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A Novel Method to Assess the Impact of a Government's Water Strategy on Research: A Case Study of Azraq Basin, Jordan

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Abstract: Water scarcity drives governments in arid and semi-arid regions to promote strategies for improving water use efficiency. Water-related research generally also plays an important role in the same countries and for the same reason. However, it remains unclear how to link the implementation of new government strategies and water-related research. This article's principal objective is to present a novel approach that defines water-related research gaps from the point of view of a government strategy. The proposed methodology is based on an extensive literature review, followed by a systematic evaluation of the topics covered both in grey and peer-reviewed literature. Finally, we assess if and how the different literature sources contribute to the goals of the water strategy. The methodology was tested by investigating the impact of the water strategy of Jordan's government (2008–2022) on the research conducted in the Azraq Basin, considering 99 grey and peer-reviewed documents. The results showed an increase in the number of water-related research documents from 37 published between 1985 and 2007 to 62 published between 2008 and 2018. This increase should not, however, be seen as a positive impact of increased research activity from the development of Jordan's water strategy. In fact, the increase in water-related research activity matches the increasing trend in research production in Jordan generally. Moreover, the results showed that only about 80% of the documents align with the goals identified in the water strategy. In addition, the distribution of the documents among the different goals of the strategy is heterogeneous; hence, research gaps can be identified, i.e., goals of the water-strategy that are not addressed by any of the documents sourced. To foster innovative and demand-based research in the future, a matrix was developed that linked basin-specific research focus areas (RFAs) with the MWI strategy topics. In doing so, the goals that are not covered by a particular RFA are highlighted. This analysis can inspire researchers to develop and apply new topics in the Azraq Basin to address the research gaps and strengthen the connection between the RFAs and the strategy topics and goals. Moreover, the application of the proposed methodology can motivate future research to become demand-driven, innovative, and contribute to solving societal challenges.

Keywords: research gap; water strategy; Azraq Basin; water management; water governance

1. Introduction

Water scarcity is a severe problem for Jordan [1–3] and undermines the country's societal and economic development [4]. Research in the water sector is important and necessary. Essential investments in water-related research have been made using internal funding and international aid [5]. Although collaboration between academia and decision-makers at different levels, from governmental institutions through to water works and private stakeholders owing water rights, offer multiple benefits for both [6], the impacts of new water-related policies on research outcomes and vice versa remains unclear.

Academia could provide policymakers and practitioners with evidence-based knowledge from the research findings that directly feed the decision-making process [7]. Even if some research findings do not directly contribute to the decision-making process, those findings can indirectly affect policy development and practitioners' actions [8]. Therefore, decision-makers are advised to use evidence in making policy decisions [9,10] and should consider research findings in the policy development process [11].

Although there is a growing emphasis on research-based policy decisions, such as "research utilization", "knowledge transfer", "knowledge brokering", and "evidence-based policy" [12], factors such as financial constraints, shifting timescales, and decision makers' experiential knowledge may reduce the direct influence of research evidence on decision making [13]. In this work, the aim is to present a methodology based on an extensive literature review and analysis to evaluate the impact of the Jordan's water strategy (2008–2022), developed by the Ministry of Water and Irrigation, on research production. The water strategy contains a set of goals to achieve a better management of the kingdom's water resources to achieve the vision of the ministry in 2022. In particular, the focus is on the identification of research gaps that have not been accounted for during the period of implementation of the strategy.

One of the aims of conducting and publishing this research is to identify research gaps and propose ways to advance and harness knowledge in order to fill these gaps [14]. The definition of a research gap is context-dependent and can differ from topic to topic [15]. In general, Robinson et al. [16] refer to a research gap as "When the ability of the systematic reviewer to draw conclusions is limited" [16] (p. 1). Accordingly, a research gap is deemed to be a missing body of information, information that is needed to address a specific and pressing research question [17]. Understanding the nature of research gaps and their origin is regarded as the most critical step in producing good-quality research [18].

Moreover, while substantial methodological guidance already exists to identify the scope, conceptualization, analysis, and further synthesis of a "systematic literature review", a methodology to identify research gaps from these systematic reviews is still a matter of debate [18,19]. Based on the works of Müller-Bloch and Kranz [17] and Robinson et al. [16], Miles [18] identified seven types of literature gaps, namely: (1) evidence gaps arise when new-found research contradicts the conclusions of the previous study; hence, a need to collect more evidence to arrive at a concise conclusion; (2) knowledge gaps indicate the lack of knowledge (e.g., theories, methodologies) in a particular field or the delivery of some unexpected results from studies; (3) practical-knowledge gaps convey the need for new research when there is a difference between actual professional practices and research findings on a specific topic; (4) methodological gaps explore the conflict that may arise between research methods, the effects of research methods on research results, and the lack of research methods for a specific study area; (5) empirical gaps arise when a particular study area or topic has not been previously explored empirically in past research; (6) theoretical gaps explore the conflict that may arise when a certain topic is explored with a single theory or when one theory becomes superior to other theories; and (7) population gaps arise when a certain group of the population categorized based on race, ethnicity, economical status, etc. is underrepresented in the research.

Our work aims to present a comprehensive methodology for defining and identifying water-related research gaps, which can support demand-driven research, inspire new research topics to transform future research to become imaginative and innovative, and help the government to achieve the goals set within its strategy. Furthermore, the methodology developed helps to show the heterogeneous impact of the governmental strategy on various research focus areas (RFAs) and highlights the scientific fields contributing the most to the governmental strategy. The methodology was developed to evaluate the impact of Jordan's water strategy [20] on research involving the Azraq Basin (specifically) but can be applied to evaluate any context of impacts between government and academia.

2. Study Area

A total of twelve river basins exist in Jordan [21]. The Azraq Basin is located in the north-eastern region of Jordan and covers approximately 12,700 km^2; about 94% of the basin lies in Jordan, while about 5% and 1% are in Syria and Saudi Arabia, respectively. The basin is the second-largest basin in size and the second most exploited after the Amman-Zarqa basin [21,22]. Topographically, the basin is located within the highland region in Jordan, where the elevation ranges from 490 m above sea level in the Azraq Mudflat area, in the center of the basin, to more than 1300 m above sea level on Jabal Druze area in Syria (Figure 1). Jabal Druze is considered the main recharge area of basalt aquifer [23–26]. The Azraq Basin climate is arid to semi-arid, with a dry and hot season extending from May to September, with a wet and cold season extends from October to April [27–29]. The primary water resource of the basin is categorized as renewable groundwater sources [21], and its importance is threefold: Firstly, besides supplying the Azraq area, the basin provides drinking water for major urban areas in Jordan, mainly Amman and Zarqa cities, [30–33]. Secondly, it provides water for agricultural activities surrounding the basin area [21,34–36]. Finally, the basin's ecological importance is manifested through the Azraq wetland, a prosperous provider of ecosystem services in the area, which has deteriorated over time due to over-pumping of groundwater resources [37,38].

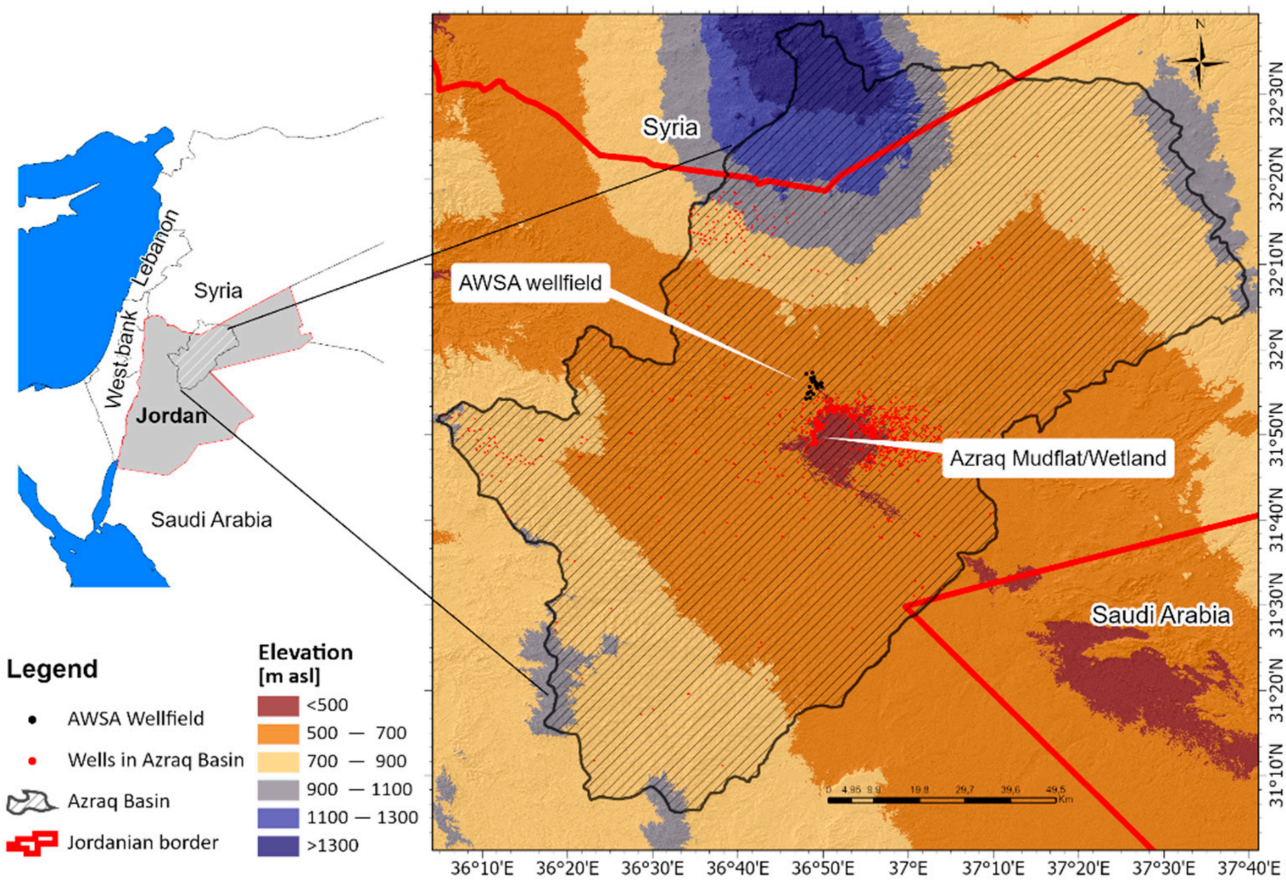


Figure 1. The elevation and extension of the Azraq Basin (the elevation unit is meters above sea level (m.a.s.l.)).

