

PARTICIPATORY WATER RESOURCES MANAGEMENT FOR SUSTAINABLE AGRICULTURAL WATER ALLOCATION: A CASE STUDY OF THE MARUN-JARAHİ BASIN, SOUTHWEST IRAN

GESTION PARTICIPATIVE DES RESSOURCES EN EAU POUR UNE ALLOCATION DURABLE DE L'EAU AGRICOLE : ÉTUDE DE CAS DU BASSIN DE MARUN-JARAHİ, DANS LE SUD-OUEST DE L'IRAN

Ali Shahbazi ^{*1}, Abbas Sadrianfar², Ali Sharifi³, Fatemeh Zakerihosseini⁴, Arash Mahjobi⁵, Nooroddin Bazgir⁶, Narges Zohrabi⁷, Masoud Asadi⁸, and Seyyed Hossein Mousavi⁹

ABSTRACT

Sustainable water resources management in arid and semi-arid regions has become one of the most complex governance challenges of the twenty-first century, driven by intensifying climate variability and growing competition among water-use sectors. While traditional, centralized management approaches are no longer sufficient to cope with hydrological uncertainty and rising social demands, emerging governance paradigms emphasize the integration of technical planning, stakeholder participation, and multi-level dialogue. This paper examines the design, implementation, and evolution of a participatory management structure in the Marun-Jarahi basin in southwest Iran. This structure emerged in response to the severe 2021 drought and the ensuing social tensions caused by water scarcity, unequal resource distribution, and declining public trust in water management processes, and matured through a gradual four-year process. Using a parallel, participation-based approach, it involved representatives of the counties located along the Marun River, including county governors, representatives of agricultural unions, progressive farmers, and water allocation and planning managers, in decision-making, planning, implementation, and monitoring processes.

In this model, the county was selected as the smallest unit of participation in order to preserve social convergence and practical consensus while preventing excessive growth in the number of stakeholders and the complexity of decision-making. Participatory management meetings were held at key stages of water resources and water allocation management, including seasonal cropping plans, water releases, irrigation scheduling, and inter-county water allocation. The decision-making process was based on integrating technical analyses, climate forecasts, hydrological data, and direct stakeholder participation in risk assessment and the formulation of implementation plans. Implementation monitoring was carried out using a hydrometric network, satellite imagery, and drone-based systems, and the data were shared transparently among members of the participatory management task force.

The results showed that implementing this structure led to improved water use efficiency, strengthened food security, and better water governance indicators in the basin. Production of

1*Deputy of Comprehensive Water Resources Studies, Khuzestan Water and Power Authority (K.W.P.A), Iran, Email: alish1980@gmail.com (Corresponding Author)

2 CEO and Chairman of the Board of Directors, (K.W.P.A), Iran.

3 Director of Reservoir and River Planning Management, (K.W.P.A), Iran.

4 Director of Water Resources Integration and Accounting Group, (K.W.P.A), Iran. Email: zakerfatemeh@gmail.com

5 Deputy of Irrigation and Drainage Networks, (K.W.P.A), Iran. Email: Arashmahjoobi@Gmail.com

6 Deputy of Water Resources Protection and Utilization, (K.W.P.A), Iran.

7 Associate Professor, Department of Water Sciences and Engineering, Ahv.C., Islamic Azad University, Ahvaz, Iran, Email: narges.zohrabi@iau.ac.ir, nargezohrabi@gmail.com

8 Chairman of the Khuzestan Agricultural Farmers Guild, Iran.

9 Chairman of the Coordination Council of Agricultural Guilds of Khuzestan Province, Iran.

strategic autumn crops, especially wheat, increased significantly under reduced water consumption conditions; water-intensive crops such as rice were removed from the basin cropping pattern through stakeholder consensus; and the sustainable supply of water to the vulnerable date palm groves of Shadegan was maintained even under severe drought conditions. In addition, information transparency, direct stakeholder participation, and the creation of a shared understanding of water resource constraints contributed to improved water equity, increased public trust, and enhanced social stability. This study shows that participatory governance within the IWRM framework can be an effective strategy for strengthening socio-hydrological resilience, improving drought management, and reducing water-related conflicts in stressed basins.

Keywords: participatory water governance, IWRM, stakeholder participation, Marun-Jarahi basin, Iran, drought management, socio-hydrological resilience.

RÉSUMÉ

La gestion durable des ressources en eau dans les régions arides et semi-arides est devenue l'un des défis de gouvernance les plus complexes du XXI^e siècle, sous l'effet de l'intensification de la variabilité climatique et de la concurrence croissante entre les secteurs utilisateurs de l'eau. Alors que les approches traditionnelles et centralisées de gestion ne suffisent plus à faire face à l'incertitude hydrologique et à l'augmentation des demandes sociales, les nouveaux paradigmes de gouvernance mettent l'accent sur l'intégration de la planification technique, de la participation des parties prenantes et du dialogue à plusieurs niveaux. Cet article examine la conception, la mise en œuvre et l'évolution d'une structure de gestion participative dans le bassin de Marun-Jarahi, dans le sud-ouest de l'Iran. Cette structure est apparue en réponse à la grave sécheresse de 2021 et aux tensions sociales qui ont suivi, provoquées par la rareté de l'eau, la répartition inégale des ressources et le recul de la confiance du public dans les processus de gestion de l'eau ; elle a ensuite mûri progressivement pendant quatre ans. Fondée sur une approche parallèle et participative, elle a associé aux processus de prise de décision, de planification, de mise en œuvre et de suivi des représentants des comtés situés le long de la rivière Marun, notamment les gouverneurs de comté, les représentants des syndicats agricoles, les agriculteurs pionniers ainsi que les responsables de l'allocation de l'eau et de la planification.

