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Stakeholders' Interaction in Water Management System: Insights from a MACTOR Analysis in the R'Dom Sub-basin, Morocco

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Abstract

This paper aims to examine the stakeholders' interaction in the water management system at the R'Dom Sub-basin (Morocco). For this purpose, The MACTOR participatory approach was implemented to involve all key water stakeholders and to analyze their interactions. The action system was characterized by the analysis of related water issues and relevant actors on the ground. Thus, ten actors and twelve objectives were identified and assessed in this study. The analysis of stakeholder role allowed to identify the typology of stakeholders according to their strategic objectives and to evaluate their power, influence and dependence, as well as their convergence in a global water cycle management. The results show a significant level of convergence among stakeholders, despite the existence of certain stakeholders who may be considered autonomous, given their low involvement in integrated water management. Furthermore, there was a limited involvement of stakeholders in certain strategic objectives such as capacity building, technical means, and awareness-raising actions. The paper shows the need to generate greater collaborative efforts among water stakeholders involved in the implementation of integrated water resources management in the R'Dom sub-basin.

Keywords Water Management · R'Dom Sub-basin · Stakeholders' interaction · MACTOR analysis

Introduction

Economic development, population growth and urbanization have led to an increasing water demand, accompanied by higher levels of pollution, especially in arid and semi-arid areas where water resources are generally limited (Okello et al. 2015). Therefore, management models have played a crucial role in the rational exploitation of available resources even if they are limited. These models can be impacted by several factors, of which the human factor has an important contribution (Ahmadov 2020). Taking into account the specificities of each region and territory, water managers and water users adopt specific methods that are sometimes adapted to the local contexts (Akhmadiyeva and Abdullaev 2019; El Mezouary et al. 2020b). In this way, the integrated water resources management (IWRM) framework has been widely used as management approach that takes into consideration, in a combined manner, economic, environmental, and social aspects (Collins et al. 2020; Giordano and Shah 2014; Lenton 2011; Schröder 2019). In line with the IWRM approach, the sharing of water data and information among actors, as well as stakeholder participation, represent essential supporting elements for water resources management policy planning and implementation (El Mezouary et al. 2020a; Godinez-Madrigal et al. 2019; Jarar Oulidi 2019). Several water managers and experts have developed and used various models and analysis tools to support the implementation of water management policies (Cosgrove and Loucks 2015; El Mansouri and El Mezouary 2015; Elhassnaoui et al. 2021; Hermans 2005; Hermans and Thissen 2009; Saleem et al. 2021). However,

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experience has shown a gap between the work of stakeholders and the real use of proposed solutions by water experts, despite their use of new and advanced technologies (Hermans 2005; Pellegrini et al. 2019). As for the role of policy makers, they often do not implement the solutions proposed by the different actors, especially the water experts, which is mostly linked to a misunderstanding of the water management issue (Hargrove and Heyman 2020; Morrison 2003; Pahl-Wostl et al. 2020). In the literature review, several methods of stakeholder analysis were used to solve water resources issues (Ennabili 2020). These used methods take actors as a starting point and produce knowledge about the involved actors in the water sector, their interests and influences, and their strategic objectives (Ahmad and Al-Ghouti 2020; Hermans 2005; Libiad et al. 2020; Yeo and Benchekara 2015). However, in Morocco, the interaction between stakeholders in water management remains a field that still needs further investigation (Ait Kadi and Ziyad 2018; Hargrove and Heyman 2020; Hermans and Thissen 2009; Ingold and Tosun 2020). This context led us to reflect on the analysis of the interaction among different stakeholders and the exploration of their future roles within the overall water management system in Morocco, with a case study at the level of the R'Dom sub-basin in the Meknes region. The analysis of stakeholders' interaction in the field of water management is justified by several changes in the water management system in Morocco. These changes are manifested by the development of a new water law (Law no. 36-15) in 2016. This law has redefined the responsibilities of water stakeholders and introduced new bodies in the water sector, such as the hydraulic basin council, and new fields of action, such as the mobilization of non-conventional water sources (Ait Kadi and Ziyad 2018, p. 201; Hssaisoune et al. 2020; Legrouri et al. 2019). On the other hand, the adoption of the 2030 Agenda and its Sustainable Development Goals (SDGs) in 2015 is an additional reason to highlight the interaction among different stakeholders.

Furthermore, Morocco has developed a National Water Plan, which is based on three pillars, (1) water demand management and water development, (2) water supply development, and (3) preservation of water resources, and adaptation to climate change. This plan constitutes a roadmap to deal with the challenges of water over the next 30 years (2020–2050). In addition, the introduction of new technologies in the water sector, such as the use of decision support tools and real-time water management make it necessary to position the various stakeholders in the management system, with the aim of achieving an integrated and sustainable water management system (Jarar Oulidi 2019; Johansen 2018; Mapani et al. 2019). In this context, it appeared useful, even necessary, for a key public sector such as the water sector to identify the main issues and major actors related to water management, understand their strategies and identify the main synergies and potential conflicts (Ennabili and Radoux 2022). This questioning of the interactions among actors will allow decision makers and political actors to understand the dynamics of the system that integrate all actors and to frame their future intervention in the implementation of water-related public policies (Brown et al. 2020; Fritsch and Benson 2019; Ingold and Tosun 2020; Pezij et al. 2019). The objective of this paper is to conduct the analysis of stakeholder's interaction in water management system at the level of the R'Dom sub-basin. To do this, we adopted a participatory approach through the involvement of key stakeholders in the definition of objectives and possible interactions and influences between stakeholders.

Case Study

Study Area Characteristics

The study area is located in northwestern Morocco, about 140 km east of Rabat city and 60 km west of Fez city. Geographical coordinates are: Latitude: 33°53′36″ North, Longitude: 5°32′50″ West, Elevation: 531 m. It is an area that extends 35 km from east to west and about 50 km from north to south (Tahri 2005) (Fig. 1). The area is characterized by a semi-arid climate, intra-annual variability of temperature, and an average annual rainfall of 500 mm, recorded in the Meknes station (Allaoui 2019; Kessabi et al. 2022). The surface water, in the R'dom sub-basin, is represented by the R'dom River and the confluence of the Boufekrane, Ouislane and Bouishak rivers (Alitane et al. 2022). The rivers are strongly dependent on the springs that feed them. The Atrous, Ribaa, and Bittit springs are the most important and are found in the foothills of the El Hajeb-Ifrane Plateau; they are located about 30 km South-East of the Meknes city (Amraoui et al. 2004; Ben-Daoud et al. 2021).