3. Methodology

3.1. Collection Process

Between December 2019 and January 2020, the research team led a one-month field research trip/excursion to Jordan. The trip/excursion consisted of 18 unstructured interviews with current and retired employees of the Jordanian Ministry of Water and Irrigation (MWI) and employees of cooperation projects between the MWI and international partners. The visit aimed to (a) understand the current archiving process of project reports in the MWI, (b) collect the final reports that were conducted under the umbrella of the MWI, and (c) propose the development of an archiving system for final reports, taking into consideration the recommendations of the MWI and international partners. We have been able to collect 2200 digital documents (e.g., final reports, report sections, letters, incomplete reports, presentations, or report drafts) present in the Ministry's record, spanning from 1963 to 2019.

In addition to the collected research from MWI, grey literature was searched online through Google searching, Scopus, Web of Science (WoS) engines, and the websites of the MWI and the MWI partners' websites (e.g., Helmholtz-Zentrum Umweltforschung GmbH (UFZ), Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), United States Agency for International Development (USAID), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)). In this work, we consider only conference proceedings and final reports from the government and their partners as grey literature. Dissertations, Master's and Bachelor's theses, and posters are excluded in the review and analysis (Table 1).

Table 1. Type of literature included/excluded in this study.

Included Literature	Excluded Literature
• Technical reports by MWI (available digital copy) • Technical reports by international projects (available digital copy) • Final reports/studies	• Technical reports by MWI (only available in hard copy) • Technical reports by international projects (only available in hard copy) • Studies that are not related to Azraq Basin
• Peer-reviewed literature • Proceeding conference paper	• Studies that are included within the daily activities of the MWI employees (e.g., small study to give a license to build a specific factory)
	• Master's, Bachelor's and Ph.D. theses. • References that are cited in other documents but were not accessible.

The search for peer-reviewed publications was collected using Google Scholar (GS), Scopus, and Web of Science (WoS) search engines. The literature collection process started with GS, given that it is the most comprehensive web search engine for literature, where it contains 95% and 92% of literature that exists in WoS and Scopus, respectively [39,40]. To ensure the search remained as vast as possible, queries were used with general keywords (e.g., "Azraq Basin" OR "East* Jordan" AND "Water"). The obtained results were reviewed, and only research results related to water in the Azraq Basin were added to the literature inventory up to the year 2018; research published in and after the year 2018 was excluded. The same procedure was repeated using Scopus and WoS search engines, utilizing Publish and Perich 7 software to search and analyze academic citations [41].

3.2. Analysis Process

The MWI published the "Jordan's Water Strategy 2008–2022" report [20], aiming to ensure the availability of water for people, businesses, and nature by accomplishing a set of goals within the topics of water demand, water supply, institutional reform, water for irrigation, wastewater, and alternative water resources in the year 2022. To achieve the objective of this paper, the goals of the collected research were compared to the water strategy goals, highlighting whether or not these research goals contributed to one or more of the MWI water strategy goals (Table 2). Some of the MWI strategy goals are excluded from the analysis as they focused on a specific study area different to the Azraq Basin. For example, the MWI water strategy goal 6.b., which states, "Desalination projects at the Red Sea are operational", cannot be compared with the collected research goals because this goal targets the Red Sea; consequently, we excluded goal 6.b. from the analysis of this paper.

In the analysis process, we followed the framework that Müller-Bloch [17] introduced to identify research gaps. Research gap results were first identified by synthesizing a systematic literature review of the subject by using straightforward localization methods such as the chart method. This method organizes the reviewed literature into a chart according to the MWI strategy goals. A goal in the chart can be associated with one or more literature documents, indicating that at least one document addresses this goal, or it can be left empty, indicating a research gap. After locating a research gap, verification processes continued by double-checking if no research could be sourced to fill the gaps; finally, the goals were presented according to the number of documents that were associated with each goal. According to the classification of Miles [18], the comparison between the conducted research and the MWI goals allow the identification of a "practical-knowledge gap".

Any MWI goal that registers no contribution by the collected research is considered a research gap, and any research that contributed to the MWI strategy goals is regarded as potentially demand-driven research. To better assess the topic of demand-driven research, a comparison was conducted between the collected studies before and after the implementation of the MWI strategy, to highlight if a change in the research direction towards the MWI goals could be identified.

To study the variable impact on research involving the basin from different types of research institutions (i.e., academic, non-academic, national, and international), the peer-reviewed studies were first categorized based on the affiliations of the author. Such a procedure was only applied for peer-reviewed literature because the affiliation of each of the authors of specific grey literature is not always defined. Furthermore, the specific research focus of each study was then identified and listed according to nine main RFAs: agriculture, energy, hydrogeological field measurements, geophysics, modeling, remote sensing, socio-economy, laboratory soil sample analyses, and laboratory water sample analyses (Table 3). It is noted that the subdivision depends on the available literature, and it can vary in different catchments. The selection of the RFA is to some extent arbitrary and it is based on the main keywords and topics covered in the analyzed documents. The applied methodology, however, is not significantly affected by this choice. In fact, the key point of defining RFAs is not to identify which discipline is contributing more or less to the strategy goals, but to classify the available contribution to the goals from different communities of researchers and in terms of interdisciplinarity. Each document will have only one primary RFA and can have several secondary RFAs. The number of conducted studies were compared within each RFA before and after implementing the MWI strategy. Additionally, each RFA was categorized according to which MWI topic it targeted. A schematic diagram of the methodology we followed is shown in Figure 2.

As stated previously, the collected research did not include studies conducted after the year 2018, because the MWI published a new strategy in 2016 for the period 2016–2025, which modified the older strategy. Considering the typical time needed for writing and publishing scientific works, it was assumed that the impact of the old strategy may still have an effect on water-related research up to two years after the publication of the new strategy.

Table 2. The topics and goals of MWI strategy (2008–2022).

	1. Water demand
1.a.	Water use for agriculture shall be capped.
1.b.	Jordanians are well aware of water scarcity and the importance of conserving and protecting our limited water resources.
1.c.	The management of water resources shall duly consider the potential risks derived from Climate Change induced impacts on the water balance.
1.d.	Viable options to reduce water demand within each sector are readily available.
1.e.	Water tariffs within and outside the water sector should support water demand management
1.f.	Non-revenue water to be 25% by 2022.
	2. Water supply
2.a.	Uninterrupted safe and secure drinking water supply achieved including continuous flow in Amman. Zarqa. Irbid. and Aqaba.
2.b.	Water supply from desalination is a major source.
2.c.	Drinking water resources are protected from pollution.
2.d.	Surface water is efficiently stored and utilized.
2.e.	Treated wastewater effluent is efficiently and cost-effectively used.
2.f.	Data on the availability of water resources will be acquired via a telemetric observation network safeguarding continuous information flow. Modern information technology will provide a sound basis for the monitoring and the management of Jordan's water resources.
2.g.	Special management plans to ensure safe yield principle being applied in groundwater extraction
2.h.	The concept of utilizing greywater and rainwater is fully embedded in the codes and requirements of buildings.
2.i.	Our shared water rights are protected.
	3. Institutional reform
3.a.	National Water Law is enacted and enforced.
3.b.	Strong policy development and water resource planning strategies and capabilities forged.
3.c.	Governance functions and operational functions are separated.
3.d.	"Wholesale" operations (national infrastructure) and "retail" operations (service delivery) are separated.
3.e.	A Water Council is operational allowing for broad stakeholder input into water management
3.f.	A Water Regulatory Commission of Jordan is established.
3.g.	Commercial principles drive water management while the needs of the poor are supported
3.h.	Staff is trained. Its number is optimized. Conflicts of interests are eliminated, and a dynamic working environment is created that is responsive to the needs of the sector.
3.i.	The National Water Master Plan is institutionalized representing the binding strategic management instrument of the Water Sector as stipulated by the National Water Law.
	4. Water for irrigation
4.a.	The annual water allocation for irrigation in the Jordan Valley will be increased to 377 MCM in 2022 (293 MCM in 2007) and in the Highlands reduced to 184 MCM in 2022 (297 MCM in 2007).
4.b.	Efficient bulk water distribution as well as efficient on-farm irrigation systems are established.
4.c.	All treated wastewater generated will be used for activities that demonstrate the highest financial and social return including irrigation and other non-potable uses.
4.d.	Jordan will have one service provider for irrigation water for the whole country, whereas the retail function for irrigation water will be privatized and/or handled by empowered farmers' associations.
4.e.	Appropriate water tariffs and incentives will be introduced in order to promote water efficiency in irrigation and higher economic returns for irrigated agricultural products.
4.f.	Alternative technologies such as rainwater harvesting for enhancing irrigation water supply will be promoted.
	5. Wastewater
5.a.	All the major cities and small towns in Jordan are provided with adequate wastewater collection and treatment facilities.
5.b.	All major industries and mines have wastewater treatment plants.
5.c.	New high-rise buildings use greywater for internal non-drinking purposes.
5.d.	Public health and the environment, in particular groundwater aquifers, are protected from contaminated wastewater in the areas surrounding wastewater treatment plants.
5.e.	Treated wastewater is used for activities that provide the highest return to the economy. For irrigation use in the Jordan Valley and in the Highlands, a comprehensive risk management system is in place.
5.f.	The quality of treated wastewater from all municipal and industrial wastewater treatment plants meets national standards and is monitored regularly.
5.g.	Tariffs for wastewater collection are rationalized.
5.h.	All treatment plants are operated according to international standards and manpower is trained accordingly.
	6. Alternative water resources
6.a.	Treated wastewater will be used for the activity that provides the highest social and economic return and standards for use in agriculture will be introduced and reinforced.
6.b.	Desalination projects at the Red Sea are operational.
6.c.	Rainwater harvesting is encouraged and promoted.
6.d.	Infrastructure for desalination of sea and brackish water is sufficient.
6.e.	An alternative energy source to keep the cost of desalination as low as possible is available.

