Chapter

Introductory Chapter: Water Resources Planning, Monitoring, Conservation, and Management

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1. Introduction

River Basin Management (RBM) is an integral process to protect several wildlife species, sources of drinking water for animals, plants, and humans, sources of navigation channels, flood regulation, and others. On the other hand, RBM relies on effective public participation and management from all beneficiaries. RBM can be considered as the integration of strategic planning and management of quantity and quality of water resources through sustainable development [1, 2].

The rapid growth of population and water demand globally developed stress on the river basin to meet water demands, including municipal, agricultural, recreational, industrial, and other water demands. In addition, climate change impact is imposing threats/stresses on small to large river basins globally [3]. With projected global climate change and water demands, there are potential risks to the river basin, including loss of native biodiversity, ecosystems, and humans from increased flood and drought disasters [4]. Global climate change and global warming might cause frequent droughts, shifts in precipitation, lower water levels in water bodies, and consequently, less water to dilute pollutants.

Therefore, an integrated approach that includes planning, monitoring, and management using in situ and satellite measurements and modeling should be implemented to reduce the stresses on the river basin. This integrated approach requires significant contribution and participation from stakeholders, such as policymakers, watershed/water resources managers, researchers, forest managers, industries, farmers, growers, and several other natural resource users who are directly or indirectly responsible for additional stresses to the river basins.

The primary goal of this book is to address some of the critical issues of river basins through effective planning and management under the changing climate. This book includes the following four sections and 13 book chapters.

2. Water resources planning and conservation

Currently, we are concerned about the potential water scarcity in the face of increasing, primarily population-driven, water demands and its impact on energy and food production and food security [5]. In addition, the combined pressures of population growth and climate change significantly increased water demand [6]. Therefore,

water resource planning and conservation are critically important globally. The effective planning and conservation of water resources provide water resource security, which is important for agricultural, municipal, and industrial water demands.

Water resource planning and conservation are strongly connected because both processes complement each other. For example, the best and most effective planning is needed to conserve water resources. The best management practices in any watershed, whether agricultural, urban, or forested watersheds, help conserve water resources. For example, if farmers practice climate-smart farming for an agricultural watershed, they can conserve water resources and increase food production.

This section includes three highly diverse chapters focusing directly and indirectly on water resources planning and conservation. For example, while one chapter focused on approaches to improve water productivity, the other discussed the multiscale perspective for the conservation planning of riverine fishes. Further, this section focused on multiscale environmental relationships, which are important for water resource conservation and river basin planning. This section also discussed potential approaches to improve migration routes for aquatic animals, which are critical for biodiversity and the ecosystem.

3. Water resources management

Freshwater, which includes water in glaciers, lakes, reservoirs, ponds, rivers, streams, wetlands, and groundwater, is a limited natural resource. Therefore, many countries globally are experiencing water scarcity due to increased water demand due to the increasing population and living standards [7]. Some of the potential challenges associated with water resources management are low availability per capita, uneven temporal and spatial distributions, inconsistency in spatial distributions and productivity, and fragile water ecology and environment [7]. Traditional approaches for water resource management were to provide adequate water for municipal use without paying enough attention to its sustainable development and management [8].

Water resource management includes political, economic, cultural, social, technical, legislative, and organizational ingredients in one river basin or a total water cycle [8]. River basin management is indeed a complex process that requires several components to be incorporated, such as precipitation, evaporation, evapotranspiration, infiltration, and other inputs and withdrawals from the river basin system (**Figure 1**). Therefore, new strategies, advanced tools, techniques, monitoring, and evaluation system are critical and must include most aspects for effective water resource management in a river basin.

The challenge is that integrated water resources management (IWRM) should address complex water issues to maximize economic and social welfare equitably without compromising the sustainability of vital ecosystems [9, 10]. In addition, climate change impacts increased water demand and the challenges for integrated water resources management [11]. Despite several challenges, at a conceptual level, IWRM has gradually become an accepted framework for good water governance [12].

This section includes four chapters focusing on water resources management. For example, while one chapter focused on trend analysis of streamflow and precipitation in a river basin to support water resources management, the other discussed the characteristics and process interactions in natural fluvial riparian ecosystems. Further, this section investigated the impact of hydraulic infrastructures on the water resources management of the river basin. This section also conducted a comparative

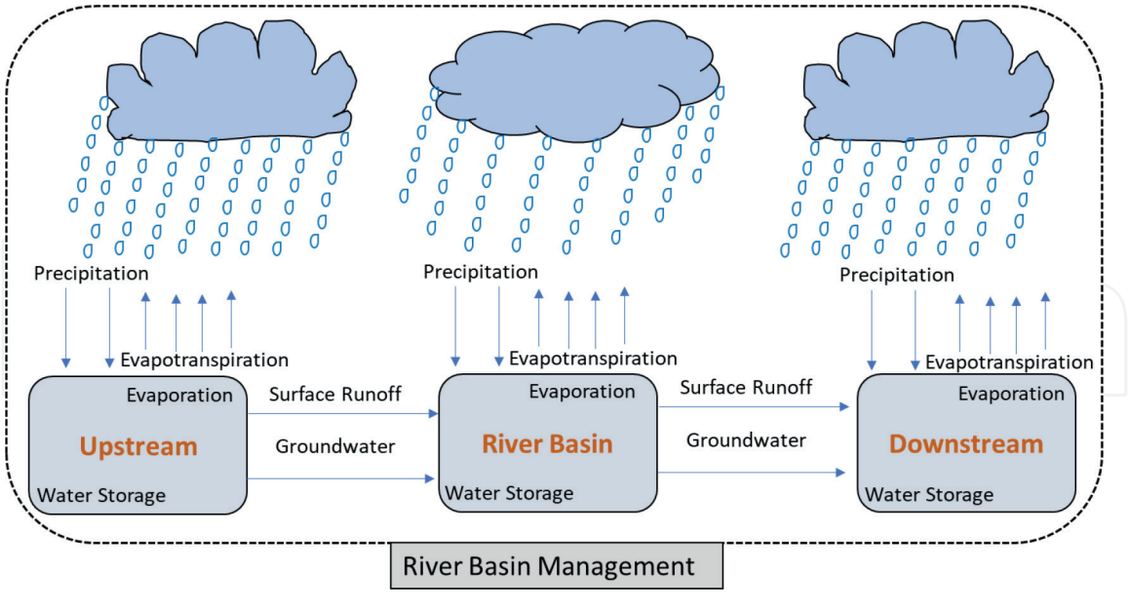

Figure 1.
Driving parameters essential to quantify for effective river basin management.

