities with stabilized or compressed soil; Having the sediment walls to prevent the transportation of hazardous waste against possible accidents to the lake in the orange areas.	-Not selling treasury land in the Green Belt Conservation Area.

Table A.19 : The provisions related to the *land use dimension* defined in the Environment and Protection Plans of Melen Dam-Lake.

Plans	Land Uses				
	Settlment areas	**Agricultural areas**	**Industrial areas**	**Commertial areas**	**Recreational areas**
Environment Plan	-Not opening the slopes of more than 25% to urban development except in case of disasters, national infrastructure investments; -Determining of structuring conditions in the areas defined as urban settlement area & residential area in sub-scale plans In Long Range Protected Area; -Freezing the rural settlement, residential buildings, public institution, industrial facilities, etc. remaining in an urban settlement in Short- Range Pro. Area &in Medium Distance Protected Area (Modification may be allowed with no change in the purpose of use); -Removing scattered structures outside the urban & rural residential areas; -Preserving existing structures located in urban & rural settlement In the basin Conserved area; -Not planning new construction area in the basin Conserved Area; -In practice, providing the integrity of the uses specified in this plan within the relevant institution's framework.	-Allowing non-integrated agriculture to meet the needs of resident populations in Medium Distance Protected Area.	-Prohibiting industrial, residential & tourism settlements in Short-Range Protection Area, & in Medium Distance Protection Area; -Making vineyard or cottage in Medium Distance Protection Area; -Rehabilitating the existing industrial area & small industrial sites.	-Supporting uses for the service sector; -Determining structuring conditions commercial areas, in sub-scale plans in Long-Range Protection Area.	-Forming pockets for the benefit of the lake, picnic, swimming, fishing, and hunting needs In the Absolute Conservation Area (no closer than 300 meters to the water intake structure). These pockets are determined in sub-scale plans; -Permitting recreation & picnic facilities in Short- Range Protected Area.

Table A.19 (Continued) : The provisions related to the *land use dimension* defined in the Environment and Protection Plans of Melen Dam-Lake.

Plans	Land Uses				
	Settlment areas	**Agricultural areas**	**Industrial areas**	**Commertial areas**	**Recreational areas**
Protection Plan	-Protecting the neighborhood having the status of rural settlement as settlement boundary of the village-built area the Red and Orange area; -The maximum building height is 6.50 meters and the maximum building floor area is 150m2 in the Red area & Orange area; -Removing the existing building that repair is not possible to them, without causing any pollution and to replace without a change in use propose, & density increase; -Constructing new structure compatible with the current plan intensity in the Orange area within the established area boundaries; -Not building less than 10,000 m2 outside the settlement boundaries in the Orange area; -Not expanding building boundary by making zoning plans in the Red area & the density not exceed 5 persons/ha in the settlement area of Red area, 10 persons/ha in Orange area, &20 persons / haktar in the Basin Protection Area.	-Not allowing resettlement in agricultural land of Red areas but only detachable structures only -Not allowing new agricultural areas in the Red &Orange areas -Not permitting livestock activities in the Green Belt Conservation area.	-In the Purple area, permitting new industrial facilities on condition that they do not produce &store hazardous waste; -Not allowing new industrial establishments, in Dam-Lake Green Belt protected& Red area; -Not allowing mining in the surface & underground in Green Belt Conservation. & Red Areas area just rehabilitation the existing enterprises with the relevant regulations; - No mining using enrichment operations, solution mining, &chemical decomposers throughout the basin.		-Allowing applications for the structures &facilities such as daily use, public, transient, wild coffeehouse, buffet, picnic units, just on the forest passage of four determined areas in the sub-scale plans under the Recreation Area Regulation. -Allowing the sportive purpose, fishing, water sports & so on in Dam Lake Conservation Area, just not less than 300 meters from the point of receiving drinking water; -Allowing vehicles & sails running on sailboats, paddles, or accumulators within the Dam Lake Conservation Area. -Creating Pockets in the Green Belt area, as a permanent facility for angling & water sports, only not less than 300 meters from the water intake structure.

Table A.20 : The provisions related to *the economic dimension* defined in the Environment and Protection Plans of Melen Lake.