Table 3. Description of the categorization of the research focus areas (RFAs) in the collected studies.

Research Focus Area (RFA)	Included:
Agriculture	Any study related to agriculture including irrigation efficiency, crop type, farming area, abstraction amount for agriculture.
Energy	Any study related to energy including current energy costs and renewable energy production.
Hydrogeological Field Measurements	Any study related to field surveys and to field measurement campaigns (water level, water and soil parameters, land cover/use classification).
Geophysics	Any study related to the application of geophysical methods (vertical electrical sounding, transient electromagnetics, seismic refraction).
Modeling	Any study related to the application of a mathematical model (groundwater flow model, solute transport, climate, surface water model, erosion, geochemical model, decision support system, vulnerability mapping, statistical analysis).
Remote Sensing	Any study related to satellite images use and processing.
Socio-Economy	Any study related to social or/and economic aspects (income, education, employment, community development, cost of water, the degree of public satisfaction with governmental decisions, degree of awareness of water scarcity in the basin, population growth).
Laboratory Soil Sample Analyses	Any study related to collection of soil samples to conduct biological and/or chemical analysis (nutrient or contaminant), and/or to investigate the physical properties of the soil.
Laboratory Water Sample Analyses	Any study related to surface or groundwater samples to conduct chemical, biological or physical analyses.

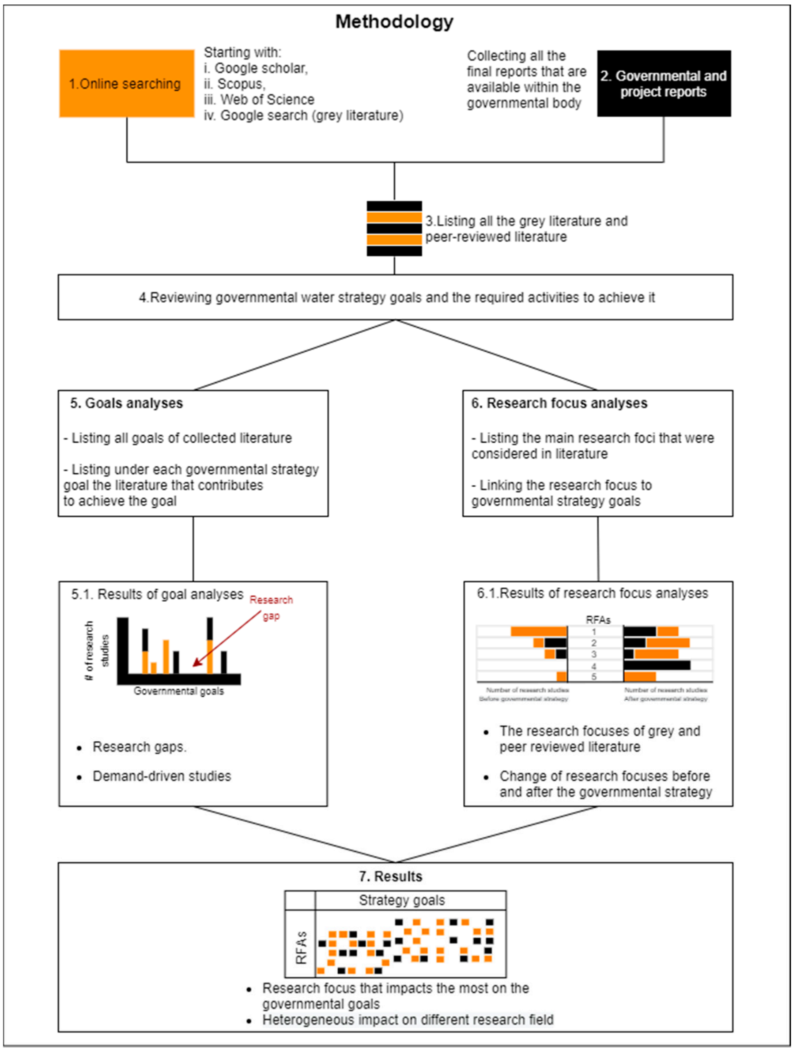


Figure 2. Schematic figure for the methodology we followed in this paper.

4. Results

4.1. Collection Process

It was noticeable that there was no systematic way for archiving project reports at the MWI. When a project is concluded within the MWI or with international partners, the final report is usually submitted to the principal employee from the MWI (focal person of the project). At times, the final reports would be submitted to more than one person. Subsequently, these submitted reports remained scattered in different departments of the institution and were not allocated to a specific storage location, system, or person. For example, to have access to a specific report, the project's focal person must be identified and contacted to retrieve a copy of the report. In some instances, the employee may have already retired, which made the retrieval process difficult.

A total of 2200 documents were collected from the MWI. From these files, 26 final reports related to water resources in the Azraq Basin were extracted. This number is not to be taken as a representation of the total number of final reports on the Azraq Basin in the MWI, given that some reports were difficult to access because they were not available as digital copies. In addition, three reports were recovered through online research, as well as nine conference proceeding articles, totaling 37 grey literature sources. During the collection process, 62 peer-reviewed articles were recovered online, encompassing the period 1980 to 2018.

Figure 3a shows that the production of research documents increased between 1985 and 2020. The oldest grey literature report included was published in 1985 by Rimawi and Udluft [42], and the oldest peer-reviewed article included in this analysis was from 1992 by El-Waheidi et al. [43]. Overall, it is observed that peer-reviewed research production in the Azraq Basin has continuously increased since 1998. However, the only exception was for the year 2011, with no research relating to the basin published. The years 2014 and 2016 evidenced the largest number of conducted research studies (both grey literature reports and peer-reviewed articles combined) with nine studies. The year 2018 had the highest number of peer-reviewed articles, with eight published articles compared to all other years since 1985. Conversely, the years 1996, 2014, and 2015 showed the highest grey literature number with four studies per year.

This result is consistent with overall research production in Jordan (Figure 3b). According to the database of Scopus, the total number of produced studies in Jordan increased from 139 to 4456 between 1985 and 2018. These studies consider all topics, including water-related topics. The percentage of studies that include the word "water" in the title, abstract, and keywords ranges between 8% and 16% over the whole period. At the same time, the number of studies that include the word "water" in the title, abstract, and keywords increased from 21 to 376. Therefore, the increasing trend in research production in the Azraq Basin follows the same upward trend of the number of studies produced in Jordan from all disciplines.

Most of the peer-reviewed publications were led by academic institutions. In 42 publications, only academic institutions contributed to the publication, while 12 publications were conducted by a combination of both academic and non-academic institutions. Conversely, nine publications were led by members from non-academic institutions, with only one of them in cooperation with an academic institution (Figure 4a). Academic international and national institutions published 11 and 43 studies, respectively. In contrast, non-academic international and national institutions published only three and six studies (Figure 4b).

4.2. Analysis Process

The analysis process categorized the documents based on their contribution to the MWI strategy goals and their research focus. The results showed that a total of 79 documents addressed at least one of the MWI strategy goals, 29 before and 50 after the water strategy; 20 documents are not aligned to the MWI strategy (8 before and 12 after the implementation of the water strategy). Additionally, the number of RFAs that were considered within each research varies between one and five focuses. Figure 5 shows a summary of the results of the conducted analysis process of peer-reviewed and grey literature.