Dans ce modèle, le comté a été retenu comme plus petite unité de participation afin de préserver la convergence sociale et le consensus pratique, tout en évitant une augmentation excessive du nombre de parties prenantes et de la complexité du processus décisionnel. Des réunions de gestion participative ont été organisées aux étapes clés de la gestion des ressources et de l'allocation de l'eau, notamment pour les plans culturels saisonniers, les lâchers d'eau, la programmation de l'irrigation et l'allocation de l'eau entre comtés. Le processus décisionnel reposait sur l'intégration d'analyses techniques, de prévisions climatiques, de données hydrologiques et de la participation directe des parties prenantes à l'évaluation des risques et à l'élaboration des plans de mise en œuvre. Le suivi de la mise en œuvre a été assuré au moyen d'un réseau hydrométrique, d'images satellitaires et de systèmes fondés sur des drones, et les données ont été partagées en toute transparence entre les membres du groupe de travail sur la gestion participative.

Les résultats montrent que la mise en œuvre de cette structure a amélioré l'efficacité d'utilisation de l'eau, renforcé la sécurité alimentaire et fait progresser les indicateurs de gouvernance de l'eau dans le bassin. La production des cultures stratégiques d'automne, en particulier du blé, a augmenté de manière significative malgré une réduction de la consommation d'eau ; les cultures à forte consommation d'eau, comme le riz, ont été retirées du schéma culturel du bassin par consensus des parties prenantes ; et l'approvisionnement durable en eau des palmeraies dattières vulnérables de Shadegan a été maintenu même dans des conditions de sécheresse sévère. En outre, la transparence de l'information, la participation directe des parties prenantes et la création d'une compréhension commune des contraintes liées aux ressources en eau ont contribué à améliorer l'équité dans l'accès à l'eau, à accroître la confiance du public et à renforcer la stabilité sociale. Cette étude montre que la gouvernance participative dans le cadre de la gestion intégrée des ressources en eau (GIRE) peut constituer une stratégie efficace pour renforcer la résilience sociohydrologique,

améliorer la gestion de la sécheresse et réduire les conflits liés à l'eau dans les bassins soumis à de fortes pressions.

Mots-clés : Gouvernance participative de l'eau; IWRM; Participation des parties prenantes; Bassin de Marun-Jarahi; Iran; Gestion de la sécheresse; Résilience socio-hydrologique.

1. INTRODUCTION

Drought and water scarcity have emerged as critical challenges in water resources management within arid and semi-arid regions globally over recent decades. These challenges have been exacerbated by climate change, population growth, agricultural expansion, and increasing competition among various water-use sectors (IPCC, 2023; UN-Water, 2021). In numerous river basins, the decreasing predictability of rainfall and runoff, coupled with an increase in extreme hydrological events, has diminished the efficacy of traditional water planning models (UNESCO, 2024; FAO, 2023). Consequently, water resource management has transcended purely technical considerations, becoming increasingly intertwined with institutional, social, and governance dimensions.

International literature suggests that Integrated Water Resources Management (IWRM) is most effective when it incorporates not only technical coordination between supply and demand but also institutionalized stakeholder participation, information transparency, accountability, and social learning (Global Water Partnership, 2000; Pahl-Wostl, 2007; OECD, 2015). Furthermore, the resilience of river basins against drought and climate change hinges on a combination of analytical capacity, institutional flexibility, and genuine stakeholder engagement (UNDRR, 2022; World Bank, 2023).

Despite the widespread acceptance of IWRM, a persistent challenge in many countries lies in bridging the gap between its theoretical framework and its practical implementation within actual water governance contexts. In practice, translating principles such as integration, participation, and inter-sectoral coordination into operational mechanisms encounters obstacles like institutional fragmentation, information asymmetry, weak stakeholder representation, and limited implementation capacity (Biswas, 2004; Medema et al., 2008). From this perspective, case studies of successful implementation are valuable as they demonstrate how IWRM can evolve from a normative framework into an operational practice in real-world water stress scenarios.

Within the agricultural sector, which is the largest consumer of freshwater in many developing countries, decisions regarding water allocation and distribution are inherently technical, social, economic, and political (FAO, 2023). Reductions in water availability or shifts in allocation priorities can lead to decreased production, jeopardized livelihoods, heightened local tensions, and eroded public trust. Therefore, transitioning from purely centralized models to participatory governance is considered a key prerequisite for sustainable water management (Ostrom, 1990; Meinzen-Dick, 2007; Pahl-Wostl et al., 2012).