Plans	Agriculture, husbandry, & aquaculture	Industrial production & mining	Tourisim & eco-tourisim development	Energy & fuel production
Environment Plan	Doing controlled grazing & natural methods of agriculture & fruit growing under the control of the Ministry of Food in Short- Range Protected Area & in the Absolute Conserved Area; Applying the Regulation on Soil Pollution Control to agricultural lands in Short- Range Protection Area; Not using artificial fertilizers & pesticides in medium and short distance protected area &in the Absolute Conserved Area; Possibility of agriculture & fruit growing by natural methods in the Absolute Conserved Area; Protecting agricultural soils & aquaculture production sites having an important share in crop production.	Determining structuring conditions in small industrial areas, tourism facility areas, in sub-scale plans In Long Range Protected Area; Not allowing repairs or add-ons in the industrial facilities in the Absolute Conserved Area; Not allowing new mining facilities &quarries in Short- Range and Absolute Protected Area; Not allowing excavations except for the technical infrastructure requirement in Short- Range Protected Area.	Evaluating the existing tourist facilities within the scope of the legislation; Complying the tourism investment & enterprises with this plan scope and regulation.	Not allowing service stations, fuel filling, and LPG supply /filling stations in Karstic aquifer and limestone areas; -Not allowing LPG filling stations & chemical storage tanks, service stations, fuel filling stations in the green belt, Red & Orange areas excluding existing stations with the relevant standards ; Not permitting wind power plant & solar power plant in green belt conserved area & Red area; Establishing a wind power plant & a solar power plant based on the relevant regulatory in Orange area & Basin Protected Area.
Protection Plan	Using biological & biotechnical methods instead of the use of pesticides; and planting irrigation channels connected with the rivers feeding the dam lake by administration inappropriate ways; Leading organic agriculture through farmers' training in Red areas & good agriculture in basin protection area by integrated ecosystem services; Switching to pressurized irrigation systems if not the irrigation methods other than release irrigation; Not allowing agricultural activities in Dam Lake Green Belt Conservation Area; Allowing animal husbandry activities in the pastures registered in Basin Protection Area; Making ponds to animals' use, into dry streams feeding the dam lake; Encouraging organic livestock activities basin protection area and allowing animal husbandry activities only for the needs of the inhabitants in the Red area & Orange area; Livestock establishments in the form of animal integrated facilities if the wastes & solid wastes are disposed of by means of appropriate methods; Not allowing fishing in Dam Lake Conservation and aquaculture in Red areas; Allowing aquaculture in Basin Protected Area if wastewater is treated according to the discharge standard with the opinion of the administration.	Not installing a new car wash station in Red areas and not generating radioactive raw material except for hospitals and research centers; Removing all solid & liquid wastes; Not affecting the solid waste & air emissions from a new industry; and not allowing industry of flammable, chemical production; acid manufacturing; pesticides production; battery manufacturing; pharmaceutical synthesis factories; scrap paper making facilities; metal hardening, metal coating, surface cleaning with acid, production of heavy metal salt, polishing of glass the wool washing functions in the basin; Preparing Nature Rescue Plans; Not allowing excavation material & exploration, drilling, research pit, & similar exploration works in Dam Lake Green Belt Conserved Areas & Red areas; Closing the mining activities made for the dam construction within one year in Red areas and protected area; Allowing limestone, dolomites, travertine, marble, are opened in suitable areas in basin protected areas and allowing alluvium aquifer within the framework of Mining Law in the basin protection area if there is no harm to health and the quality of water.	Identifying the tourism development zone following the Tourism Incentive Law & related regulations determined in the Environment Plan; No new tourism facilities except for environmentally sensitive ecotourism facilities in Red and Orange areas.	Fuel stations & other similar activities on existing roads may be permitted if they keep the standards.

Table A.21: The provisions related to *the social dimension* defined in the Environment and Protection Plans of Melen Dam-Lake.