The surface water is used for irrigation and to supply the Meknes city with drinking water (Ben-Daoud et al. 2021; Essahlaoui 2000; Kessabi et al. 2022). Others springs are located 20 km south of the Meknes city, such as Aghbal, Boujaoui and Maarouf, and they are also used to supply drinking water to the Meknes city. From a hydrogeological point of view, there are two important aquifers in the R'dom sub-basin, the deep aquifer and the Plio-Quaternary aquifer (El Mezouary et al. 2015; Essahlaoui 2000; Kessabi et al. 2022). The region is marked by important economic activities, such as agriculture and food industry (Ben-Daoud et al. 2012). These important economic activities have a negative impact on water sustainability in terms of quality and quantity (Ben-Daoud et al. 2011). Moreover, the water

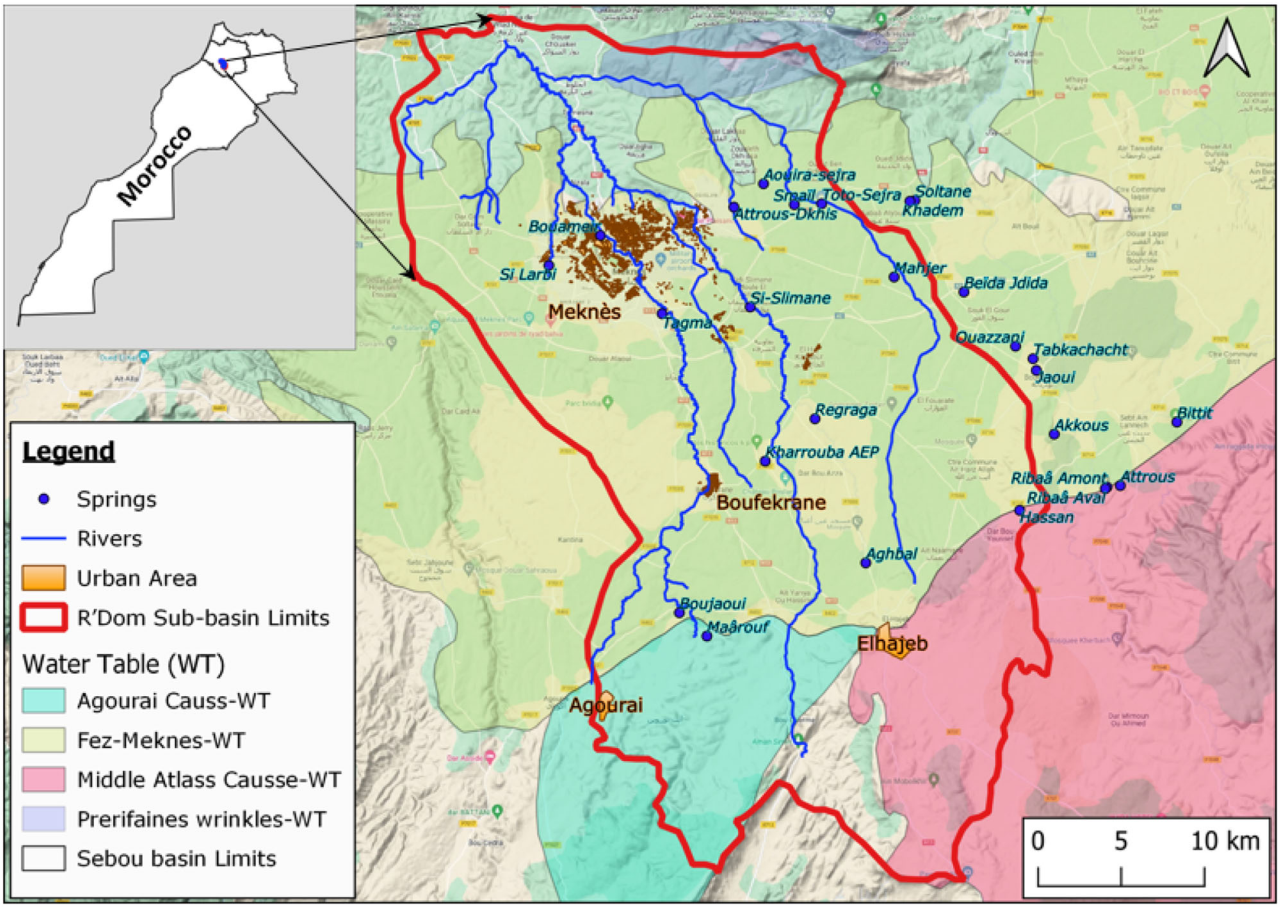

Fig. 1 Study area location

management system in the region is experiencing several challenges, such as, the overexploitation of the water table, controlling the intensification of agricultural activities that consume groundwater resources and the establishment of policies that mix awareness raising and regulation.

Water Management Stakeholders in the Study Area

Water management policy in Morocco has progressed through two distinct phases. The first phase was characterized by a water supply management through the development of hydraulic infrastructure and the construction of dams (Ait Kadi and Ziyad 2018; Ben-Daoud et al. 2021; Legrouri et al. 2019). The second phase was characterized by water demand management, which was supported by the development of the water strategy 10 years later. Beyond this policy, there exists a legal and institutional arsenal allowing the implementation of the water resources management policy at different scales (Ben-Daoud et al. 2021, p.). Several actors are involved in the water sector in Morocco. Some of them are involved at both the national and local levels (Ait Kadi and Ziyad 2018; Legrouri et al. 2019) (Fig. 2).

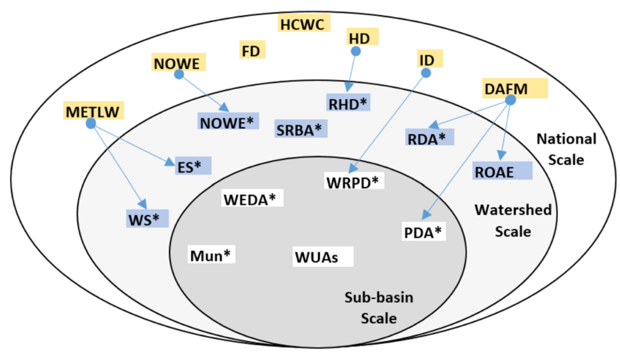

Fig. 2 Relevant water management stakeholders in the study area (*involved stakeholders in the present study). National scale actors: METLW: Ministry of Equipment, Transport, Logistics and Water; HCWC: Higher Council Water and Climate; DAFM: Department of Agriculture and Fisheries Maritime; ID: Interior Department; HD: Health Department; FD: Finance Department. Watershed and sub-basin actors: SRBA: Sebou River Basin Agency; WEDA: Water and Electricity Distribution Agency; NOWE: National Office of Water and Electricity; RDA: Regional Direction of Agriculture; PDA: Provincial Department of Agriculture; ES: Environmental Service; RHD: Regional Health Department; WS: Water Service; Mun: Municipalities; WRPD: Water Research and Planning Directorate; WUAs: Water Users Associations; ROAE: Regional offices for agricultural enhancement