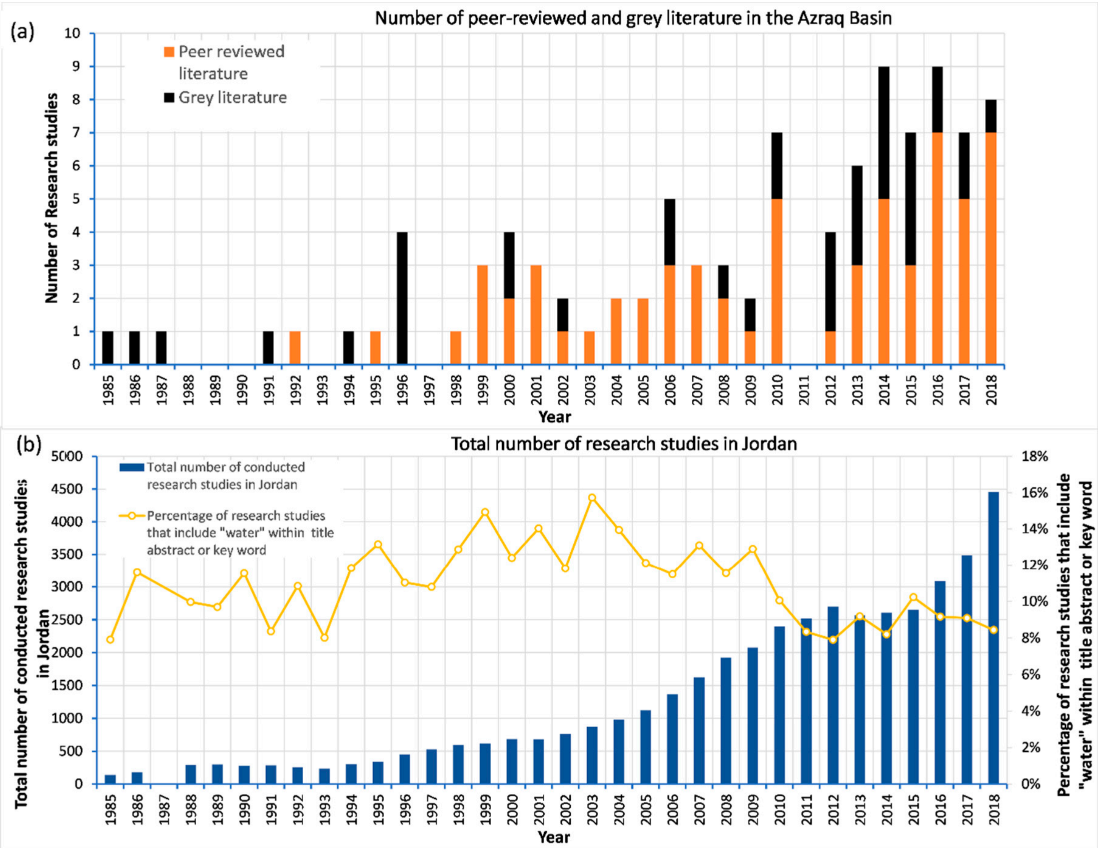
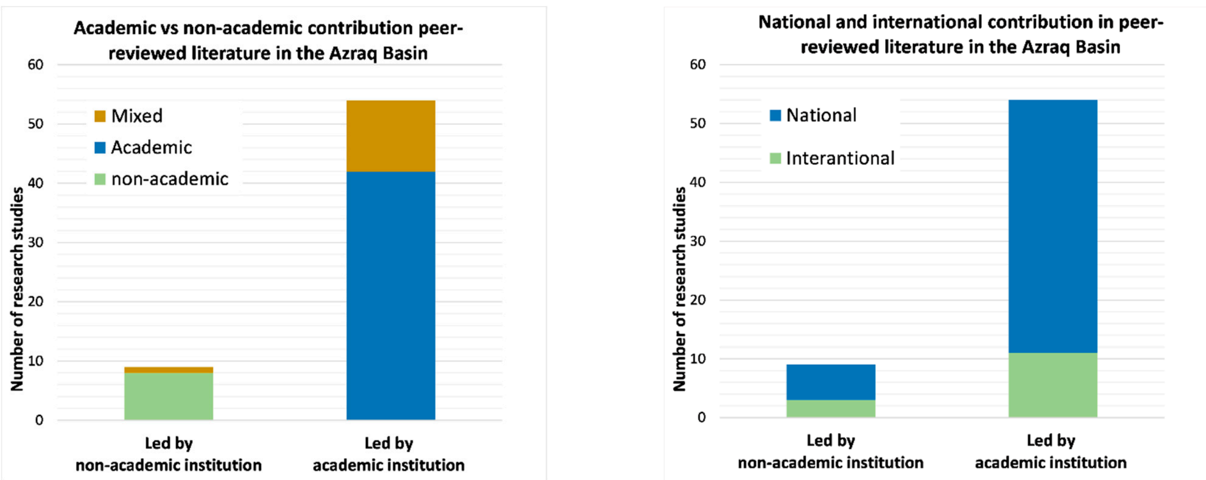


Figure 3. (**a**) Number of grey and peer-reviewed literature spanning the period (1985–2020). (**b**) Total number of documents that exist in the Scopus database produced by Jordanian institutions (blue column), percentage of number of documents stating the word "water" in the body of the document (orange line), percentage of number of documents stating the word "water" in a title, abstract or keyword of the document (grey line).



(**a**) (**b**)

Figure 4. Number of peer reviewed research studies conducted by (**a**) only academic, only non-academic and combination of academic and non-academic institutions, and (**b**) national and international institutions based on the affiliation of the first author of the literature.

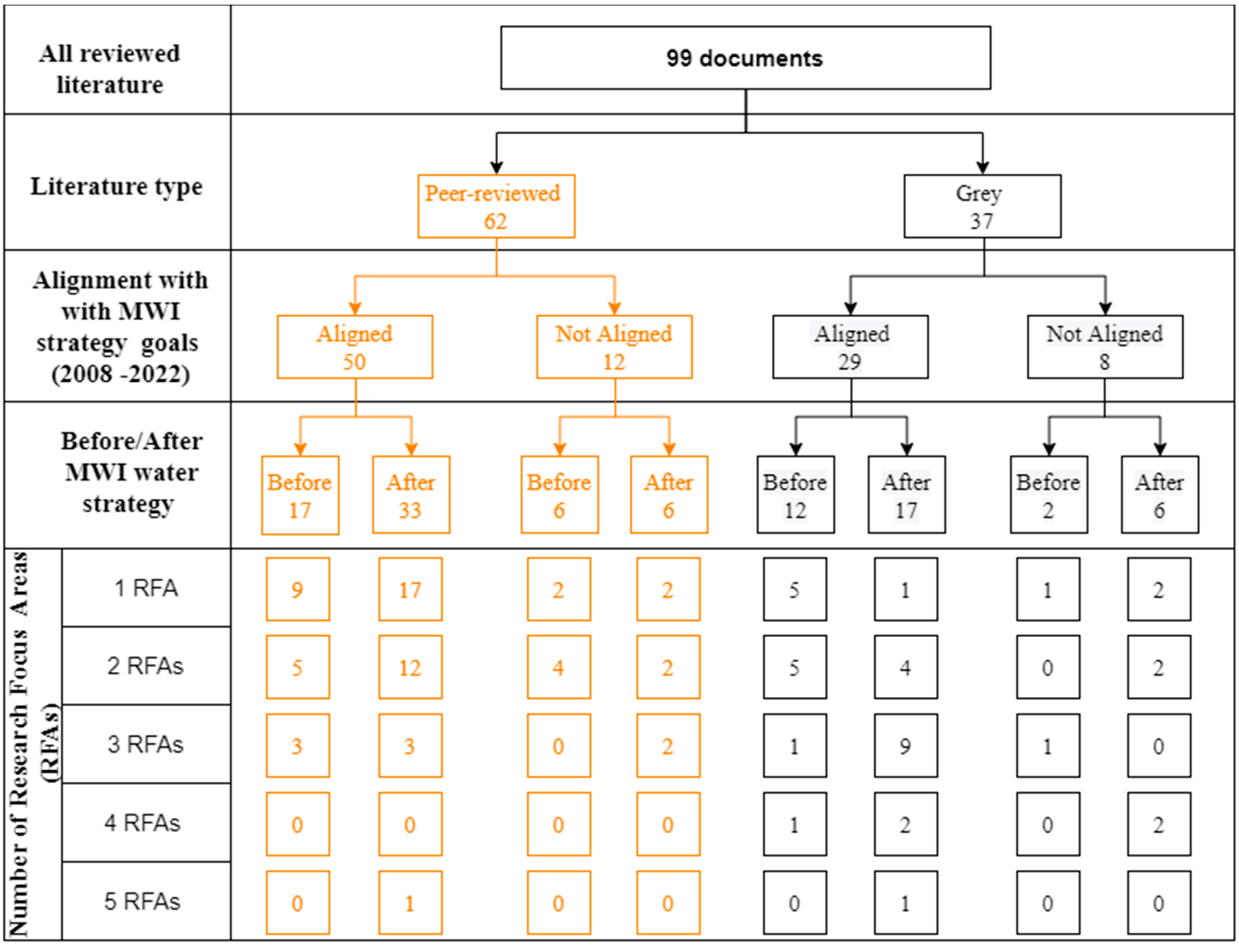


Figure 5. Summary of the results of the analysis process.

4.3. MWI Goals Analysis

The MWI strategy consists of 43 goals covering six topics (Figure 6). To define the research gaps in the Azraq Basin, the collected research goals were categorized with the MWI strategy goals (Figure 6). As stated previously, 79 studies are aligned to one or more of the MWI strategy goals. A total of 15 and 60 studies align with goals related to the two topics of water demand and supply, respectively. Water irrigation and alternative water resource goals are addressed in 13 studies and only two studies focus on goals related to wastewater.