Plan	Social Right &Values	Public Health	Behvior attitudes
Environment Plan	-Within the limits of this plan, if necessary, performing safety, health, education etc. social equipment areas, municipal service in the basin; -Including the social reinforcement areas in the zoning plans -the public mandatory service facilities in Short- Range Protected Area & in Medium Distance Protected Area.		
Protection Plan	-Public lands located in the basin are also subject to restrictions for the protected area; -Not allowing new clay, sand &gravel taking in basin protected zones, wherea alluvial aquifer is present, except temporary periods by considering the public interest.	-Monitoring of surface groundwater quality by the administration at the designated points in the dam lake and in the streams; -Waiting period of at least 21 days after using animal compost in pasture & agriculture to control the public and animal health risk; -Not allowing the industries in the basin protected area except industries don't lead to irreversible consequences in human health & the environment; -Ensuring the quality and quantity of the water reaching the consumer, the drinking water safety plan, included in the basin protection plan by the administration.	

APPENDIX B: Questionaire Form

Questionnaire Date: …… /…. / 2019

This survey is conducted for the thesis titled "Relationship between Water basin Management and Urban Planning in Sustainable Development." The study aims to prioritize the criteria, main factors, and sub-factors that are considered in the process of water basin planning. The information you provide under this survey will not be shared in any other way. We appreciate your patience and time in answering the questionnaire.

Please read the following instructions carefully before completing the questionnaire.

Description of Survey Form:

***Step 1*:** Compare two decision elements (A and B) given in each criterion. Select the decision-making element that is more important in terms of its features and functions.

***Step 2*:** Select this criterion by using the decision-making scale that is important for you. Accordingly, mark one of the numerical values from 1 to 9 on the scale line.

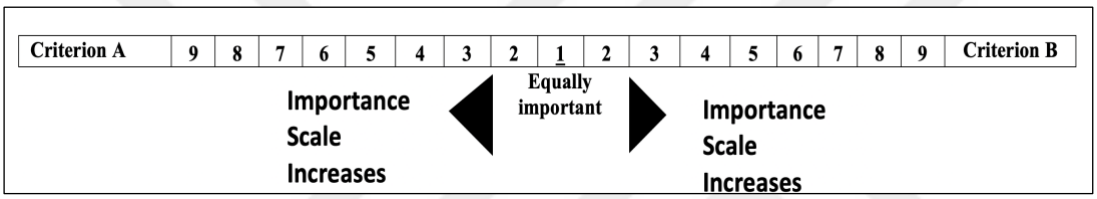

Figure B.1: Pairwise comparison between two criteria of A and B.

Table B.2: Numerical values and their importance levels.

Criteria A and B	Interpretation
1	A and B are equally important
3	A is slightly more important than B
5	A is more important than B
7	A is strongly important that B
9	A is absolutely more important than B

This thesis has identified five main disciplines in the planning of the water basin management, which are:

1: Ecological Planning: The main challenges of this plan is to identify and protect the water and natural sources, ecosystem, biodiversity and to control the natural risks and water pollution.

2: Physical Planning: It is dealing with sub-factors of Infrastructure and utilities, Transportation and Logistik, Historical and Cultural Values, and Land Use Planning

3: Social Planning: This plan includes sub-factors of social right and values, public health and sanitation, the behavior (the preference and perception of the people in the basin)

4: Economic Planning: It considers all functions and development to improve financial sources in the water basin, such as agriculture, mining, industry, tourism, and commerce.

5: Water Management: It considers the institutional structure, participation, management, and finance sub-factors in water basin planning.

Table B.3. Pairwise comparison of the Main Factors in Water Basin Planning process.

Which one is more important to you in water Basin Planning?																		
Criterion A	← Importance Increase →																	**Criterion B**
Ecological Planning	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Physical Planning
Ecological Planning	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Economic Planning
Ecological Planning	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Social Planning
Ecological Planning	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Water Management
Physical Planning	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Social Planning
Physical Planning	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Economic Planning
Physical Planning	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Water Management
Economic Planning	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Water Management
Economic Planning	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Social Planning
Social Planning	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Water Management

Table B.4. Pairwise comparison of the Sub- Factors of Ecological Planning.