Research indicates that stakeholder participation, when supported by credible information, clear roles, and reliable operational mechanisms, can enhance the legitimacy of decisions, adherence to agreements, and perceived equity, while simultaneously reducing conflicts (Molle, 2008; OECD, 2015; Suhardiman et al., 2017). This is particularly crucial during severe drought periods. In West Asia, structural water stress, high dependence of livelihoods on irrigated agriculture, and the socio-political sensitivity surrounding water allocation amplify the importance of participation in water governance (Allan, 2001; Weinthal et al., 2014; Mirumachi, 2015).

Iran, situated within the arid and semi-arid belt, has faced intensifying water stress and increasing instability due to drought and climate change in recent decades (Ashraf et al., 2021). The agricultural basins in the southwest of the country, with their high reliance on surface water resources, ecological sensitivity in downstream areas, and diverse water use patterns, provide a suitable context for examining the effectiveness of participatory water management models. The Marun-Jarahi basin is one such area that has recently experienced reduced water resources, competition between upstream and downstream users, vulnerability of date palm groves and the Shadegan wetland, and social

tensions during periods of water scarcity. The severe drought of 1400 (2021-2022) highlighted that without effective mechanisms for dialogue, transparency, participation, and consensus-building, managing water resources and allocation faces significant operational and social limitations.

From a research gap perspective, much of the water governance research in arid regions has focused either on macro-level policy analyses or on technical assessments of water resources and use. In contrast, empirical documentation of experiences where participatory mechanisms have been institutionalized at the basin level, directly linked to agricultural water planning, allocation, implementation, and monitoring, remains limited, especially within contexts similar to southwest Iran. This study, therefore, aims to contribute to reducing this gap between theoretical knowledge and practical experience by documenting the case of the Marun-Jarahi basin.

Accordingly, this paper has been developed with the objective of elucidating the experience of designing, establishing, and evolving a participatory management structure within the Marun River basin. The primary focus of the study is to address the question of how a participatory mechanism, grounded in the integration of technical analysis, institutional coordination, and local stakeholder engagement, can lead to improved agricultural water allocation, enhanced water equity, reduced conflicts, and increased basin resilience against drought. This paper also seeks to demonstrate how the experience of the Marun-Jarahi basin can be considered as a transferable model for other river basins in the country within the IWRM framework.

2. STUDY AREA

The Marun-Jarahi basin, spanning an area of 25,632 square kilometers, is situated in southwestern Iran. Geographically and hydrologically, the mountainous section, which serves as the primary source of water generation for the basin, is located in the Kohgiluyeh and Boyer-Ahmad Province. However, the majority of the agricultural lands and the main water utilization networks are found in the Khuzestan Province. The average annual rainfall in the basin is approximately 197 mm, indicating limited water resources in the region.

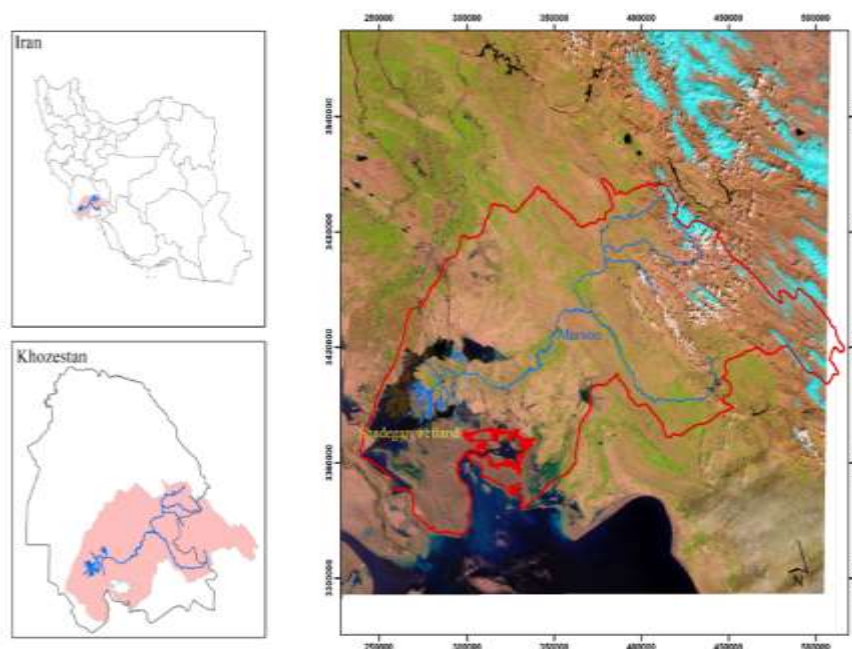


Figure 1. Geographical location of the Marun-Jarahi basin in southwest Iran

The heavy dependence of agriculture on surface water flows and the diversity in cropping patterns complicate allocation management within this basin. Ensuring a sustainable water supply for downstream ecosystems, particularly for date palm plantations and the Shadegan wetland, represents one of the most significant challenges in the basin. Given these climatic constraints, high social sensitivities, and the specific context of local communities reliant on agriculture, integrated and simultaneous management of water resources and consumption holds paramount strategic importance for this basin.