4.3.1. Goals Related to Water Demand

The number of studies contributing to the improvement of the water demand topic recorded the second-highest number of instances after the topic of water supply. Unlike the water supply goal, each of the studies listed under the improving water demand goal contributes to only one of the goals related to water demand. However, the 15 studies focusing on water demand contributed to three of the six goals. Three studies contributed to goal 1.a., aiming to reduce the water use for agriculture in the basin. These studies investigate the options of purchasing water rights from farmers [44], introducing energy farming [45] and incentives for farmers [36], acting as a guide to the ministry in issuing legislation for these alternatives. Goal 1.b. aims to increase the awareness of people about water scarcity and the importance of conserving water resources, where five studies focus on this topic; for example, Hamberger, K. et al. [46] mapped stakeholder networks to identify the links between the main stakeholders by interviewing farmers of the basin and Al Naber, M. and Molle, F. [47] investigated the response of the farmers towards the challenges that they face and evaluated the factors that impacted the cost of the crops. Such studies may help the MWI to target the appropriate stakeholder groups who are unaware of/deny water scarcity. Al-Bakri, J. T [35], and Al-Bakri et al. [48] defined areas and the volume of illegal abstractions, and one study included the farmers in an association and conducted regular meetings that included technical and non-technical messages aiming to increase the awareness of water scarcity among farmers [49]. Goal 1.c. focuses on improving water resource management, considering the impact of climate change on the water balance. From seven studies that address this goal, three studies investigated the impact of climate change on temperature, rainfall, and runoff [32,50,51]; three studies considered the impact of climate change as an input to a groundwater model [52–54]; and one study examined droughts [55]. No study addressed the options to reduce water demand within each sector (goal 1.d.), evaluating the water tariff (goal 1.e.) or aiming to reduce the non-revenue water in the basin (goal 1.f.).

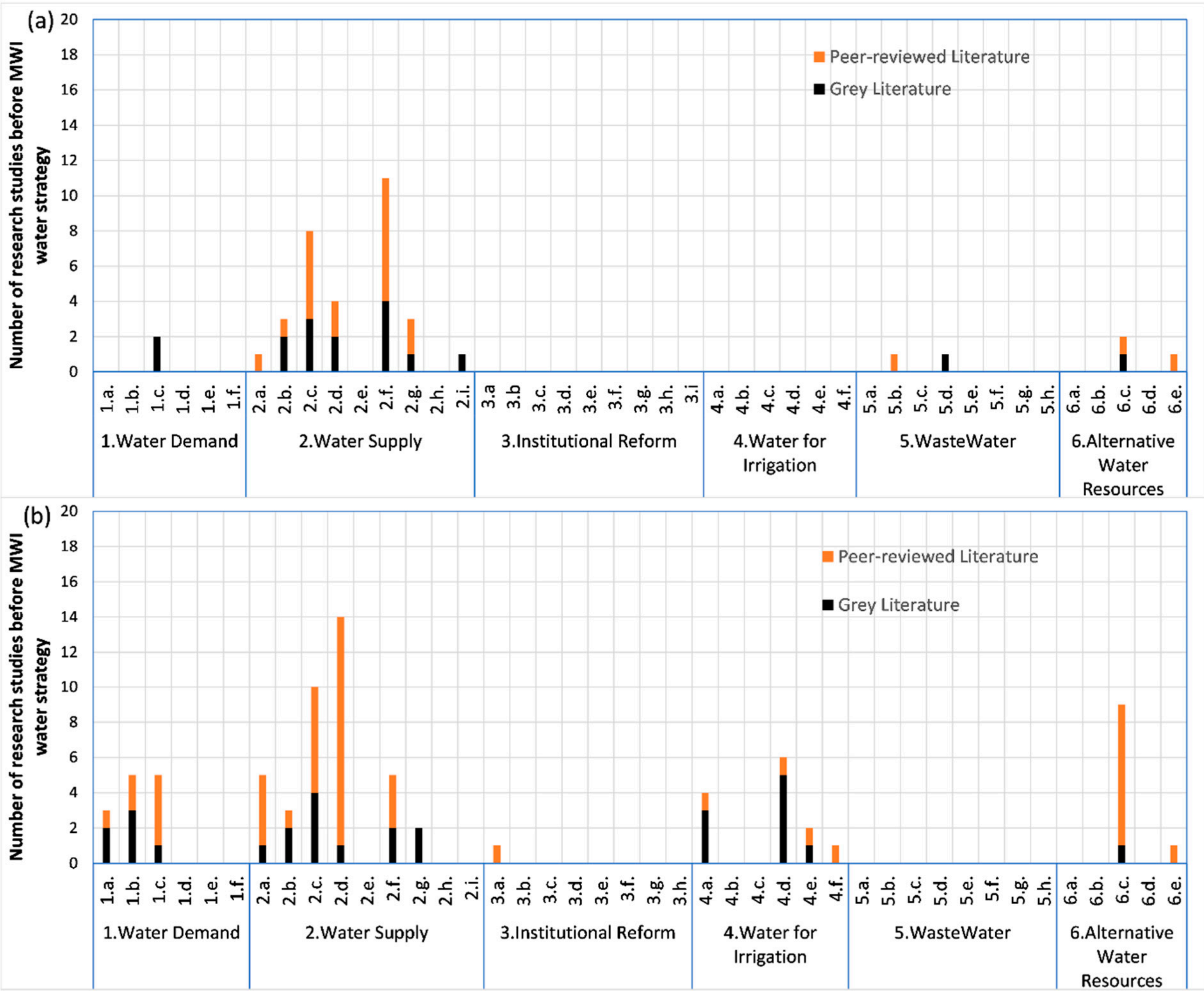


Figure 6. Number of grey and peer-reviewed studies that align with MWI water strategy goal 2008–2022 (**a**) before and (**b**) after the water strategy.

4.3.2. Goals Related to Water Supply

Approximately 60% of the references collected contribute to seven out of nine goals related to water supply; goal 2.a., which focuses on developing a secure and safe water supply in the area, is included in six studies; four focus on allocating new water sources [56–59], and two studies focus on sustainable management [52,60]. While six studies were found to be aligned with goal 2.b., which focuses on using desalinated water as a major source for water supply, four focused on saline water intrusion [43,61–63], one on hydrochemistry [42], and one on salinization scenarios [64]. Additionally, a total of 18 studies contributed to the MWI strategy goal 2.c., which focuses on protecting drinking water resources from pollution. Jasem and Alraggad [65], Al-Adamat et al. [66], and Ibrahim and Koch [67] presented a groundwater vulnerability map for the area, Gassen et al. [68] delineated the protection zones of AWSA wellfield, and the remainder contributed to this goal by investigating the quality of groundwater in AWSA wellfield area [61,62,64,69–73], in the northern region of the basin [74,75], in the southern region of the basin [76], in Qaser tuba landfill [77] and the Azraq Basin as a whole [26]. Furthermore, 18 studies contributed to goal 2.d., which focuses on improving the efficiency of storing and utilizing surface water, with 17 addressing various opportunities to utilize the surface water quantity and defining the suitable locations for managed aquifer recharge (MAR) [51,78–93]. Only Salameh et al. [94] addressed the topic of investigating the surface water quality.

Moreover, a total of 16 studies align with goal 2.f., which focuses on improving data availability and the monitoring system. Baïsset, M. et al. [73] described how to improve the data availability and monitoring system, and the remaining studies focus on assessing the availability and sustainable exploitability of water resources in the basin [23–26,29,31,52,54,64,95–99]. Only BGR/ESCWA [100] indirectly targeted goal 2.i., which focuses on the protection of shared water rights. BGR/ESCWA [100] focused on investigating the shared water resources in Jordan and Syria rather than protecting the Jordanian share rights. Contrarily, the remaining two goals related to water supply, namely: goal 2.e. "Treated wastewater effluent is efficiently and cost-effectively used." and 2.h. "the concept of utilizing greywater and rainwater is fully embedded in the codes and requirements of buildings" were neither addressed by peer-reviewed literature nor by grey literature.

4.3.3. Goals Related to Institutional Reform

Concerning goals related to institutional reform, only Leyroans [101] contended the one focusing on achieving sustainable and collective governance of groundwater resources: the Azraq Basin first needs to be recognized as a resource in "the commons" category, differentiated from being a private or public resource; second, the state needs to hold a subsidiary function that ensures the effective implementation of water management decisions made by the local population at the local level through adopting participatory methods. These recommendations mainly align with the suggested legislation to manage the issues of "traditional water rights in Jordan", aiming to balance the traditional water rights with the state's water rights moving towards achieving a national water law that is enacted and enforced (goal 3.a). The remainder of the goals were not addressed directly by the collected studies.

4.3.4. Goals Related to Water for Irrigation

According to the MWI water strategy 2008, irrigation practices in the highland region, including irrigation in the Azraq Basin, are not adequately controlled, and are categorized as exhibiting poor irrigation efficiency practices. Therefore, the MWI addressed the water irrigation topic in the strategy. The first goal 4.a. aims to reduce the annual water allocation for irrigation in the area, and a total of four studies were aligned with this goal; while GIZ [45] and Al-Tabini, R. et al. [44] analyzed the economic return of reallocation water use to sectors other than agriculture, Octavio, R. et al. [102] focused on conducting a survey to evaluate factors affecting agriculture water use, and Demilecamps, C. and Sartawi, W. [36] proposed project ideas to reduce water use in agriculture. Goal 4.d. recorded the largest number of studies contributing to the topic of water irrigation; four of the six studies focused on monitoring the abstractions in the basin, and two focused on establishing and empowering farmers' forums.