analysis of the precipitation variation in relation to the water availability in the rivers for the previous period and subsequent periods to determine the change in the availability of water in the ecosystem.

4. Water quality monitoring and management

Water quality monitoring is a basic tool for managing freshwater resources. Monitoring water quality in a river and its status gives clues for the health of the river and also the health of the river basin. River basin approach has been introduced to monitor and manage water quality in all most all countries in the world [13]. Therefore, this book introduces the section on water quality monitoring and management under the river basin.

There are many ways to monitor water quality. The conventional method of assessing water quality is evaluating the physical, chemical, esthetic, and biological properties of water. However, biological measurements of the abundance of animal life and aquatic plant and the use of bioanalytics, use of remote sensing, and IoT are becoming popular. Biomonitoring is considered more efficient and effective than traditional methods. It is widely used worldwide to monitor river pollution as bioindicators are sensitive enough to detect environmental change [14]. Biomonitoring is of two types active and passive. Active biomonitoring uses organisms under controlled conditions into the site to be monitored, whereas passive biomonitoring uses organisms, organism associations, and parts of organisms that are a natural component of the ecosystem and appear there spontaneously [15]. Aquatic insects can be used as bioindicators in aquatic ecosystems. Each aquatic insect has a different tolerance value to environmental conditions in which only a few species can survive in polluted ecosystems. One chapter discusses the use of aquatic insects to assess water quality along with some physical and chemical parameters. In addition to aquatic insects, algal communities are robust indicators of the physical, chemical, and biological changes of water induced by environmental flows which alter

nutrient concentration, salinity, and alkalinity. One chapter in the book offers a comprehensive review of the monitoring conditions of rivers and streams using biological indices with an emphasis on algae. However, monitoring the point source pollution, such as effluent disposal from the industry to a waterbody, can be done efficiently using the conventional evaluation technique for the chemical, physical, and biological status of the water. One another chapter in this section deals with the pollution evaluation of industrial effluents from consolidated breweries using conventional approaches.

Improving access to clean water for drinking, bathing, and irrigation as per the standard is a top priority in all countries. The nature-based solution that leverages ecosystem functions is gaining more attention and is widely used to manage water quality [16]. The watershed management approach considers the nature-based concepts where forests, wetlands, and grasslands, as well as soils and crops, are managed properly. These well-managed watersheds provide high-value green infrastructure for enhancing source water protection.

5. Community's role in river basin management

It is now well recognized that the use of engineering measures with regulation-based management strategies has limited capacity to manage river basin and their water resources. Participatory approaches that engage stakeholders and the public in river basin management are promising and sustainable. Different basin users have conflicting water quantity, quality, flood risk, and ecological health demands. These demands can be managed while introducing best management practices to different land uses of the basin through a participatory approach. In addition, river basin management is data-intensive as it requires a picture of the entire socioeconomic and ecological health of the basin where stakeholders have these fragmented data in different scales [17]. Therefore, the role of the stakeholders is well understood.

Once the river basin or watershed of the river basin management plan is set, stakeholders are the entities that implement the agreed management activities. Therefore, getting their consent is highly encouraged even though sometimes agreed decision is not that quality [18]. Community participation has the power to make decisions autonomously in order to be able to solve the needs and interests of life and improve the standard of their living. Thus, one chapter of this section discusses in detail the community participation in river basin management.

Particularly, when managing the water demand and conserving the water in the basin, the stakeholder's role is highly acknowledged, and giving incentives is one way of getting users involved in conserving water in a river basin or a catchment. One chapter of this section discusses how water users use the property rights theory to conserve water. The results from the analyses indicated that property rights would be significant in curtailing water demands in a catchment by acting as incentives in water resource utilization, specifically by motivating water users to conserve water.

The catchment area becomes transboundary when it extends between two or more countries. The cooperation of the stakeholders is important for better managing the water of such river basins. Transboundary cooperation incorporating robust water diplomacy pathways for sustained water management is required rather than technical water management [19]. One of the chapters of this section discusses the impacts and sub-regional cooperation around a transboundary hydrological system.

6. Concluding remarks

Water resource planning, management, conservation, and monitoring of any river basin must address complex science and issues using available resources, tools, and techniques under a changing climate. While much of the complexities of river basin management are human-induced, climate change has increased the complexities and challenges. Each river basin/water resources system is unique with respect to its management issues, challenges, and climatic and environmental conditions. Therefore, river basin planning, management, and conservation approaches must adapt to these situations. River basin planning, management, and conservation strategy should be based on those situations, especially when we have to plan, manage, and conserve water resources of the river basin under changing climate.

This book has focused on using an integrated approach, which includes modeling, trend analysis, the role of infrastructure, and community participation in river basin management under changing climate. The participation and contribution of stakeholders in river basin management are critical to building sustainable water resource management in a river basin. This chapter has summarized the 13 chapters of the book in four sections for water resources planning, conservation, monitoring, and management, including modeling.

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