3. MATERIALS AND METHODS

3.1 *Conceptual framework for participatory management in the IWRM context*

The conceptual framework presented in this study serves as a complementary and enabling layer for the operational implementation of Integrated Water Resources Management (IWRM). Unlike traditional approaches that often rely on centralized, top-down management, this framework shifts the decision-making paradigm toward a participatory, decentralized, and horizontal model. This fosters “Shared Awareness” and mutual understanding among diverse stakeholders, promotes political commitment, and facilitates the effective engagement of stakeholders and key actors throughout all stages of planning, allocation, management, and monitoring of water resources and consumption.

In this structure, senior county representatives act not as mere recipients of decisions but as strategic partners working alongside provincial managers. This approach is grounded in continuous data exchange, transparency, and the enhancement of a common understanding regarding water resource status. This framework aligns with international literature emphasizing the roles of multi-level governance, stakeholder participation, and social learning in enhancing the adaptive capacity of water systems (Pahl-Wostl, 2009). From this perspective, participation is effective only when it is institutionalized across all stages—problem diagnosis, options assessment, execution, and monitoring—rather than being limited to mere consultation.

3.2 *Stakeholders and composition of the participatory structure*

The composition of this structure includes a network of stakeholders and relevant institutions at both local and provincial levels. The objective of this integration is to create sustainable convergence between the technical requirements of water management, institutional implementation capacities, and the socio-economic realities of the basin, thereby providing a foundation for aligning technical considerations with operational needs and stakeholder concerns.

3.3 *Operational framework for participatory management*

The operational framework designed to implement this participatory model is based on two fundamental dimensions: “spatial” and “temporal,” with a high degree of flexibility.

In the **spatial dimension**, considering the political-administrative structures and the necessity to manage social tensions, the “county” has been designated as the smallest basic unit for participation, planning, and monitoring. This facilitates the management of local conflicts.

In the **temporal dimension**, this structure is fully aligned with the hydrological cycles, agricultural seasons, and key stages of dam operation. Participatory meetings and working groups are convened at sensitive and decision-making junctures of the water year. These junctures include:

- Initial planning for determining the optimal cropping pattern.
- Adjusting the water release schedule from dam reservoirs.
- Designing rationing programs during water stress conditions.
- Monitoring and evaluating the allocated amounts.

In this cyclical process, the outputs from technical models and data provided by specialists (such as supply and demand forecasts) are integrated with the demands, field experiences, and livelihood constraints of local stakeholders. This approach ensures that water allocation plans are implemented in the field with the highest level of social commitment. Figure 2 illustrates the schematic structure of this operational framework.

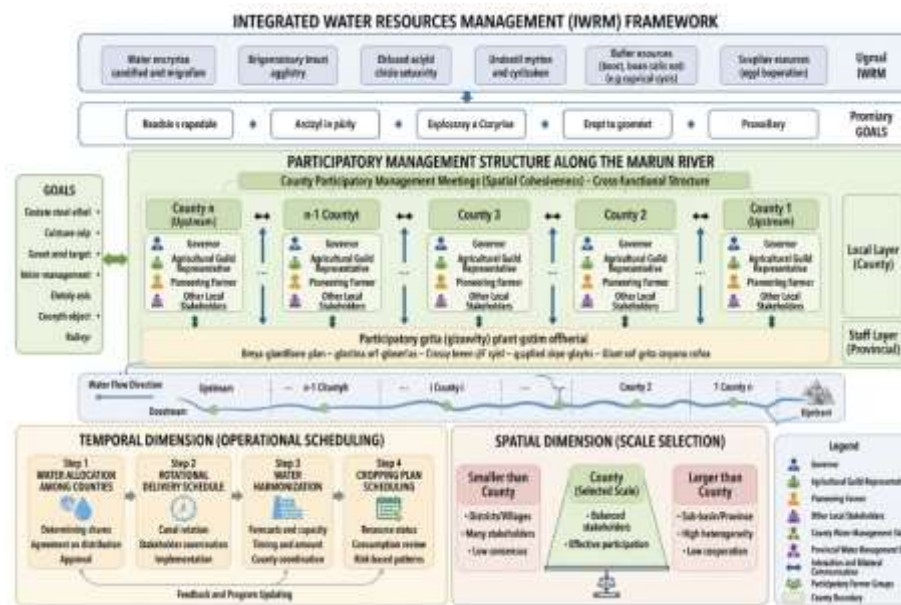


Figure 2. Operational Framework for Participatory Management of Water Resources and Consumption in the Marun-Jarahi basin, Aligned with the IWRM Decision-Making Cycle.