Table 1 Roles and responsibilities of water stakeholders

Stakeholders	Roles & responsibilities
METLW ES WS	Coordination, promotion and protection of water resources at the national level. Enforcement of legislation and the reduction of pollution in aquatic ecosystems.
HCWC	Strengthen coordination between actors, including ministries, public agencies and water users, Assessing the national strategy on climate change and its impact on water resources.
DAFM RDA PDA ROAE	Supervising irrigation management. Management of hydraulic facilities for small and medium hydraulics (SMH) and the expansion of water saving techniques Implementation of agricultural projects Support of irrigators in changing their practices, particularly in the grouping of water users in associations
ID WRPD	Engaged in water management. Assists local communities in solving water and sanitation problems.
HD RHD	Monitoring drinking water quality Developing water standards
FD	Supervises the fiscal aspects of utilities and the awarding of concession contracts, as well as proposals for rate adjustments
SRBA	Entrusted with the regulation, management and the development of water resources, Supervision and regulation of water usage and quality, and the planning of water-related emergencies
WEDA	Supply of drinking water to the urban agglomerations of the Meknes prefecture, Management of hydraulic facilities and treatment of wastewater
NOWE	Generalization of access to electricity and drinking water, wastewater treatment, Extension of production, marketing and distribution networks of water resources,
Mun	Generalization of drinking water and sanitation services and choice of management options through the creation of autonomous communal services, or the assignment of management to private concessionaires,
WUAs	Participative management with decentralized services. Local interlocutors and guarantors of the financing of infrastructures within the framework of the policy of participative management of irrigation

To facilitate the identification of the stakeholders involved in the following research, the role of each actor is provided in Table 1. It should be noted that not all of these water stakeholders were questioned within the framework of this study, either because of the arbitrations made on the final choice concluded by the participants in the workshop, or because the positions of the actors excluded from the exercise were already represented through their decentralized services (case of the ministerial departments).

Materials and Methods

In this paper, stakeholder interaction was defined as a mode of regulation of the relationships among a set of actors in the water resources management system. To analyze their interaction in the R'Dom basin, this paper proposes a methodological approach inspired by the strategic analysis of Crozier and Friedberg (1980) as a theoretical framework. Crozier and Friedberg's (1980) approach emphasizes the relational aspect of power between stakeholders where power is a "relationship/interaction" between people/actors linked by common issues. As for the empirical framework, the MACTOR (Method Actors, Objectives, and Force Reports) model served as a coherent tool for this approach (Crozier and Friedberg 1980; Godet 1994). Thus, MACTOR is a method to support actors to decide on the implementation of their alliance and conflict policies. Moreover, several workshops and meetings were organized to classify the 10 organizations involved as key stakeholders in water resources management in the study area and to collect the necessary data for the stakeholder analysis (Hermans and Thissen 2009; Schmidt et al. 2020).

Identifying actors and objectives

The first step in data analysis is the identification of key stakeholders, which play a major role in the integrated water resources management system in the R'Dom sub-basin (Yeo and Benchekara 2015). Thus, the selected stakeholders were mobilized and interviewed through a participatory approach including the presentation of the study objectives (Godet 2013).

In order to be included in a MACTOR analysis, a stakeholder (actor) is considered as a social or economic group with a capability of action, and organized through a strategy, to achieve its objectives (Crozier and Friedberg 1980; Godet 1994). In this research, stakeholders were only represented by public bodies and institutions, as they are the main contributors to the water management process and are closely related to water problems in the region (Ben Nasr and Bachta 2018). All administrative actors were consulted in depth, which helped legitimize the participatory process and build trust between the research team and involved stakeholders (Ben Nasr 2015). The number of interviewees was chosen based on criteria that allowed access to reliable data such as specialty, area of expertise, involvement in the water management process and many others. Indeed, all interviewees have a profile that allows them to provide sufficient and reliable information on water management issues in the study area (Ben-Daoud et al. 2021).

The participatory approach was conducted through discussion workshops and working meetings with stakeholders to address the issue of stakeholder interaction in the IWRM process. Stakeholders' engagement led to the identification of expected goals for each stakeholder that are embedded in their future policy agenda (Smyth et al. 2020; Tuokuu et al. 2019). A list containing twelve objectives was established (Table 2). These goals were explained and described in sufficient detail to allow for a methodological assessment of each actor's position (Yeo and Benchekara 2015).

Data collection

As for the data collection methodology, participants were asked during a workshop to rate their appreciation of the influence of each stakeholder on the others. The influences and affinities to the objectives were noted according to the MACTOR method from (0) to (4) depending on the importance of the possible challenge for the stakeholder (Godet 2010; Knaggård et al. 2019), (Table 3).

The construction of data analysis took place in two stages, which were conducted in parallel, (1) conducting the individual meetings with each stakeholder and (2) conducting workshop sessions bringing together all the stakeholders (Hermans and Thissen 2009; Manzano-Solís et al. 2019). The confrontation between the key feedbacks from the interviews, and the reflections of the working group made it possible to

Table 3 Scoring system based on the MACTOR method

Matrix of Direct Influences (MDI)	
Score	Classes (Influence between actors)
0	No influence
1	Operating procedures
2	Project
3	Missions
4	Existence
Valued Position Matrix (2MAO)	
Score	Classes (Objective level and affinity to the objectives)
0	Objective has a bleak outcome
1	Objective is vital for its operating procedures (management, etc…)
2	Objective is vital for the success of the actor's projects
3	Objective is indispensible for the accomplishment of the actor's mission
4	Objective is indispensible for the actor's existence

Table 2 List of strategic objectives

Objectives	Acronyms
1. Ensure the continuity of water resource data, which makes it possible to assess the impact of the use on the environment	Water Data
2. Implement tools allowing the production of integrated water management indicators over a long period	Assessing.Tool
3. Leading a reflection and action at the watershed scale	Man.scale
4. Taking a global vision of the multiple water uses and take them into consideration in water management	Water.U.I
5. Strengthen the partnership between different water stakeholders	Partn.lev
6. Strengthen participation with steering groups and working meetings with a large number of stakeholders	Stak.consu
7. Make a large number of awareness campaigns aimed at the public and all users of water resources.	Awareness
8. Ensure a Long-term stable funding integrating other uses and environment preservation	Funding
9. Ensure the compliance with water laws and standards (Law 10-95; Law 36-15; Standards…)	Regulation
10. Implement applicable techniques adapted to integrated water management	Tech.means
11. Adopt a medium- or long-term planning taking into account parameters evolution	Planning
12. Develop a capacity-building plan that meets the needs	Capa.build

Table 4 Matrix of direct influences (MDI)

	WEDA	NOWE	SRBA	RDA	PDA	ES	RHD	WS	WRPD	Mun
WEDA	0	4	1	0	0	1	2	1	3	4
NOWE	4	0	2	0	0	1	1	3	4	4
SRBA	2	3	0	3	1	4	3	3	3	3
RDA	0	1	0	0	4	1	1	1	1	0
PDA	1	1	0	4	0	1	1	1	1	0
ES	2	2	2	1	1	0	2	2	2	1
RHD	2	0	1	0	0	1	0	1	0	1
WS	4	4	4	3	2	1	1	0	2	4
WRPD	4	3	4	1	1	2	0	1	0	3
Mun	2	0	0	0	0	1	2	0	2	0

delimit the system database to be taken into account in the MACTOR analysis (Anggraeni et al. 2019; Newton and Elliott 2016). The representation of stakeholder's interaction is carried out through the identification of the actors and their associated objectives, which constitute the two entry points in the analysis exercise in our case study. Thus, the representation of the system (actors, objectives) is largely determined by the perception of the actors (participants) (Godet 2010). Given the time allocated for reflection, and the perceptions of the system by all the actors involved in this reflection, this approach does not claim to be an exhaustive coverage of the problem of analyzing the interactions among the actors of integrated water resource management.