Furthermore, Al Naber, M. [47], and Molle, F. and Al-Naber, M. [103] investigated the economic returns of different crops in the basin, which aligned with goal 4.e., aiming to introduce a new tariff and incentive system to promote water efficiency in irrigation and higher economic returns for irrigated agricultural products. The promotion of methods and technology to enhance the irrigation water supply (goal 4.f.) is addressed only by Al-Zubi, J. et al. [89], who focused on water harvesting feasibility for irrigation use in the Wadi Muhweir catchment in the basin. The collected studies are neither aligned with the goal 4.b., which states, "Efficient bulk water distribution as well as efficient on-farm irrigation systems are established." nor with goal 4.c., which states that "All treated wastewater generated will be used for activities that demonstrate the highest financial and social return including irrigation and other non-potable uses.".

4.3.5. Goals Related to Wastewater

The ministry aims to expand the wastewater network in the kingdom and consequently increase the amount of treated wastewater for non-drinking purposes. Hence, eight goals were listed under the wastewater topic. However, only Baban et al. [74] addresses goal 5.b., by estimating the impacts of cesspools on groundwater in the basin under various scenarios; the estimation and analysis of these impacts will inform the MWI of future locations for implementing treatment plants, in order to minimize the threats of wastewater disposal on adjacent drinking water resources. Additionally, Al-Adamat et al. [75] targeted goal 5.d., which aims to protect the public health and environment; this study set specifications and standards procedures of septic tank usage in the Azraq Basin. The remainder of the goals related to wastewater were not addressed in any of the previous studies.

4.3.6. Goals Related to Alternative Water Resources

Given that Jordan's renewable water resources are limited [21], one of the MWI aims is to explore new water resources such as treated wastewater, greywater, and desalinated water. Therefore, the alternative water resources topic was addressed in the MWI strategy of 2008. Only two goals were addressed in the collected literature: firstly, goal 6.c., which aims to promote and encourage rainwater harvesting, where 11 studies addressed the potential of implementing rainwater harvesting in rural areas of the basin [78,80,81,84–89,91,92]. These studies differ from each other mainly in that there is primary focus on different locations of the basin. Secondly, goal 6.e., which aims to find an alternative energy resource for desalination, was found to have only two contributing studies: Sawariah [104] defined the areas with high potential for thermal water sources, and Mohsen [105] studied the feasibility of using solar energy for water desalination in the basin. The remainder of the goals in this topic were not addressed by a reference.

4.4. Research before and after the MWI Strategy

Figure 6 shows that the number of grey literature studies in alignment with the MWI strategy goals increased after the MWI water strategy implementation by 30%. A greater increase is observed in the peer-reviewed literature, where the total publications doubled during the same period. While this result may be expected considering the overall increasing trend in research production shown in Figure 3, it is noteworthy to observe that prior to the implementation of the strategy, only two studies aligned with the goals related to water demand, while this number increased to 13 studies after the implementation of the strategy. More specifically, the number of studies that align with water supply only increased from 27 studies (four of which contributed to two goals) to 33 studies (six of which contributed to two goals) before and after the MWI strategy, respectively. No study aligned with the water irrigation goals before the MWI water strategy, while 13 studies align with water irrigation goals after implementing the water strategy. Furthermore, the number of studies that align with goals related to wastewater goals reduced from two to zero before and after implementing the MWI strategy.

4.5. Research Focus Areas Analysis

The analysis showed that 60 studies of the collected studies have more than one RFA, indicating that a large part of the collected studies are interdisciplinary. In such cases, the

RFAs were categorized as either primary or secondary in nature, where the secondary area supports the primary RFA; for example, in the work of Abu Rajab and El-Naqa [63], geophysics is the study's primary RFA. However, the researchers collected and analyzed water samples to support the geophysics analysis; in this case, the laboratory water sample analyses are categorized as a secondary RFA. The following section represents a review of the collected studies categorized according to the primary RFA. Moreover, a complete overview is given in Appendix A.

About 35% of the collected documents focused on modeling in terms of: (a) estimating the recharge rate [50,106], (b) enhancing the recharge amount [78,80,81,84,85,87–90,92], (c) studying the impact of climate change on water resources [53], (d) assessing surface water and drought [51,55,107], (e) locating potential areas for groundwater abstraction [58,59], (f) analyzing time series [32,108], (g) building water quality models [70], (h) building groundwater models [29–31,54,96–98], (i) delineating isohyetal maps for rainfall [93], (j) creating vulnerability maps [65–67], and (k) proposing sustainable water management plans [52,60].

Although the modeling RFA had the most significant percentage among the collected literature, the basin was still an exciting area for researchers to conduct geophysical investigations to (a) study the saline water body in the basin [43,57,61–63,69,109], (b) investigate the suitability of water harvesting of Laval tunnels in the north of the basin [86,110], in the Dier al Kahif region [82], and in the Asra dam [83]; (c) investigate the impact of Qaser Tuba landfill on groundwater [77]; and (d) identify the geological formations of the Bishrya dam [111].

Socio-economy was the main focus of the studies that investigated: (a) the water governance in the basin [22,101], (b) the farming system and practices [36], (c) the socio-economic factors that impact the farmer's practices [44,46,102,112,113], (d) the impact of governmental regulations and socio-economic impacts on farmers and agriculture practices [47,103,114], (e) the challenges of managing groundwater in the basin [49], action plan to manage the groundwater [115], and (f) the socio-economic impact of applying solar farming in the basin [45]. Furthermore, two studies focused mainly on energy topics: one study to investigate the feasibility of applying solar energy for water desalination in the basin [105], and another study to investigate the potential for using thermal water as an alternative energy source [104].

Beyond the studies that conducted sampling campaigns as secondary RFAs [61,63,66,67,77,87,88], sampling campaigns were the main RFA in 20 studies. Water samples were collected, and isotopes were analyzed to (a) study the recharge rate in the Azraq Basin [23], (b) define the recharge origin in the basin [24,25,116], (c) group water types [26,42,76], (d) study the salination process [64,71–73], (e) evaluate nitrate leaching to groundwater [74,75], and (f) inspect the eutrophication process of surface water [94]. Soil samples were collected in the basin to (a) explore soil suitability for agriculture [117–119], (b) define the source of sulfur and gypsum [120], (c) estimate the recharge rate [33], and (d) map the soil moisture of the Al-Bagureyya area [121].

Hydrogeological field measurement was the main RFA to (a) review the groundwater resources [79,95,99,100]; (b) create geological maps [122]; (c) delineate protection zones [68]; and (d) to set an action plan [56]. Furthermore, Remote sensing techniques were used in the basin to (a) estimate the abstraction [34,35,123,124]; (b) create hydrological maps [91,125], and (c) study land change over time in the basin [126–129]. The agriculture RFA was not the main focus of any of the collected research; however, it was considered in 13 studies [36,45,47,49,52,60,74,103,112–114,124,130], and more reports with regard to agriculture are expected to be found in the ministry of agriculture, as shown in Table A1.

Figure 7 shows that the number of studies increased in all the RFAs after the implementation of the strategy, except in the laboratory sample analysis; the number of studies that focus on soil and water analysis decreased from 8 and 10 before the strategy to four and eight studies after the strategy, respectively. However, in the laboratory water sample analysis RFA, the number of peer-reviewed studies increased from five studies before the strategy to six studies after the strategy.

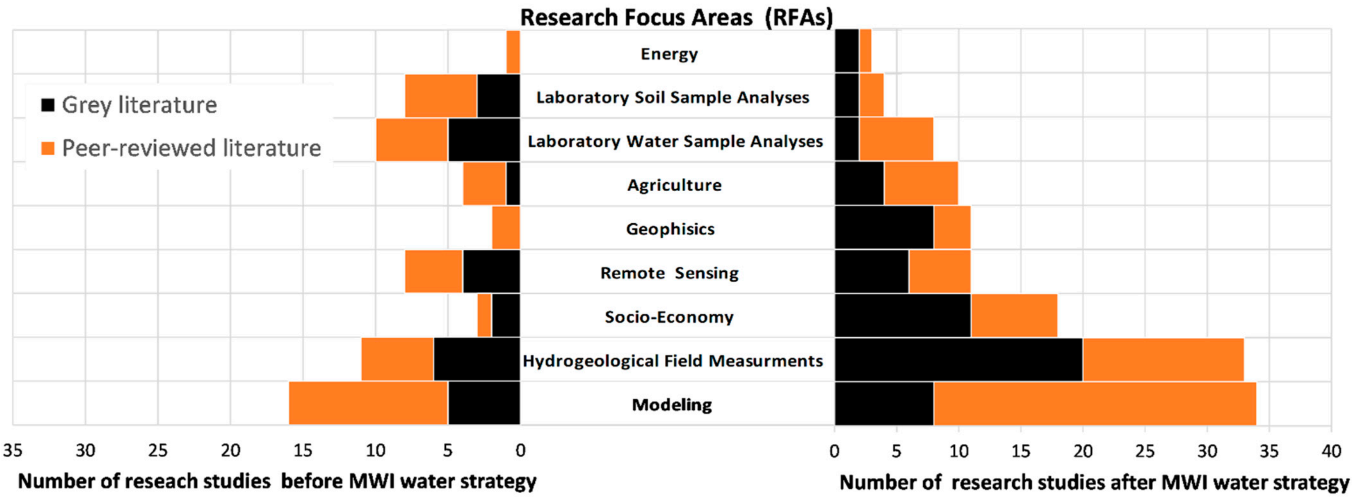


Figure 7. Research focus of the collected literature before and after the implementation of MWI water strategy.