Which one is more important to you in Ecological planning of water basins?																		
Criterion A	← Importance Increase →																	**Criterion B**
Water Resources	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Other Natural Sources like soil, forest, air
Water Resources	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Ecosystem and Biodiversity
Water Resources	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	En. Problems (Natural disaster &climate change)
Water Resources	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Environmetal Pollution
Other Natural Sorces like soil, forest, air	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Ecosystem and Biodiversity
Other Natural Sorces like soil, fores, air	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	En. Problems (Natural disaster &climate change)
Other Natural Sorces like soil, forest, air	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Environmetal Pollution
Ecosystem and Biodiversity	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	En. Problems (Natural disaster &climate change)
Ecosystem and Biodiversity	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Environmetal Pollution
En. Problems (Natural disaster &climate change)	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Environmetal Pollution

Table B.5 : Pairwise comparison of the Sub- Factors of Physical Planning.

Which one is more is more important to you in Physical Planning of water basins?																		
Criterion A	← Importance Increase →																	**Criterion B**
Transportation& Logistic	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Infrustructure and Utilities
Transportation& Logistic	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Histrorcal & cultural Values
Transporation& Logistic	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Land Uses & density
Infrustructure and Utilities	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Histrorcal & cultural Values
Infrustructure and Utilities	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Land Uses & density
Histrorcal & cultural Values	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Land Uses & density

Table B.6 : Pairwise comparison of the Sub- Factors of Social Planning.

Which one is more important to you in Social planning of water basins?																		
Criterion A	← Importance Increase →																	**Criterion B**
Social Rights and Values	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Public Health and Sanitation
Social Rights and Values	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Behavior (preference and perception of the residents)
Public Health and Sanitation	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Behavior(preference and perception of the residents)

Table B.7 : Pairwise comparison of the Sub- Factors of Economic Planning.

Which one is more important to you in Economic planning of water basins?																		
Criterion A	← Importance Increase →																	**Criterion B**
Agriculture & husbandry, Aquaculture	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Industrial Production & Mining
Agriculture & husbandry, Aquaculture	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Tourism & eco-tourism
Agriculture & husbandry, Aquaculture	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Energy & Fuel services
Industrial Production & Mining	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Tourism & eco-tourism
Industrial Production & Mining	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Energy & Fuel services
Tourism & eco-tourism	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Energy & Fuel services

Table B.8 : Parewise comparison of the Sub- Factors of Management in Water Basin Planning process.

Which one is more important to you in Management of water basins?																		
Criterion A	← Importance Increase →																	**Criterion B**
Institutional Structure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Participation
Institutional Structure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Management
Institutional Structure	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Finance
Participation	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Management
Participation	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Finance
Management	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Finance

Table B.9 : Parewise comparison of the Sub- Factors of Land Use Planning.

Which one more important to you in Management of water basins?																		
Criterion A	← Importance Increase →																	**Criterion B**
Settlement area	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Commercial area
Settlement area	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Industrial area
Settlement area	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Agricultural area
Settlement area	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Recreational area
Commercial area	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Industrial area
Commercial area	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Agricultural area
Commercial area	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Recreational area
Industrial area	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Agricultural area
Industrial area	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Recreational area
Agricultural area	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Recreational area

Personal Information

Name and surname if you want: .....

Gense:

Female Male

Place of your hometown: .....

Your age: .....

The Major and level of your Education: .....

Your Profession: .....

CURRICULUM VITAE

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Place and Date of Birth **:**

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PUBLICATIONS, PRESENTATIONS AND PATENTS ON THE THESIS:

- **Pouya S.,** 2019: Integrated Water Management and its Challenges in Urban and Water Basin Scales, The 1st International Conference on Energy and Sustainable Built Environment: Design Today Save Future, 19th-20th June, Istanbul Gedik University, Istanbul, Turkey.
- **Pouya S.,** 2019: Water Footprint Assessment in Contribution with Urban Planning

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- **Pouya S.,** Turkoglu H., Arpacioglu, U., 2020: Using the analytic hierarchy process to evaluate sustainability factors in watershed planning and management , *Urbani Izziv*, 31(1), 81-19. DOI: 10.5379/urbani-izziv-en-2020-31-01-002.
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