Data input matrices

Two input matrices were developed in consultation with the involved stakeholders and through the organized workshops (Ben Nasr and Bachta 2018). The position of stakeholders in the water resources management system depend not only on the position of each stakeholder regarding the objectives, but also on the power of these stakeholders and their ability to influence the others (Yeo and Benchekara 2015). It is therefore important to emphasize these two types of relationships below:

The influence of actors on each other The relationship among actors has enabled to develop the Matrix of Direct Influences (MDI) or Matrix "Actor X Actor". This matrix reflects the power relationships among actors, with the sums in rows and columns showing the global influence of each actor on the others (in rows) and its global dependence on the others (in columns) (Godet 2010). The calculation of the matrix of direct and indirect influences will make it possible to draw several conclusions about the interaction between the different actors (Table 4).

Actors' position regarding the objectives The relationship among actors allowed to develop the Valued position matrix (2MAO) or Matrix " Actor X Objective ". This matrix provides information on the actor's position on each objective (pro, against, neutral) and the hierarchy of its objectives (Ben Nasr 2015; Ben Nasr and Bachta 2018; Godet 2013). The Valued position matrix provides a measurement of the conflictual or consensual character of the objectives based on the sum of the agreements and disagreements in the columns (Table 5).

Model operation

Although the data input only concerns direct influence among actors, it also takes into consideration indirect influence that is exercised through the use of influence with other intermediary actors (Fig. 3) (Godet 2013).

Direct and indirect influences

The calculation of the matrix of direct and indirect influences (MDII) is done through formula (1). This matrix contains, for each pair of actors, the direct influence added to the sum of the indirect influences of each possible intermediate actor.(-Lakner et al. 2018; Munteanu and Apetroae 2007).

$$\mathrm{MDII_{ij}} = \mathrm{MDI_{ij}} + \sum\nolimits_{k} \left(\min\left(\mathrm{MDI_{ik}}, \mathrm{MDI_{kj}}\right)\right) \quad (1)$$

Where: i, j, and k three actors; $MDII_{ij}$: The direct influence that actor 'i' has on actor 'j'. $\sum_k \left(min\left(MDI_{ik}, MDI_{kj}\right)\right)$: The sum of all indirect influences that actor 'i' exerts on actor 'j' and that transit through a relay actor 'k'

Two indicators are calculated from the MDII matrix according to Eqs. (2) and (3).

$$\mathrm{I_i} = \sum\nolimits_{j} \left(\mathrm{MDII_{ij}}\right) - \mathrm{MDII_{ii}} \quad (2)$$

$$\mathrm{D_i} = \sum\nolimits_{j} \left(\mathrm{MDII_{ji}}\right) - \mathrm{MDII_{ii}} \quad (3)$$

Ii: The degree of direct and indirect influence of each actor.
Di: The degree of direct and indirect dependence of each actor

Table 5 Valued position matrix (2MAO)

	Water Data	Asses.Tool	Man.scale	Water.U.I	Partn.lev	Stak.consu	Awareness	Funding	Regulation	Tech.means	Planning	Capa.build
WEDA	4	4	0	0	4	4	2	2	3	3	3	2
NOWE	2	2	2	3	2	2	3	2	4	3	3	2
SRBA	4	4	2	1	2	3	3	2	3	3	3	4
RDA	1	1	0	1	1	2	1	0	2	3	1	1
PDA	3	3	2	4	1	2	4	4	2	3	3	1
ES	3	2	3	4	4	4	3	1	3	3	4	3
RHD	2	2	1	2	3	3	1	2	1	2	1	1
WS	2	1	2	2	3	2	2	3	2	3	2	2
WRPD	3	2	1	3	3	4	1	3	3	2	4	0
Mun	3	0	0	0	2	3	2	1	3	0	2	3

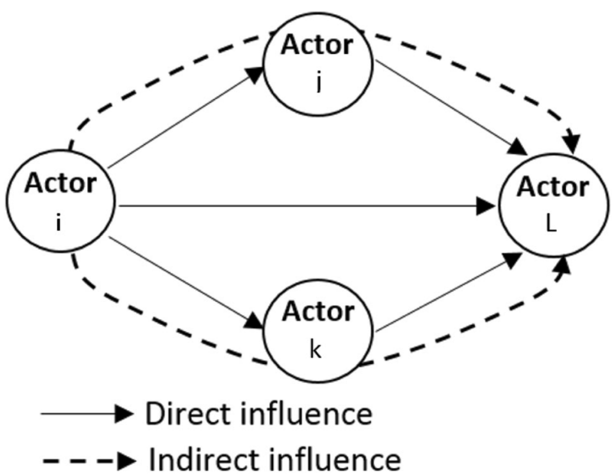

Fig. 3 Direct and Indirect influences between actors*. *The influence of 'i' on 'j', is the sum of the direct influence it has on 'k' and of all indirect influences it gains through all the other third actors (here 'j' and 'L')

Indirect influences are determined by using at least two direct influences, generating an overall value that is the unweighted sum of all direct and indirect influences. The MDII matrix calculates the influence (Ii) and dependence (Di) which are the respective sums of the matrix rows and columns (Fetoui et al. 2021; Munteanu and Apetroae 2007).

Balance of power between actors

The balance of power makes it possible to assess an actor's relative weight in the regulation of the water management system. This balance of power is measured by calculating a synthetic indicator called the Balance of Power (Ri) from the matrix (MDII), according to the Eq. (4) (Fetoui et al. 2021; Godet 2010).

$$\mathrm{Ri} = \left(\frac{(\mathrm{I_i} - \mathrm{MDII_{ii}})}{\sum_i (\mathrm{I_i})}\right) \cdot \left(\frac{\mathrm{I_i}}{\mathrm{I_i} + \mathrm{D_i}}\right) \tag{4}$$

The (Ri) coefficient is normalized in 1, therefore, if all the actors had the same relationship, all the (Ri) quotients would be equal to 1. An actor that has a normalized balance of power greater than 1 has a stakeholders' relationship superior to the mean (Godet 2013; Lakner et al. 2018). Normalization is given by its mean, defined as (Eq. (5)):

$$\mathrm{Q_i} = \overline{\mathrm{R}}_\mathrm{i} = \frac{\sum \mathrm{R_i}}{\mathrm{n}} \tag{5}$$

Where n = number of actors

Therefore, the normalized (Qi) quotient is the one shown below (Eq. (6)):

$$\mathrm{Q_i} = \mathrm{n} * \frac{\mathrm{R_i}}{\sum \mathrm{R_i}} \tag{6}$$

Actors' objectives relationship The actor/objective plan is derived from a factorial correspondence analysis (FCA) performed on the Weighted valued position matrix (3MAO) using the MACTOR tool. This matrix is obtained automatically by multiplying the Valued position matrix (2MAO) by the (Ri) coefficient according to the Eq. (7) (Godet 2013).

$$3MAO_{ij} = 2MAO_{ij} * R_i \tag{7}$$

Indeed, this process makes it possible to identify the stakeholders' position in an influence/dependence map.

