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Progressive Watershed Management Approaches in Iran

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***Abstract*—**Expansionism and ever-increasing population menace all different resources worldwide. The issue, hence, is critical in developing countries like Iran where new technologies are rapidly luxuriated and unguardedly applied, resulting in unexpected outcomes. However, uncommon and comprehensive approaches are introduced to take all the different aspects involved into consideration. In the last decade, few approaches such as community-based, stakeholders-oriented, adaptive and ultimately integrated management, have emerged and are developing for efficient, Co-management or best management, economic and sustainable development and management of watershed resources in Iran. In the present paper, an attempt has been made to focus on state-of-the-art approaches for the management of watershed resources applied in Iran. The study has been then supported by reports of some case studies conducted throughout the country involving previously mentioned approaches. Scrutinizing results of the researches verified a progressive tendency of the managerial approaches in watershed management strategies leading to a general approaching balance situation. The approaches are firmly rooted in educational, research, executive, legal and policy-making sectors leading to some recuperation at different levels. However, there is a long way ahead to naturalize detrimental effects of unscientific, illegal and over exploitation of the watershed resources in Iran.

***Keywords*—**Comprehensive management, ecosystem balance, integrated watershed management, land resources optimization.

I. Introduction

DIFFERENT types of land degradation exist in the world. There are also various land degradation issues in Iran [1], [2], among which, soil erosion stands as the first priority. In many parts of the country, it is greatly influenced by land use and management [1]. Land degradation development is one of the existing issues in human communities. Degraded lands cover approximately 23% of the global terrestrial area, increasing at an annual rate of five to 10 million ha. Additionally, this might be due to changes in potential triggering forces [3], [4]. The developing country of Iran, like many other countries in the world, faces serious land management issues. These issues play an important role in highlighting Iran as being located one of the most vulnerable regions to climate change, owing to the country's greater susceptibility, being located in an arid to semi-arid part of the world. Such that, any uncontrolled utilization of soil and water resources may have significant implications for water productivity and food security as well [5].

Iran, as a developing nation, currently faces many soil and water crises issues. High potential sensitivity of land resources, improper and unnecessary development of infrastructures, land use changes and unlawful exploitation of resources are supposed as main reasons behind irregularities in ever-increasing issues. Much of Iran is covered by hyper- and semi- arid climate, as shown in Fig. 1. Iran suffers from irreparable damage of soil erosion to watershed ecosystems causes serious economic loss. Many changes have been made in Iran watersheds during last century and especially in past half century. These made in physical as well as managerial aspects leading to detrimental effects in land uses and coverage. Soil erosion and sediment related issues were further augmented due to over exploitation of natural resources and leading to fully degraded watersheds [6]. The problem is so significant and serious that sometimes it costs more than petroleum revenue of the country. Ever-increasing population of the country, enforcing new technologies and careless management and utilization of watershed resources seriously threat different all existing ecosystems worldwide. They led to more serious issues in developing countries where introduced or imported technologies are incautiously and imprudently applied while no integrated managerial approach is taken into account in order to comprehensively consider all involving components of the watershed systems [7].

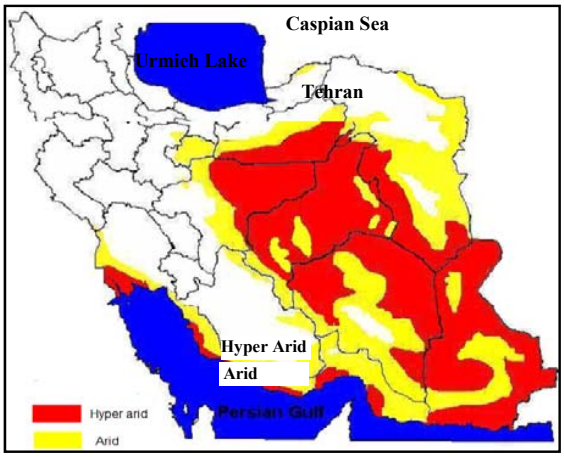

Fig. 1 Distribution of arid and hyper arid areas of Iran

Considering issues and conditions explained above, more comprehensive and integrated watershed management approaches are essentially needed to adopt developmental

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plans and improve soil and water resources management leading to sustainable land use and land productivity in the most productive parts of Iran [1]. Accordingly, such programs with deep insight into direct and indirect aspects of the human interventions resulted from their essential needs and of course, periodical avidities in the ecosystem would facilitate the sustainable utilization of the watershed resources. Accordingly, some valuable approaches viz. Zero Net Land Degradation (ZNLD), watershed health and assessment, Comanamgement and also Integrated Watershed Management (IWM) have been recently introduced in Iran to achieve the optimum use of resources, leading to sustainable and balanced outcomes. The first two ones have been successfully conducted as pilot research. Whilst, the latter is currently under process. In the following, the detailed procedure has been articulated.