3.4. Process of establishing the participatory management structure

The process of establishing the participatory management structure along in the Marun River emerged in response to the severe drought crisis of the year 1400 (Iranian calendar) and its subsequent social repercussions. At that time, a sharp decline in water resources and a failure to achieve water equity, in addition to exacerbating economic and environmental damages, led to widespread social tensions and a decrease in public trust towards the water resource management system. Consequently, creating a mechanism to enhance transparency, gain stakeholder participation, and strengthen the legitimacy of decisions became a priority. This process can be explained through a multi-stage evolutionary cycle:

1. **Problem Identification:** The initial stage involved reaching a consensus on the necessity of changing the water governance approach, analyzing social tensions, and identifying key stakeholders.
2. **Framework design and initial meetings:** This stage faced significant challenges, including insufficient support from the political sector, mistrust from farmer representatives regarding the structure's effectiveness, and weak social capital.
3. **Trust-building and transparency:** Through the consistent provision of supply and demand data, explanation of hydrological limitations, and the direct involvement of stakeholders in water distribution plans, mutual trust and social acceptance were gradually enhanced.
4. **Operational maturity:** Participatory meetings became an integral part of the formal planning process. Decisions related to cropping patterns, water releases, rationing, and water allocation among counties were implemented with the backing of stakeholder participation.

Over a four-year period, this structure evolved from an emerging mechanism to an accepted institution and a public demand. The effectiveness of this process was clearly demonstrated during the severe drought of the water year 1403–1404 (Iranian calendar), which, while reducing social tensions, also established effective coordination between local and provincial levels. The evolutionary spectrum of this approach and the enhancement of interaction levels from information dissemination to joint decision-making are presented in Figure 3.

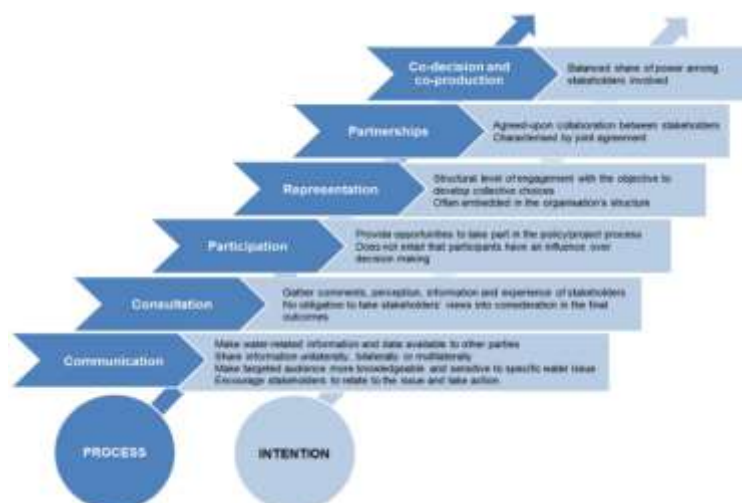


Figure 3. Evolutionary levels of stakeholder participation in water governance; from information sharing to co-production and co-decision-making (adapted from standard participation frameworks)

3.5. Monitoring data and tools

For the purpose of technical support, enhancing information transparency, and controlling deviations in the participatory management structure, an integrated network for monitoring water resources and consumption was designed and deployed in the Marun-Jarahi basin along four axes:

3.5.1. Rain gauge network

The rain gauge network was utilized to monitor the spatial and temporal distribution of rainfall during the cropping season and to assess the contribution of rainfall to meeting the water requirements of the downstream areas of the Marun Dam. The data from this network were used to evaluate rainfall's contribution to downstream water needs and to forecast local runoff, thereby serving as a basis for adjusting and modifying water distribution plans in conjunction with the Marun Dam's release schedule.

3.5.2. Hydrometry network

The hydrometry network, supported by hydrometric stations, served as the primary tool for controlling the implementation of water allocation plans through real-time, hourly monitoring of transit flows and withdrawal volumes for each county. The resulting data formed the basis for evaluating the performance of operational units and ensuring compliance with quotas approved by the participatory working group.

3.5.3. Satellite-based monitoring

Using Sentinel-2 satellite imagery, the trends in cultivated area development and land moisture status were continuously observed. The regular extraction of this data and its presentation to stakeholders provided the necessary transparency to control crop compliance with approved plans.

3.5.4. *Drone monitoring*

This field monitoring tool was employed to identify unauthorized withdrawals and document violations in critical areas. Alongside other data, it enabled the participatory management structure to react quickly and implement control measures.

3.5.5. *Summary of the monitoring network's performance in participatory management*

The integration of field data and remote sensing technologies made it possible to continuously monitor resources and consumption at multiple levels. By enhancing transparency, precisely controlling implementation deviations, and strengthening accountability, this integrated network ensured the effectiveness of the participatory management institution. The simultaneous use of these tools in data-driven water governance is essential for independent verification and rapid response to violations (Bastiaanssen et al., 2000; Karimi et al., 2013).