Convergence and divergence between actors The 3MAO matrix was used to obtain the convergence matrix (3CAA (Eq. (7)) and divergence matrix (3DAA (Eq. (8)). This matrix identifies, for a couple of actors, the number of common positions they have on the objectives. This makes it possible to identify the number of possible alliances between actors (Munteanu and Apetroae 2007)

$$\mathrm{3CAA_{ij}} = \frac{1}{2}\sum\left(\left(|\mathrm{3MAO_{ik}}| + |\mathrm{3MAO_{jk}}|\right) \cdot \left(\mathrm{3MAO_{ij}} \cdot \mathrm{3MDII_{jk}} > 0\right)\right) \tag{8}$$

$$\mathrm{3CAA_{ij}} = \frac{1}{2}\sum\left(\left(|\mathrm{3MAO_{ik}}| + |\mathrm{3MAO_{jk}}|\right) \cdot \left(\mathrm{3MAO_{ij}} \cdot \mathrm{3MDII_{jk}} < 0\right)\right) \tag{9}$$

Table 6 Matrix of direct and indirect influences (MDII)

	WEDA	NOWE	SRBA	RDA	PDA	ES	RHD	WS	WRPD	Mun	Ii
WEDA	14	10	9	4	4	8	8	8	12	15	78
NOWE	17	13	12	7	5	9	9	9	14	18	100
SRBA	18	15	12	9	8	13	13	13	16	16	121
RDA	6	5	5	7	7	6	5	6	5	5	50
PDA	6	6	6	7	7	7	6	7	6	6	57
ES	14	12	10	7	6	11	11	11	13	12	96
RHD	6	5	4	3	3	5	6	4	6	6	42
WS	17	16	11	10	8	13	12	12	17	19	123
WRPD	15	15	10	7	5	12	13	12	16	15	104
Mun	7	5	5	2	2	5	5	4	5	6	40
Di	106	89	72	56	48	78	82	74	94	112	811

Results and Discussion

The MACTOR method offers several graphic representations and aggregate coefficients to help in the interpretation of model results.

Direct and Indirect Influences

Through the MACTOR method, we devoted the first analysis exercise to the influence among actors by developing the Direct and Indirect Influences Matrix (MDII) (Table 6).

This aims to provide a more complete vision of the interactions and power relations among involved stakeholders in the water management process. Indeed, one actor can limit the choices of another one through an intermediate actor. Furthermore, two indicators have been calculated from the matrix (MDII), to explore the influence and dependence among actors, as follows:

(1) The indicator (Ii) calculated by summing the matrix's rows, which represents the degree of direct and indirect influence of each actor,
(2) The indicator (Di) calculated by summing the matrix's columns, which represents the degree of direct and indirect dependence of each actor.

Following the calculation of both indicators (Ii) and (Di), it was noted that actors with high values of (Ii) indicator (i.e., with a high degree of influence, such as NOWE, SRBA, WS, and WRPD), have lower values of (Di) indicator, i.e., more influenced by other actors (Table 6). These two indicators will be used later to categorize the actors in the influence/dependence map.

Map of Influences and Dependencies among Actors

The map of influences and dependencies among actors shows their power relationships (dominant and dominated actors) (Fig. 4). On the axis of control, the dominant actors are SRBA, WS and ES, given their strong influence and low dependence on other actors; in fact, they are regulatory actors.

The dominated actors are represented by, WEDA, RHD and Mun. These actors are more sensitive regarding the actions of other actors, which requires their evolution in terms of capacities and means. Note that the power relations among actors are not limited to the simple appreciation of direct capacity of action. Thus, one actor can influence another through a third one (relay actor). In this case study, the intermediary actors are represented by WRPD and NOWE, which have a strong influence and dependence, as they are influenced by some actors (i.e., SRBA and WS) and have an influence on others, acting as an intermediary between two categories of actors (dominants and dominated actors). WRPD plays an important role in the planning and monitoring of surface and groundwater resources. NOWE is in charge of the generalization of access to electricity and drinking water, wastewater treatment and the extension of production and distribution networks of water resources. If the projects and objectives of these actors are not realized, or if these actors do not evolve, the water management process will remain blocked. Moreover, Fig. 4 highlighted a fourth category of actors who are neither influencers nor dependents, and are thus autonomous, such as PDA and RDA.

This classification is very important for the implementation of policies related to water management while focusing on the category suitable for influencing the role of other stakeholders. In this sense, the relay actors, such as WRPD and NOWE, have a strong influence and dependence that can facilitate the search of stability for the balance of power between actors. These two actors act as intermediaries between two categories of actors (dominant and dominated). Thus, all stakeholders need to understand that the relay actors are strategic actors in maintaining the balance in the management process (Bettencourt 2010; Godet 2013; Lakner et al. 2018). This first analysis shows the unstable character of the actor role, given the presence of some actors who are autonomous and less involved in the water resources management system. This unstable nature

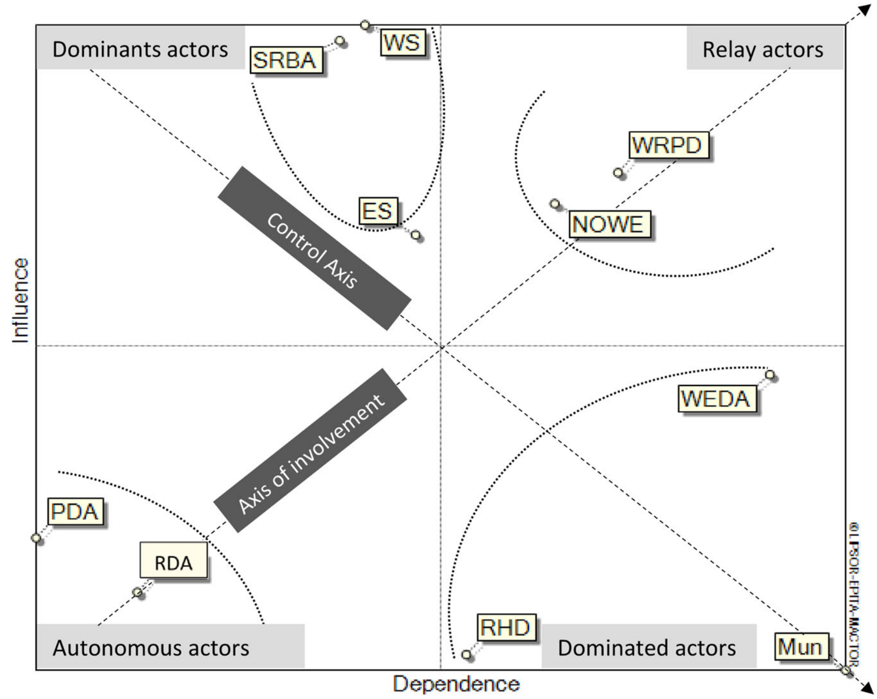

Fig. 4 Map of influences and dependences between actors

of the actor role in the water resources management system requires further analysis in terms of the power relations among the actors (Bettencourt 2010).