II. Zero Net Land Degradation (ZNLD)

Developmental projects mainly lead to population changes and the land use change [8]. Qualitative and quantitative analysis of population and land use changes are therefore necessary to appropriately apply managerial approaches. Apart that, due to the growing population, subsequent increasing demands as well as economic development, utilization of all available resources is inevitable. On the other hand, the unsustainable management strategies due to incorrect identification of natural resources, increases the land degradation. Appling appropriate management plans is therefore necessary to mitigate damages, proper utilization and economic development needs. In this regard, adaptive management is a systematic approach, provides optimal management of natural resources and reduces land degradation through minimizing uncertainty and greater convergence among stakeholders. ZNLD strategy as a new approach, which can be achieved when non-degraded land remains healthy and already degraded land is restored, thus reducing to zero the net rate of loss in productive land. A case study was conducted in the Shazand Watershed (1740 km^2 in Markazi Province, Iran) where rapid industrialization and consequent different type of land degradation existed to evaluate practical application of ZNLD strategy.

The study was conducted to achieve a management perspective due to significant changes in a variety of land uses, management and industrial development from 1973 to 2014 and consisted of four periods of 1973-1986, 1986-1998, 1998-2008, and 2008-2014. Based on recent available literature, the average annual flow and sediment yield were, respectively, 0.84 and 1.19 times in post industrialization (1991-2008) of those for pre industrialization period. So that the sediment yield increased by some 5000 tons annually [8]. Besides that, changes in and affecting factors on Environmental Sensitivity Area Index (ESAI)-based ZNLD were studied for the study periods. These findings could practically help local and even national managers and decision makers to designate appropriate managerial strategies.

III. Co-Management Approach

A watershed has many considerable dimensions including technical, social, economical, physical, ecological and organizational essentially needed for proper planning and management. Due to complex interactions among different aspects of the watershed, application of an integrated management approach is therefore vital to coordinate previously mentioned study aspects. Accordingly, decision making for the management of the watershed to achieve an optimal solution with maximum fulfillment of conflicting demands of different stakeholders is difficult. The comanagement approach may be therefore a solution to such complicated issue allowing different stakeholders to be involved actively in decision-making processes. In this pursuit, various management tools have been developed to facilitate multi-objective decision-making processes. Additionally, the effectiveness of the study approach on target ecological variables with further focus on hydrologic behavior is also necessary to optimize decisions in the watershed scale. In this regard, the initiative application of game theory approach [9] was assessed for the comanagement of the Galazchai Watershed (103 km^2 in West-Azarbaijan Province, Iran) with various stakeholders and demands. The study aimed to analyze the conflicting interests of different stakeholders within a framework of best comanagement practices based on game theory in. For this attempt, the analysis of the site selection for the best management practices based on stakeholder's perspective was conducted using Condorcet, Borda scoring and fallback bargaining algorithms in game theory. The feasible management scenarios then considered for the study area and corresponding effects on hydrological behavior of the study watershed were successfully analyzed. The management approaches was then prioritized based on their impacts on hydrograph and sediment graph components. The results of the present study would provide an appropriate guideline for the integrated management of the study and other similar watersheds due to providing a comanagement approach considering different socioeconomic and technical aspects.

IV. Integrated Watershed Management

Achieving the optimum use of resources, leading to sustainable and balanced outcomes is only accessible through IWM [4], [7]. Since 2012, an IWM National Mega-Project for Iran was developed. It was approved along with some other very important national-wide projects by the High Council of Sciences, Research, and Technology of the country. A four-side consortium of four universities plus a national research institute was initially established to compile the first step of Phase Zero Proposal. The initial draft of the project plan was proposed at Gorgan University of Agricultural Sciences and Natural Resources by a team of scientists in the field of natural resource management [8]. The perception and justification reports were then provided. Some background information and the plan of work, timeframe and budget plan were then prepared. The main aim of the project is formulation a national

scientific map for implementation of IWM in Iran.