3.6. *Macro-level participatory planning process*

The most important manifestation of participatory management in the Marun-Jarahi basin is the joint decision-making of stakeholders at the beginning of the cropping seasons (October for autumn crops and April for summer crops) regarding the available water volume, county quotas, and cropping patterns. Given the eight-month decision-making horizon for autumn cropping and the shorter horizon of seasonal meteorological forecasts, managing this gap requires a shared understanding of uncertainties. In this process, experts first present reports on hydrological conditions, reservoir storage, climate forecasts, and initial allocation scenarios.

Then local representatives, who have become familiar with technical terminology during the establishment of this structure, express their views on farmers' resilience, risk tolerance thresholds, and operational constraints. This interaction makes the final decisions socially acceptable and operationally realistic. In the drought management literature, shifting planning from a reactive to a proactive approach requires the development of mechanisms for risk assessment, scenario planning, and stakeholder participation in understanding and accepting uncertainty (Wilhite et al., 2014; UNDRR, 2022). Accordingly, participation in macro-level planning is considered one of the main strengths of the model examined in this study.

3.7. *Participatory process in program implementation*

After the macro plans are approved, the implementation phase begins with a focus on distribution scheduling and management of water releases from the Marun Dam. In operational meetings, the release schedule and each county's quota are coordinated, and each region undertakes to withdraw its legal share while ensuring and delivering the water required by downstream areas up to the outlet hydrometric stations of the county. Monitoring of this process is carried out in an integrated manner through technological tools (sensing networks, satellite imagery, and drones, consistent with the framework presented in Section 3.5). The distinctive feature of this stage is maximum transparency and the continuous sharing of data among task force members; so that any deviation from the plan or unauthorized withdrawal is quickly and transparently communicated to all members. This approach enables rapid response to violations, socially supported corrective action, a significant reduction in conflicts, and greater mutual trust between upstream and downstream stakeholders.

4. **OUTCOMES AND ACHIEVEMENTS OF IMPLEMENTING THE PARTICIPATORY MANAGEMENT STRUCTURE**

An evaluation of the performance of the participatory management structure in the Marun-Jarahi basin shows that the establishment of this governance system has had significant effects on improving water allocation efficiency, reducing vulnerability to drought, enhancing water equity, and decreasing social conflicts. The most important achievements are as follows:

4.1 Enhancing food security and developing strategic crop cultivation

The implementation of these programs over four years led to an approximate doubling of strategic autumn crop production (especially wheat) compared to previous periods. This achievement was realized while water resource consumption decreased. From a policy perspective, the simultaneous improvement of water productivity and strategic crop production is a key indicator of progress towards sustainable food security in water-scarce regions (UN-Water, 2021). The Marun-Jarahi basin experience demonstrates that the synergy between technical analysis and a participatory mechanism can achieve this outcome.

4.2 Modifying and adapting the cropping pattern to water resource constraints

One of the key results was the creation of consensus for modifying the cropping pattern in line with drought conditions. In this regard, the cultivation of rice (a crop with high water requirements), despite its economic benefits, was entirely removed from the basin-wide cropping pattern by the full agreement of stakeholders. This action significantly reduced pressure on water resources and increased the sustainability of meeting priority consumptive uses.

4.3. Sustainable water supply for the Shadegan date palm groves as the most vulnerable downstream area

The results indicated that the Shadegan date palm groves (the furthest and most vulnerable area relative to the dam) received a sustainable water supply even during the most severe historical droughts. Upstream and downstream coordination and collective commitment to quotas made the effective supply of this sensitive sector's needs possible. In the water governance literature, attention to vulnerable downstream areas is linked to concepts such as distributive justice and the safeguarding of water-dependent livelihoods (Boelens et al., 2018; UNESCO, 2024). Accordingly, the water sustainability for Shadegan is a key indicator of this structure's success.

4.4 Promoting water equity, public trust, and social participation

The transparency of data and the direct participation of local representatives in decision-making and implementation enhanced the indicators of water equity. This process, in addition to increasing public trust in management decisions, strengthened social capital, stakeholder accountability, and their effective participation in program implementation.

4.5. Reducing tensions and social conflicts related to water

A comparison of the basin's conditions before and after the establishment of this structure indicates a significant reduction in water tensions. The transparent mechanism for information exchange and the formation of a shared understanding of limitations played an important role in reducing distrust and increasing social acceptance of decisions (especially during recent droughts). The reduction of water conflicts is an expected outcome of participatory governance, provided that the participation process is not merely formal and is fully transparent and accountable (Zeitoun et al., 2011; OECD, 2015). The findings of this study are also fully aligned with this analytical path.

DISCUSSION

The findings of this study indicate that the success of the model examined in the Marun basin was not solely due to reduced consumption or restricted withdrawals. Instead, it resulted from the synergy between technical capacity and participatory mechanisms in managing water resources and uses. In other words, hydrological analyses, reservoir planning, climate forecasts, and monitoring tools became effective when employed within a transparent, participatory framework that was accepted by stakeholders. This outcome aligns with studies emphasizing the link between technical knowledge and social legitimacy in water governance (Pahl-Wostl et al., 2012).