Energy and agriculture were not the focus of any grey literature study before the MWI strategy implementation. However, after 2008, the work of GIZ [45] and Mesnil A. et al. [115] considered energy in their research and eight grey literature documents considered agriculture by calculating crop water requirement [35,124], investigating farming systems [36,49,103,112,113], and evaluating the economic return of current agriculture activities [45]. Additionally, the socio-economic component was only considered by Al-Adamat et al. [75] and Ibrahim [122] among the grey literature studies and by Al-Zu'bi et al. [60] among the peer-reviewed studies before the implementation of the water strategy, while it increased to 11 grey literature studies [22,36,45,46,56,87,102,103,112,113] and seven peer-reviewed studies [44,47,52,80,88,101,114] beyond 2008.

The total number of RFAs within each literature varied between one and five RFAs in both grey and peer-reviewed literature. The percentage of literature that focused only on one or two RFAs was approximately 86% of the peer-reviewed literature and 57% of grey literature. Furthermore, the documents that considered three RFAs represent approximately 13% of peer-reviewed literature and approximately 28% of grey literature. Approximately 13% of the collected grey literature studies considered four RFAs, while no peer-reviewed study considered four RFAs. However, only a single report [87] and an article [88] considered five RFAs, both of which were publications of a project conducted by the BGR in the basin. No peer-reviewed study, conducted by academic institutions, considered more than three RFAs (Figure 8).

In Figure 9, it was shown that before the implementation of the water strategy, only the studies with a research focus on remote sensing and modeling targeted three topics of the strategy [29–31,42,50,51,60,64,74,85,91,96,97,100,105,125]. In contrast, after the MWI strategy publication, the studies with a research focus on remote sensing, modeling, socio-economy, and hydrological field measurement targeted four of the five water strategy topics, wherein each of the conducted studies was targeting one or two topics of the MWI strategy. Only the modeling work of Al-Zubi [89] targeted three topics, namely: water supply, water for irrigation, and alternative water supply. The water supply topic was targeted by all research focuses, except energy, which targeted water demand, irrigation water, and alternative water resources only after the MWI water strategy came into effect. Conversely, only CES [50] and Ayed [51] include modeling as an RFA and targeted the water demand topic's goals before the strategy. Laboratory soil and water sample analyses and geophysics have neither contributed to the water demand topic before nor after the water strategy.

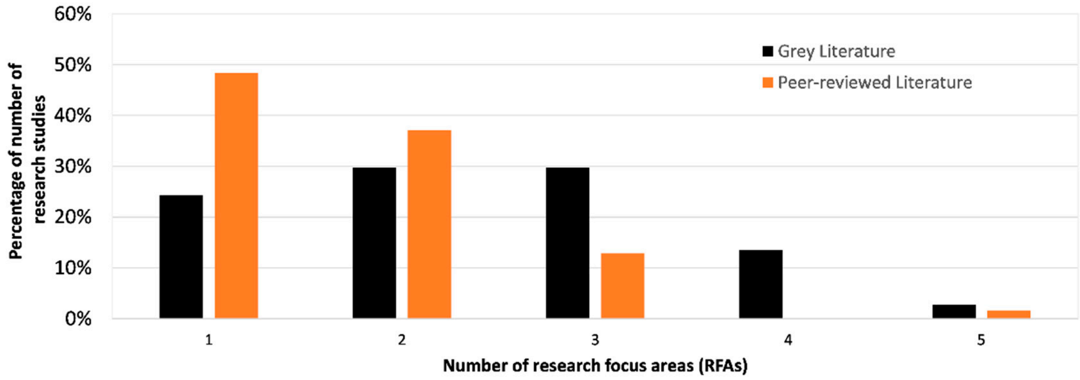


Figure 8. Number of research focus areas in grey and peer-reviewed studies.

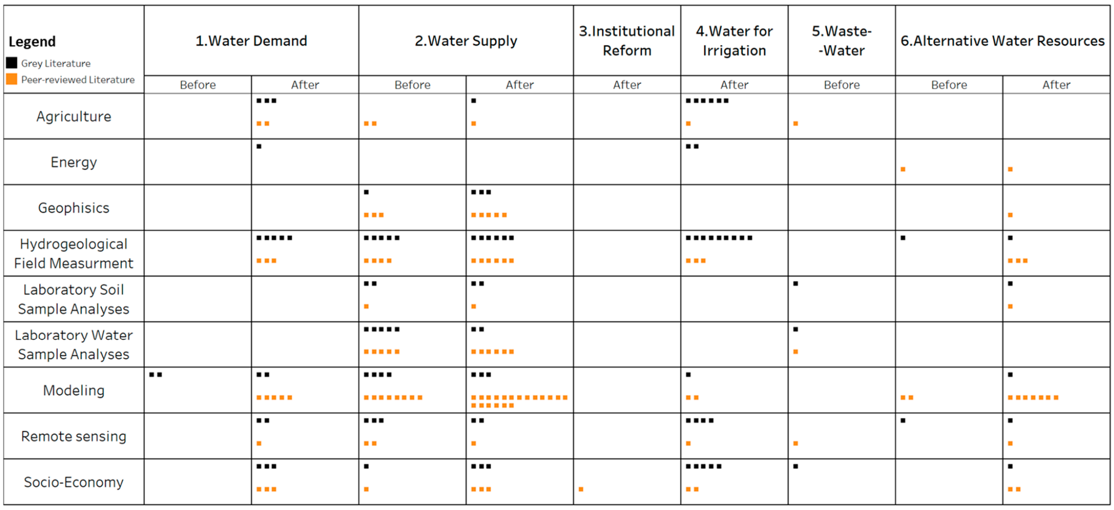


Figure 9. Relationship between the research focus areas (RFAs) and the MWI strategy topics.

4.6. Analysis of Research Topics Addressed by Documents Not Aligned to the Water Strategy Goals

As stated previously, 20 documents did not align with the MWI water strategy goals (Figure 10). These documents covered topics such as geology [99,110,121,123], soil [33,118–120,122,128], land use change [126,128,129], and time series analysis [107,108]. Although the research of Ibrahim [122], Al-Amoush and Rajab [110], Ahmad and Davies [120], Al Adamat et al [131] and UN-ESCWA and BGR [99] aimed to deepen the knowledge of the hydrogeological conditions of the Azraq Basin, these publications do not align with the MWI water strategy goals on the basis that they do not explicitly answer questions related to water management and availability, which are the core of the strategy. Nonetheless, the references [57,99,110,120,122] provide valuable information for the activities under the responsibility of the Ministry of Energy and Mineral Resources. Similarly, the MWI strategy did not explicitly address the topics of soil and land use change, which is a competence of the Ministry of Agriculture. Therefore, three studies [126,128,129] focusing on land use change, and six studies [33,117–119,121,127] focusing on soil science cannot directly contribute to the goals of the strategy. Amro et al. [33] contains important isotopic analysis that could be used to estimate the groundwater recharge in the catchment. However, since such an analysis is missing, the research was not considered to be aligned with the MWI strategy. Molle et al. [22] and Al Naber and Molle [114] represent a comprehensive overview of Jordan's water governance and policy, and their impact on Azraq Basin water resources as well as the responses of people to these policies. Such an assessment is needed for all individual basins of Jordan; this would provide the government with a compass to achieve improved water governance; however, such an assessment is not foreseen in the water strategy. The works of Shatnawi et al. [107] and Goode et al. [108] focus on time series analysis of hydrological variables. However, neither aligned with the MWI water strategy because their analyses did not explicitly address any of the goals. In particular, Goode et al. [108] presented trend analyses for groundwater levels and groundwater quality in the Azraq Basin, as a result of a cooperation project between USGS and the MWI, and still it did not align with the goals outlined in the MWI strategy. A similar event occurred in two reports [112,113], which were a result of the cooperation project between USAID and MWI. Both reports present a comprehensive socio-economic survey of groundwater wells of the basin, and it is stated in the reports that "This study was requested by the Ministry of Water and Irrigation". In these cases, there is, however, no output that explicitly fits the water strategy goals. Therefore, the fact that these 20 documents did not match the MWI strategy goals does not necessarily mean that these documents were not demand-driven research. Moreover, our analysis shows that the water strategy may in the future consider a more holistic approach in the definition of its goals.

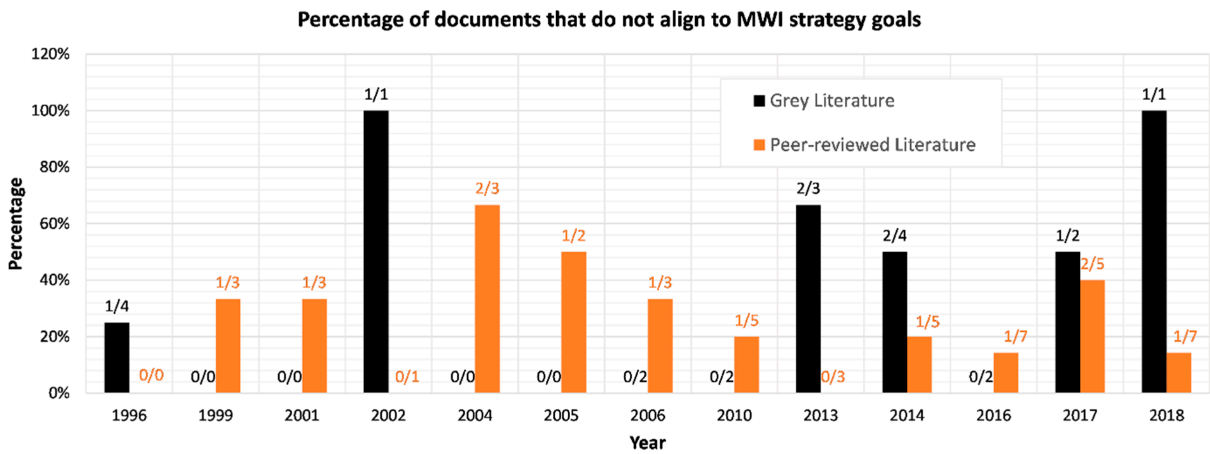


Figure 10. Percentage of studies that do not align with the MWI water strategy. The numbers above the bars represent the number of documents that do not align with MWI strategy and the total number of documents per year (the figure only represents the years, where the documents do not align with the MWI strategy goals).