The project mainly focused on a new holistic approach towards the IWM at the national level for Iran. To achieve equitable, efficient and sustainable plan for natural resources utilization in Iran, the development of policies, strategies, and plans was identified as the foundation of the project. It targeted many involved aspects of soil and water management from the very beginning stages. To highlight as many related issues as possible and to attain a range of ideas and feedbacks, brainstorming processes were arranged by conducting five nation-wide workshops with highly motivated contribution of all involved experts and decision makers from various disciplines throughout the country. The ultimate efforts were made to involve a wide range of participants from the part of policy makers, academia, researchers, practitioners, NGOs and even local communities' representatives. The workshops were convened in different universities across the country on project formulation, breakdown structure, and terms of reference for subprojects. To avoid duplications in running projects and streamline the whole process, the foundations as well as supporting strategies, conducted national projects and the potential linkages were precisely considered. The first draft of the phase zero report was already submitted to the relevant officials end users. While, the phase 1 has been subsequently commenced according to the project plans and presently runs. Currently, a few projects of phase 1 have been undertaken and it is expected to be entirely finished within next two years. The megaproject has four phases including phase zero and has been planned to be terminated within some eight years. The following main inter-related objectives and steps have been planned to be achieved [7]. The conceptual framework of the project is going to be implemented in several pilot watersheds across the country.

1. Identifying the complete dimensions of the IWM
2. Recognizing and evaluating the past and current situations of policies and plans, and adopting SWOT (Strengths, Weaknesses, Opportunities, and Threats) towards IWM
3. Identifying watershed health and sustainability indicators to customize and integrate the indicator and to prioritize the watersheds
4. Integrating applicable indicators to prioritize watersheds for implementation of the integrated management
5. Developing a database/data bank and information platform for the entire available information and data
6. Developing comprehensive social, cultural and economic policies and strategies to achieve the goals of IWM
7. Developing the stakeholder-oriented administrative, financial and legal strategies for the IWM of the country
8. Developing a master plan for IWM of the main river basins of Iran
9. Developing the monitoring programs, and developing watershed assessment toolboxes and decision support systems (DSSs) for IWM
10. Assessing the compatibility of IWM framework with other national strategic plans and national planning systems
11. Integrating and developing an Iranian customized model for IWM

V. Watershed Health and Assessment

Today, the watershed systems are being destroyed worldwide due to various human activities and natural triggering forces like climate change. Since the watershed destruction entails adverse economic and social consequences, assessment of the relative condition of watersheds is essential to prioritize and plan appropriate management practices. However, such initiative studies have been recently taken into account. Accordingly, no study has been reported for Iran.

Recently an initiative research has been conducted in Iran [10] to formulate how watershed health indices can be determined in view of comprehensive watershed management and to customize an adaptive watershed health assessment framework for conditions governing Iran watersheds. In this pursuit, three conceptual models of Reliability-Resilience-Vulnerability (RRV), Pressure-State-Response (PSR) and Vigor-Organization-Resilience (VOR) have been applied to assess watershed health of a watershed in Iran (i.e., Shazand Watershed, Markazi Province, Iran). A comparative study was conducted for years 1986, 1998, 2008 and 2014. Toward this, the basic available and accessible information and maps, viz. climatic, hydrological, soil, geologic, population, land use and land cover data were collected or obtained from relevant resources and authorities [10]. In this study, the RRV model was calculated based on the standardized precipitation index (SPI), soil erosion, discharge and impervious surfaces criteria in the whole watershed. The PSR and VOR models still have not been conducted but they are undergone. Nonetheless, the ratio of annual precipitation to evaporation and landscape metrics, the state index (S) will also be computed and finally response index (R) will be calculated with respect to the ratio of increasing the base flow to the river hydrological flow, ratio of increasing the minimum flow to the river hydrological flow, pasture lands percentage and soil degradation. In the VOR model, the criteria of Normalized Difference Vegetation Index (NDVI), soil erosion and runoff as well as slope percent will be used to calculate the vigor index (V). To calculate the organization index (O), the landscape diversity, cover analysis and movement the NDVI centroid, erosion and runoff uniformity and contributing area will then be used. In addition, for the resilience index (R) slope of NDVI model and landscape richness, periodic variation of erosion and runoff and stream density will be used. In addition, the criteria and indices will be standardized for principal component analysis (PCA). A geometric mean of the indices will be then adopted for overlaying the information layers. The watershed health will be ultimately zoned based on individual and compound indicators. Finally, according to the study, a customized conceptual model will be adapted to the study watershed. The results of this research can be a great of help to determine the effective factors of watershed health assessment, detection of healthy watersheds, choosing homogenous regions, and sustainable and comprehensive watershed management.

VI. Conclusion

A report has been given during the present article on available/ongoing managerial approaches on watershed management in Iran. The results of the present attempt showed a general progressive tendency in the management of the watersheds in Iran leading to a general approaching expected balance situation. The introduced approaches targeted different educational, research, executive, legalistic and policy-making sectors leading to some recuperations at different levels. Although the processes are perceived to be far from straightforward, it is hoped that these integrated participatory watershed management schemes would facilitate a better management of watershed resources in Iran and towards promoted socioeconomic and ecologic outcomes for the country ultimately leading to a sustainable development.

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