Another important point is the selection of the county as the basic unit for participation. In practice, this choice has created a balance between the social scale and the management scale, preventing excessive fragmentation of the decision-making process on one hand, and avoiding decisions that are detached from local realities on the other. This can be considered one of the Marun-Jarahi model's practical innovations, which also has potential relevance for other basins in the country. From a comparative perspective, the Marun-Jarahi basin experience can be categorized alongside models where stakeholder participation is not a separate institutional mechanism but is integrated with the formal processes of water allocation, planning, and implementation. For example, some adaptive water management experiences in Europe and Australia emphasize social learning, multi-level governance, and institutional adaptability under uncertainty (Pahl-Wostl, 2007; Huitema et al., 2009). In contrast, many water user association models in Asia and the Middle East have focused participation primarily at the local water distribution or system maintenance levels, with less connection to basin-wide macro-allocation and planning decisions (Meinzen-Dick, 2007; Suhardiman et al., 2017). The distinctive feature of the Marun-Jarahi basin experience is that participation is directly integrated into critical decision-making points, including seasonal planning, release scenarios, and rotational turn-taking and delivery between upstream and downstream areas.

Furthermore, this experience shares similarities with documented cases in arid and semi-arid regions globally, where successful water management depended not only on technical efficiency but also on the governance system's ability to build trust, ensure information transparency, and transform conflict into a dialogue mechanism (Molle, 2008; OECD, 2015). However, a significant difference in the Marun-Jarahi basin is that the participatory structure developed in a context with high agricultural benefit diversity along the river, as well as ecologically and livelihood-sensitive downstream areas, including date palm groves and wetlands. This combination positions participatory management in the Marun-Jarahi basin as more than just a consultative tool; it functions as an executive mechanism for balancing efficiency, equity, and resilience. Within this framework, the Marun-Jarahi basin experience can be conceptually linked to "adaptive governance" and "multi-level participatory governance" models, which emphasize the capacity of institutions to learn, revise decisions, adapt to new information, and engage continuously with stakeholders (Folke et al., 2005; Pahl-Wostl, 2009). However, unlike some international examples where participation occurred within more stable institutional settings and with more extensive data infrastructure, the participatory structure in this study evolved in response to a crisis situation through a gradual process of trust-building, transparency, and institutionalization. This characteristic could be particularly significant from a policy standpoint for other allocation-stressed basins in Iran and the region.

Nevertheless, it is important to note that the generalizability of this experience to other basins is contingent upon several prerequisites: access to reasonably reliable data, the existence of at least a minimum institutional capacity for inter-sectoral coordination, the possibility for effective stakeholder representation, and sustained managerial and political support for the participatory mechanism (OECD, 2015; World Bank, 2023). In the absence of these prerequisites, there is a risk that participation could become merely formal or lose its effectiveness.

From a methodological standpoint, one of the limitations of this paper is that some of the results are based on operational and empirical evidence and have not yet been translated into a set of standardized quantitative indicators over a long-term period. Therefore, it is recommended that future studies systematically quantify and analyze indicators such as water productivity, conflict intensity, adherence to quotas, changes in cultivated area, and indicators of perceived equity and trust.

SUMMARY AND CONCLUSION

This research, by examining the water management experience in the Marun-Jarahi basin, demonstrated that improvements in the system's performance cannot be explained by simple, single-factor explanations. Notably, the findings suggest that restricting summer cultivation alone did not necessarily increase reservoir storage or guarantee improved water management. Instead, the key difference compared to the previous water year lay in the synergy between correct technical planning

for releases, alignment with actual irrigation times and cropping patterns, and participatory management during the water consumption phase.

The main achievement of this experience has been the optimization of water allocation and consumption while maintaining, and even improving, agricultural performance. This result is significant because it shows that under water scarcity conditions, a reduction in available water does not necessarily lead to a decline in productivity, provided that the governance system can establish a connection between technical planning, timely implementation, information transparency, and stakeholder cooperation. In other words, a portion of the pressure resulting from scarcity can be compensated for by enhancing governance quality and operational efficiency.

From a theoretical perspective, this study supports the view that sustainable water allocation in arid and semi-arid basins depends on the interaction between hydrological efficiency and institutional legitimacy. Neither technical planning without adequate social backing nor participation without a technical foundation can lead to sustainable outcomes. Participatory governance is most effective when technical and social dimensions are considered complementary components of a single management system.

From a policy perspective, the results of this research emphasize the necessity of institutionalizing participatory governance in water allocation, improving release planning based on timely and field-based information, strengthening user associations and local mediation mechanisms, and better linking water policy with decisions regarding cropping patterns and agricultural support. Therefore, the Marun-Jarahi experience can serve as an important practical and analytical example for other basins in the country seeking more sustainable pathways for agricultural water allocation under conditions of scarcity.

ACKNOWLEDGEMENTS

The authors deem it necessary to express their sincere gratitude to the Khuzestan Water and Power Authority (as the main sponsor of this idea and its implementer), the Provincial Agricultural Jihad Organization, the Governorship of Khuzestan, agricultural professional associations, and the farmer representatives in the basin for their cooperation in the planning, coordination, information exchange, and implementation of actions related to participatory management in the Marun-Jarahi basin. We also extend our sincere thanks for the intellectual and scientific support of the ICID International Research Program for Irrigation and Drainage – Iran Regional Node (ICID IRPID-IRN). Undoubtedly, achieving the results of this research would not have been possible without the constructive cooperation and interaction of executive and technical institutions at local, national, and international levels.