Balance of Power between Actors

The calculation of an actor's Balance of Power (Ri) allowed to measure its relative weight in the integrated water management system. The indicator Ri is proportional to the weight of the actor role in the water management system (Fetoui et al. 2021). Conversely, if (Ri) is low, the actor is in a lower position to defend its interests in the water management system. The analysis of the direct and indirect influences of the actors has allowed to identify, in decreasing order, four groups of actors (Godet 2010) (Fig. 5):

- A first group with a very high-power ratio, composed of two dominant actors, such as SRBA and WS, these actors constitute the entry points of the water management system. They contribute as drivers or barriers to the evolution of the processes in the water management system:
- A second group with a high degree of power. This power enables the actors to defend their position in the water management process. This group is represented by ES and WRPD:
- A third group composed of most sensitive actors, such as WEDA, PDA. These actors have a significantly weaker balance of power than average, which does not allow them to impose their positions on their own:
- A fourth group of actors, represented by RDA, RHD and Mun, have the weakest power relations in the water management process.

In addition to this balance of power (Ri), the potential balance of power represented by the indicator (Qi) was calculated (Fig. 5). Qi corresponds to the maximum power ratio that the (Ri) can take in consideration, the maximum influences and direct and indirect dependencies of actors and its feedback (Fetoui et al. 2021; Godet 2010). Thus, (Qi) is a measurement of the potential balance of power, taking into consideration the intensity of the action means of one actor on the others. Furthermore, the comparison between (Ri) and (Qi) has allowed to highlight the lessons learned in relation to the role of actors in the water resource management system.

The comparison between the Ri and Qi indicators shows that the weight of certain actors, such as WRPD (from 1.24 to 1.5), RHD (from 0.33 to 0.5) and Mun (from 0.24 to 0.5), has increased in the potential power ratio. This may reflect the strong involvement of these actors in the water management system. Nevertheless, some of the others are experiencing a decrease in their means of action, such as SRBA, ES and PDA. Thus, the potential power ratio shows a decrease in the weight of SRBA (from 1.83 to 1.4), ES (from 1.26 to 0.8) and PDA (from 0.73 to 0.4). Globally, one can observe an increasing concentration of actors around an average weight between the apparent situation (Ri) and the potential situation (Qi), which shows a very high degree of connection among the water management actors (Godet 2013).

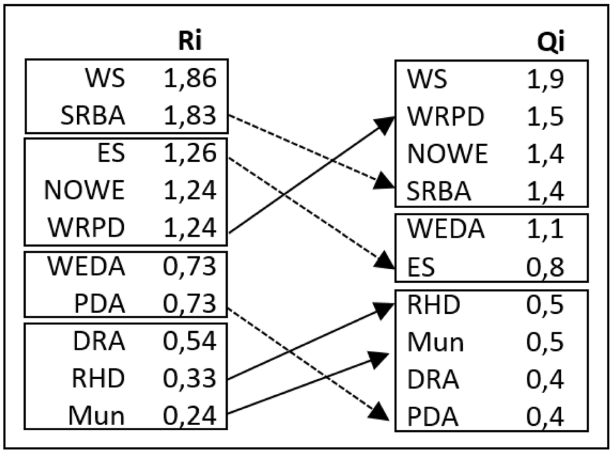

Fig. 5 Comparison between the Ri and Qi indicators

Actors' Objectives Relationship

The Actors' Objectives relationship provides an initial analysis of the consensual character of all actors around the objectives established during the workshops (Bettencourt 2010; Fetoui et al. 2021; Godet 2010). The results show the absence of negative values, which means that all the stakeholders are characterized by the convergence for all the objectives defined to achieve an IWRM in the study area (Table 7).

Actors' Objectives relationship also allowed us to measure the degree of involvement of each stakeholder on all the objectives by summing up the absolute values in rows, and to identify the objectives that most strongly engage the stakeholders, through the summation of absolute values in columns (Yeo and Benchekara 2015). Regarding the global involvement of the actors, the sum of the absolute positions of the actors gives an indicator of this involvement in the water resources management system (Yeo and Benchekara 2015). This indicator varies from 14 for the RDA to 37 for the ES (Table 7). Therefore, the most involved actors are ES, PDA, SRBA, NOWE and WEDA. These are concerned with a large number of objectives, which reinforces their projects and their missions within the water resources management system. In contrast, RDA, Mun and RHD, have the lowest level of implication, with 14, 19 and 21 respectively in the valued position matrix. They are only concerned with certain objectives. The analysis also included the degree of participation and involvement of each stakeholder in all the objectives initially established. The objectives exhibiting the highest degree of involvement are:

- Ensuring the continuity of water resource data, which makes it possible to assess the impact of the use on the environment.
- Strengthening participation with steering groups and working meetings with a large number of stakeholders.

Table 7 Valued position matrix (2MAO)

	Water Data	Asses.Tool	Man.scale	Water.U.I	Partn.lev	Stak.consu	Awareness	Funding	Regulation	Tech.means	Planning	Capa.build	Absolute sum
WEDA	4	4	0	0	4	4	2	2	3	3	3	2	31
NOWE	2	2	2	3	2	2	3	2	4	3	3	2	30
SRBA	4	4	2	1	2	3	3	2	3	3	3	4	34
RDA	1	1	0	1	1	2	1	0	2	3	1	1	14
PDA	3	3	2	4	1	2	4	4	2	3	3	1	32
ES	3	2	3	4	4	4	3	1	3	3	4	3	37
RHD	2	2	1	2	3	3	1	2	1	2	1	1	21
WS	2	1	2	2	3	2	2	3	2	3	2	2	26
WRPD	3	2	1	3	3	4	1	3	3	2	4	0	29
Mun	3	0	0	0	2	3	2	1	3	0	2	3	19
Number of agreements	27	21	13	20	25	29	22	20	26	25	26	19	
Number of disagreements	0	0	0	0	0	0	0	0	0	0	0	0	
Number of positions	27	21	13	20	25	29	22	20	26	25	26	19	

- Ensuring the compliance with water laws and standards (Law no. 36-15; water standards…).
- Adopting a medium- or long-term planning taking into account the evolution of parameters.

The highlighted objectives can be considered as priority challenges to be raised by all actors in a common project. The rest of the objectives are ranked as secondary according to the choice of the actors.

Based on these objectives drawing the strongest involvement, importance was given to the availability of water data by stakeholders, as this is crucial in evaluating the indicators' performance in the process of IWRM implementation (Ben-Daoud et al 2021). Stakeholders made this choice based on the reality that water data are not continuous and are not accessible to everyone (Ben-Daoud et al 2021). This requires the actors to spend more effort to improve the accessibility of water data for both managers, and academics, by implementing Law 31-13 on access to information.