REFERENCES

- Allan, J.A. 2001. *The Middle East Water Question: Hydropolitics and the Global Economy*. I.B. Tauris. London.
- Ashraf, B., A. AghaKouchak, A. Alizadeh, M.M. Baygi, H. Moftakhari, A. Mirchi, K. Madani and E. Hassanzadeh. 2021. Anthropogenic drought dominates groundwater depletion in Iran. *Sci. Rep.* 11: 9135.
- Bastiaanssen, W.G.M., D.J. Molden and I.W. Makin. 2000. Remote sensing for irrigated agriculture: Examples from research and possible applications. *Agric. Water Manage.* 46(2): 137-155.
- Biswas, A.K. 2004. Integrated water resources management: A reassessment. *Water Int.* 29(2): 248-256.
- Boelens, R., J. Vos and T. Perreault. 2018. Water justice and hydrosocial territories. *Water Int.* 43(1): 1-14.
- FAO. 2023. *The State of the World's Land and Water Resources for Food and Agriculture 2023: Systems at Breaking Point*. Food and Agriculture Organization of the United Nations. Rome.
- Folke, C., T. Hahn, P. Olsson and J. Norberg. 2005. Adaptive governance of social-ecological systems. *Annu. Rev. Environ. Resour.* 30: 441-473.
- Global Water Partnership. 2000. *Integrated Water Resources Management*. TAC Background Papers No. 4. Global Water Partnership. Stockholm.

- Huitema, D., E. Mostert, W. Egas, S. Moellenkamp, C. Pahl-Wostl and R. Yalcin. 2009. Adaptive water governance: Assessing the institutional prescriptions of adaptive co-management from a governance perspective and defining a research agenda. *Ecol. Soc.* 14(1): 26.
- IPCC. 2023. Climate Change 2022: Impacts, Adaptation and Vulnerability. Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. Cambridge.
- Karimi, P., W.G.M. Bastiaanssen, D. Molden and M.J.M. Cheema. 2013. Basin-wide water accounting based on remote sensing data: An application for the Indus Basin. *Hydrol. Earth Syst. Sci.* 17(7): 2473-2486.
- Medema, W., B.S. McIntosh and P.J. Jeffrey. 2008. From premise to practice: A critical assessment of integrated water resources management and adaptive management approaches in the water sector. *Ecol. Soc.* 13(2): 29.
- Meinzen-Dick, R. 2007. Beyond panaceas in water institutions. *Proc. Natl. Acad. Sci. U.S.A.* 104(39): 15200-15205.
- Mirumachi, N. 2015. *Transboundary Water Politics in the Developing World*. Routledge. London.
- Molle, F. 2008. Nirvana concepts, narratives and policy models: Insights from the water sector. *Water Altern.* 1(1): 131-156.
- OECD. 2015. *OECD Principles on Water Governance*. Organisation for Economic Co-operation and Development. Paris.
- Ostrom, E. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge University Press. Cambridge.
- Pahl-Wostl, C. 2007. Transitions towards adaptive management of water facing climate and global change. *Water Resour. Manage.* 21(1): 49-62.
- Pahl-Wostl, C. 2009. A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. *Glob. Environ. Change.* 19(3): 354-365.
- Pahl-Wostl, C., G. Holtz, B. Kastens and C. Knieper. 2012. Analyzing complex water governance regimes: The management and transition framework. *Environ. Sci. Policy.* 23: 24-34.
- Suhardiman, D., K. Righetti and F. Molle. 2017. Policy debates and actors' strategies on water users association reform in Asia. *Water Int.* 42(1): 1-10.
- UNDRR. 2022. *Global Assessment Report on Disaster Risk Reduction 2022: Our World at Risk*. United Nations Office for Disaster Risk Reduction. Geneva.
- UNESCO. 2024. *United Nations World Water Development Report 2024: Water for Prosperity and Peace*. UNESCO. Paris.
- UN-Water. 2021. *Summary Progress Update 2021: SDG 6 Water and Sanitation for All*. United Nations. New York.
- Weinthal, E., J. Troell and M. Nakayama, eds. 2014. *Water and Post-Conflict Peacebuilding*. Routledge. London.
- Wilhite, D.A., M.V.K. Sivakumar and R. Pulwarty. 2014. Managing drought risk in a changing climate: The role of national drought policy. *Weather Clim. Extremes.* 3: 4-13.
- World Bank. 2023. *What the Future Has in Store: A New Paradigm of Water Storage*. World Bank. Washington, DC.
- Zeitoun, M., N. Mirumachi and J. Warner. 2011. Transboundary water interaction I: Reconsidering conflict and cooperation. *Int. Environ. Agreements.* 11(4): 387-408.