With the same importance as water data, stakeholder participation is also crucial. Moreover, the involved stakeholders in the study area have not yet evolved to levels that allow them to have a real involvement and consultation in the decisive stages of the management process (Ben-Daoud et al. 2021; Hargrove and Heyman 2020; Newton and Elliott 2016). The insufficiency in the implementation of laws and standards related to water, such as Law no. 36-15, constitutes one of the factors limiting the real implementation of policies related to water resources management. This challenge related to the law's application must be supported by the stakeholders' awareness to participate on a more knowledge-intensive base.

Actors/objectives' Correspondence Map

The Actors-objectives' map shown in Fig. 6 is determined by the correspondence analysis provided by the MACTOR tool and which makes it possible to position the actors in relation to each other and their objectives in the context of water management. The correspondence analysis is carried out on the weighted valued position matrix. The interpretation of the correspondence map between actors and objectives is facilitated by the analysis of the percentages of inertia developed using the MACTOR method (Bendahan et al. 2004). The percentage of information were summarized by factorial axes F1 and F2, cumulating together 57.42% (Fig. 6).

Analyzing Fig. 6, the factorial axis F1 is the most explanatory, with 33.98% of the information, which reflects the dominant tendency of SRBA, as a regulatory actor in the water sector. There are also two other regulatory actors represented by ES, WS, and which are located in the gravity point of the map, which means that they have medium values. WRPD is the actor that makes the highest relative contribution to the explanation of the F2 axis. Axis F2, with 23.44% of the information, even if it is less explanatory, brings important information. Consequently, F1 axis reflects the aspects related to "planning", "partnership level" and "stakeholders participation" as important objectives to establish a more balanced water resources management system (Bendahan et al. 2004; Yeo and Benchekara 2015). The correspondence map can also be interpreted by the degree of proximity among the points that are represented by "stakeholder/actor", "stakeholder/objective" and "objective/objective".

The proximity among the stakeholders on the map means that they have similar profiles in terms of commitment to the objectives. Proximity among objectives means that there are similar degrees of overall mobilization among water actors (Godet 2013). Consequently, the existence of an influence relationship between the achievements of one objective on the other in the reality of the game is also possible. As for the proximity between an actor and an objective, it represents the indication of an attractiveness between actors and actors/

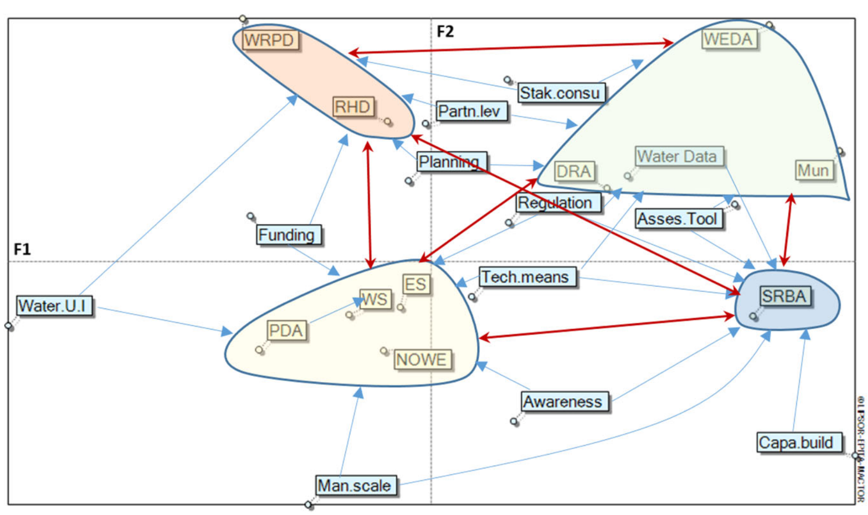

Fig. 6 Actors/objectives correspondence map

objectives. Conversely, two opposite points (actors/objectives) on the map indicate repulsion. In this way, some actors, such as ES, WS, PDA, NOWE, have a tendency to join a group because of their proximity to each other. These actors are considered in the same group despite some differences in terms of their commitment to some objectives. Other actors, like WEDA and RDA, seem to be different from the others in terms of their commitment to the objectives.

As for the link among objectives, there is a high degree of proximity between some objectives, such as "Water Data" and "Assessment tools". This alignment means that there is an influential relationship between water data and assessment tools (Ben-Daoud et al. 2021; Hargrove and Heyman 2020). In another way of seeing this connection, the assessment of the state of water resources management is certainly influenced by the availability of data in a timely manner and with reliable quality. A high degree of alignment between the objectives related to partnership level and stakeholder participation is also observed. This shows that stakeholder participation provides opportunities for partnership among actors for collaborating on water management issues (Basco-Carrera et al. 2017; Reed 2008; Smyth et al. 2020). Therefore conclusions can be drawn from the analysis of the map, on the three dimensions: "actor/actor", "actor/objective" and "objective/objective". This analysis shows the existence of an impact relationship between different actors and between different objectives. Therefore, the delay of one actor in achieving one objective can impact the achievement of the other objectives and ultimately impact the implementation of IWRM (Giordano and Shah 2014; Godinez-Madrigal et al. 2019; Schröder 2019). Consequently, stakeholders in their management process must take this relationship between objectives seriously. This brings us to the notion of "integration" in the IWRM concept, considered as a solution to the problem of interdependence between various components involved in the management process (Akhmouch and Clavreul 2016; Al-Jawad 2019; Tuokuu et al. 2019) (Fig. 6).

The interaction analysis between actors was extended using a hierarchical decomposition method obtained according to an aggregation model by the average, allowing us to identify similarities between the groups of actors and to highlight the correspondence mapping results. The investigation of similarities between stakeholders, shown in Fig. 7, allowed us to identify two main groups of stakeholders.

The similarity analysis has allowed us to divide the actors into two groups that are similar in terms of objectives and that present alliances in terms of future management actions (Bendahan et al. 2004; Helsel et al. 2020; Pati et al. 2014). This classification confirms the representation of the correspondence map regarding the concentration of regulatory actors in the same category of actors such as SRBA, ES, WRPD and NOWE. The second group is composed of

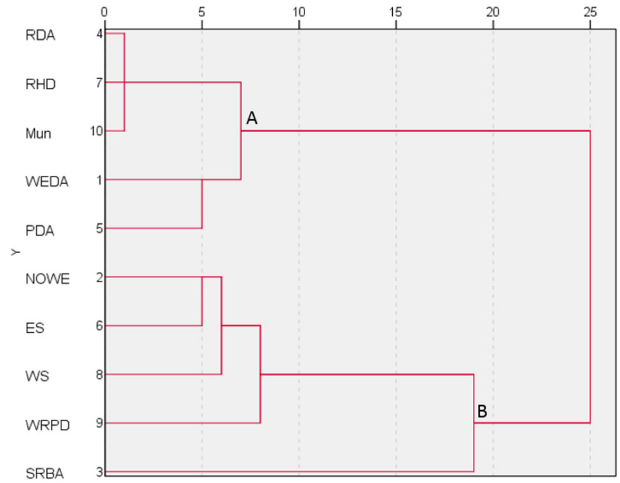

Fig. 7 Diagram of similarities between actors

the rest of the actors. Furthermore, this similarity analysis has allowed to cluster the small groups of actors identified in the correspondence map into two main groups according to their affinities (Johansen 2018).

Convergence and Divergence between Actors

The 3MAO matrix produced by the MACTOR analysis has been used to measure the degree of convergence and divergence between water stakeholders. Convergence among actors was determined by identifying the number of common positions that the pairs of actors have on the objectives (for or against). Consequently, we proceeded to the identification of the number of possible alliances between actors. Thus, the majority of actors have common interests, given the high intensity of their convergence indices (Fig. 8). In order to map the water management actors in relation to their convergences, a convergence network among actors was developed. Thus, the more actors are in proximity to each other, the more intense is their convergence (Godet 2013; Lakner et al. 2018). Figure 8 shows a clear link among the majority of the actors that are interconnected with the red line, which indicates a strong convergence. Two actors that appeared less connected to the others are the RDA and the Mun. Furthermore, proper divergences are absent among the actors. This result indicates that the level of conflict between actors is potentially low and that could support the achievement of stakeholders' objectives.

This result will be interesting during the negotiations process of future projects concerning water management in the R'Dom Sub-basin. However, it is important to take into consideration that the statements of the participants in the workshops and interviews may not completely reflect the reality. This is why it is necessary to expect conflicts in terms of water management, whether between the actors

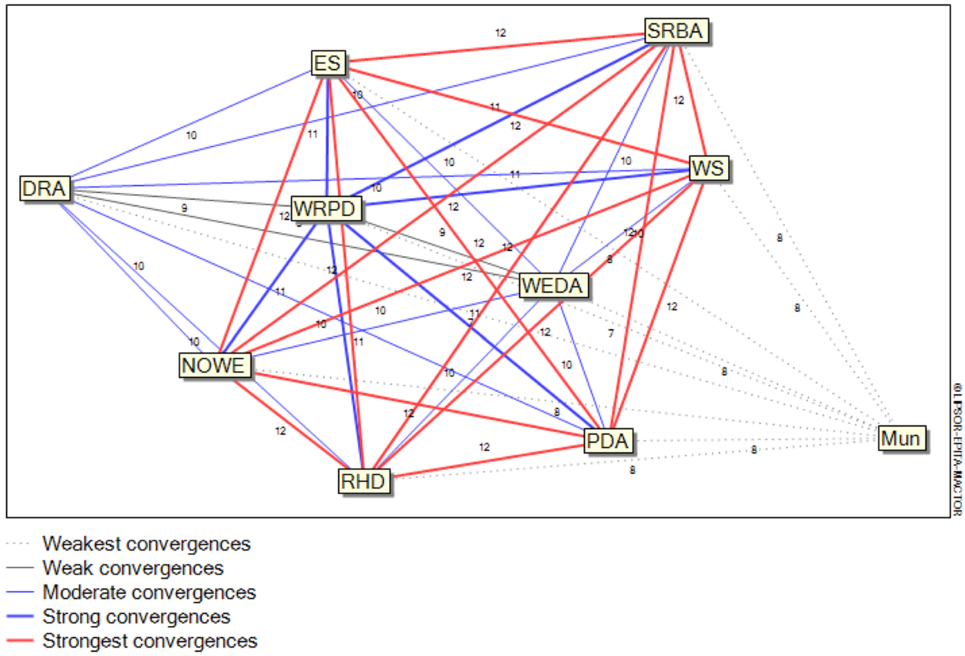

Fig. 8 Convergence network between actors

themselves or between the actors and the users. In this way, the interviews we conducted confirmed the existence of certain levels of conflict. This conflict concern the agricultural irrigation, the digging of wells and boreholes, the water use from dams and the granting of operating authorizations, all of which are sensitive and represent potential points of conflict (Ait Kadi and Ziyad 2018; Ben-Daoud et al. 2021; Del Vecchio and Mayaux 2017).

Conclusion

The analysis of stakeholders' interaction carried out in this work went beyond the question of water stakeholder identification, and moved on to complex considerations that are not easily explained by simple analysis. This paper's approach involves dimensions related to complex interactions between stakeholders, such as influence, dependence and convergence between actors in the water management process at the scale of the R'Dom sub-basin. In the study area, over the past years, planning and implementation programs for IWRM policies have still occupied a large part of the political discourse of all the actors involved in water management. Nevertheless, the reality on the ground shows a larger gap between the political discourse and the implementation of water management actions. Indeed, the following analysis was conducted to answer this question related to the interaction between water management actors.

In term of results, four indicators related to water stakeholder's interaction were examined in this article. Starting with Direct and indirect influences between water actors, the results show four categories of actors based on their degree of influence and dependence. Firstly, the more influential and less dependent stakeholders (dominants) are the most appropriate for successful implementation of the IWRM in the study area. As for the relay actors as second category, they constitute strategic stakeholders that can act to maintain the stability of the management process. For the third category of stakeholders, and despite their important role in the IWRM process, the analysis identified their autonomous character in the water management process. This requires their involvement in the management system by the relay actors. The last category, concerns the dominated actors that are more sensitive regarding the actions of other actors, given their low influence and high degree of dependence on other actors.

The second indicator analyzed concerns the balance of power between actors, which allowed us to measure the relative weight of the actors within the water management system. According to this indicator, four categories of actors have been identified. A first group with a very high-power, as represented by SRBA and WS, is made of actors who can contribute as drivers to the evolution of the process of water management. A second group with a high degree of power, represented by ES and WRPD, reflects those who can defend their positions in the water management process. The third group, with a medium degree of power, is composed of the most sensitive actors, such as WEDA, PDA. The last group, represented by RDA, RHD and Mun, is made of those who have the weakest power relations in the water management process.

The third indicator analyzed concerns Actors Objectives Relationship. Following the analysis of this indicator, the study shows a low commitment of stakeholders to some objectives, such as capacity building, implementation of technical means, water uses integration and awareness implementation. Therefore, the areas of interest that stakeholders need to address more intensively are as follows:

- Strengthening the participatory approach and the involvement of all stakeholders, especially those identified in the category of autonomous actors.
- Strengthening the capacities of water management actors, particularly in terms of new technologies and new regulations related to the water sector.
- Involving the new structures established by Law 36-15 on water, such as the basin councils, governance and monitoring bodies in the IWRM process.

The fourth indicator examined concerns the convergence and divergence between actors. Thus, the results show that the majority of the actors have common interests, given the high intensity of their convergence indices. This result indicates that the level of conflict is low between the involved actors.

It is important to highlight the limitations of the analysis conducted in this work. Thus, (1) the approach dealing with the relationships between actors could be influenced in the long term by policy changes at the central level. (2) The MACTOR analysis is also dependent on the reliability of the statements of the participants in the data collection, despite the criteria adopted in the identification of actors. (3) A local context characterized by rapid institutional dynamics that make it difficult to predict the long-term behavior and prerogatives of the various participants.

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Compliance with Ethical Standards

Conflict of Interest The authors declare no competing interests.

Consent to Publish Authors give their permission to publish.

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