5. Discussion

5.1. Research Gaps

Beyond the "practical-knowledge gap" identified in the comparison between conducted research and the MWI goals, the literature review allowed the recognition of a "knowledge gap", as defined by Miles [15]. In fact, a standard methodology to define a "practical-knowledge gap" in water-related research was not found; this study contributes to filling this gap. Decision-makers in the water sector need comprehensive studies and research to decide on a particular goal in a governmental water strategy. When missing research hinders taking a decision about a goal, it was deemed to be a "water-decision-research-gap", which is the inability to take a final decision about a governmental water strategy goal through conducting a systematic peer and grey-literature review at the basin level. It is essential to highlight when studies and research contribute to a specific goal; this contribution, however, does not guarantee that the necessary research is enough to make a decision related to the goal, and it could be that further research is needed. For instance, many studies contributed to the goal 2.d. [51,78–93], which aims to store and utilize surface water efficiently; however, only Salameh et al. [94] focused on the surface water quality of the Rajil dam in the basin, while the remainder (17 studies) focused on the amount and the suitable location for surface water harvesting. Therefore, the lack of surface water quality research hinders the decision-maker's ability to derive a conclusion from the literature review to make well-informed decisions related to the goal 2.d. Thus, the lack of surface water quality studies in various locations in the basin, in this case, is a water-decision research gap.

Furthermore, although several researchers have studied water harvesting at the local level, it is still necessary to conduct further studies at the same level (local level), similar, for example, to the study by Al-Zubi [89], which compared the feasibility of implementing water harvesting techniques at a micro and macro level in Wadi Muhweir for irrigation purposes. Goal 2.d. could be achieved if similar studies in all the locations (e.g., all main wadis and dams) were to be conducted. Furthermore, some goals (such as wastewater as an alternative water supply) in the strategy are found to be codependent, and they were not achieved because they required other goals (the goals related to wastewater) to be achieved prior, such as goal 6.a., which promotes treated wastewater as an alternative resource for agriculture; however, to study the treated wastewater viability as an alternative water resource, the goals in the wastewater topic (topic 5) must be further studied. This leads to the conclusion that a timeline for the strategy's topics and goals would help researchers to conduct demand-driven research.

It is crucial to clarify that when it is stated that a goal is not covered by literature, that this is in reference to the collected literature for the Azraq Basin within this research. The goal may be partially addressed by research work conducted on the national level, such as [132,133], that targeted the goals of wastewater topic in Jordan, or addressed by research performed in other regions or subbasins that share similar hydrological and socio-economic conditions, or addressed by reports that are not accessible according to the presented methodology, such as studies that were conducted by private engineering companies and were shared with the ministry.

5.2. Heterogeneity Impact of Research on Goals

A clear presentation of goals in governmental water strategies, such as the MWI water strategy 2008–2022, can be perceived as a prerequisite for increasing the researcher's ability to conduct demand-driven research and to contribute to achieving these goals. As stated previously, the impact of the research on the strategy goals varies, where some of the RFAs have contributed to most of the topics that were addressed by the governmental strategy (e.g., modeling RFA), while other areas contributed the least (e.g., energy RFA). Such an assessment helps the government and researchers to address the goals from a different perspective. For instance, the energy RFA contributed to the goals related to water demand, the water for irrigation, and alternative water resources with only three studies. Consequently, beyond the aforementioned topics, there is a strong argument for the need to conduct more studies about energy and water supply or energy and wastewater in the basin.

5.3. Implications for the Identification of Research Needs

The application of the proposed methodology to the Azraq river basin demonstrated that some goals were not addressed by any of the research study collected (Figure 6), which directly translates to a research gap existing. However, there can be multiple reasons that justify the occurrence of such a gap and that can explain the lack of research documents. For instance, the lack of infrastructure for a centralized wastewater treatment in the basin partially hinders research for goals 5.a., 5.e., 5.f., 5.g., 5.h., and 6.a. In fact, the Arzaq Basin is not yet connected with wastewater treatment plants but only cesspools at the present time. Therefore, studies evaluating the current impact of all wastewater disposal sites on groundwater are needed, especially for newly proposed locations that might threaten the groundwater quality, contributing to goals 5.b. and 5.d. Beyond the environmental impact assessment of the proposed sites, socio-economic assessments, technical and economic feasibility assessments are equally crucial for installing new wastewater treatment systems in the area. Therefore, it is essential to highlight that during the field visit to the MWI in January 2020, MWI staff indicated that reports on the new wastewater plant proposal in Azraq exist but could not be accessed.

The fact that a goal is addressed by several research studies does not necessarily imply that further research is not required. For example, setting a cap on water use for agricultural purposes was addressed partly by three studies [36,44,45]. However, innovative approaches to upgrade tools and technologies focusing on optimizing energy consumption and irrigation efficiency are urgently needed such that Jordanian farmers can contribute to the achievement of the goal. Goal 1.b. aims to increase awareness within the Jordanian society on the issues of water scarcity and some of the collected studies already provided measures for the farmer's awareness [46,47]. Still, there is a need to conduct similar studies that analyze the level of awareness for other social groups, such as students and industrial stakeholders, including tourism, to set up effective educational programs concerning water scarcity for different grades. Likewise, the following areas of assessment and evaluation still require further investigation to achieve the MWI's strategic goals:

i. **Investigate and improve the existing water distribution systems** in terms of technical aspects (i.e., hydraulic), management, energy efficiency, operation and maintenance, water losses, and billing and collection systems; contributing to **goal 2.a.**
ii. **Examine the deep aquifer area** in terms of water quality and quantity; contributing to **goal 2.a.**
iii. **Explore the potential of using desalinated water** in terms of technical, economic, and environmental aspects for both saline groundwater abstraction and building treatment plants; contributing to **goal 2.b.**; and also in terms of using an alternative energy source for desalination; contributing to **goal 6.e.**
iv. **Assess the existing monitoring systems** and provide proposals to improve them in terms of water quality; contributing to **goal 2.c.;** and water quantity; contributing to **goal 2.f.**
v. **Evaluate the current situation of the dams** in terms of sedimentation and water quality, focusing on conducting economic feasibility studies for sediment removal and water treatment; contributing to **goal 2.d.**
vi. **Investigate the current use of water in the recharge area** of the transboundary basin enhancing research cooperation with Syrian partners, contributing to **goal 2.i.**
vii. **Study the current irrigation systems** in terms of estimating the cost of changing it into a more efficient system; contributing to **goal 1.a.**; and drafting a farmer's incentives system for the MWI as a result of the economic and environmental benefits of these efficient systems, contributing to **goal 4.a.**, and
viii. **Examining the feasibility of installing rainwater harvesting techniques at the farm level**, similar to Zubi [82], as an alternative water resource for irrigation is still needed, thus contributing to **goals 4.f. and 6.c.**

5.4. Application to Other Areas

The developed methodology could be applied to other basins and other water strategies. However, the RFAs can be modified according to the collected research topics and the strategy's goals. If a new topic is presented, it can be added to one of the existing research areas or a new RFA may be added. Furthermore, when the methodology is applied at a national level, the corresponding national goals should be added to the methodology, and the goals addressed at a basin level should be removed. Conversely, mapping the RFAs and governmental goals can be implemented in topics other than water. This concept creates demand-driven research and helps researchers to address the goals by using the RFAs not addressing specific governmental goals.

Furthermore, to have a comprehensive water management strategy, the responsibility should not only be on the water provider [134] and the method could be developed to include other governmental strategies besides the water strategy. For instance, in the case of Jordan, this method could further be extended to cover the goals of the strategy of the ministry of agriculture and the ministry of environment. The method could be developed as a platform that connects different ministries and research institutions, where researchers can update the platform with new research and address the gaps that are identified with the methodology presented in this work. Finally, the governmental body may update the strategy goals accordingly.

6. Conclusions

A comprehensive methodology to define research gaps in water-related studies was developed and tested by investigating the impact of Jordan's water strategy (2008–2022) on research production in the Azraq Basin. The number of documents focusing on the basin increased after issuing the MWI strategy but there is no significant proof that this increase is due to issuing the MWI strategy, as the total number of published studies in Jordan addressing all topics also shows a positive rate of increase. Therefore, categorization of the research produced according to the MWI strategy goals is suggested, to better identify if and how they are addressed by peer-reviewed and grey literature. The results showed that the number of documents that align with the MWI strategy varies depending on the goal of the strategy and the RFAs considered within the document.

Involving governmental actors in the research design and literature collection process represents one of the most innovative and relevant points in the proposed methodology. In fact, grey literature is generally not easily accessible without involving actors from the ministries and its relevance in filling research gaps has been demonstrated in our work. The methodology allows the identification of a methodological research gap. This lack of research may hinder taking decisions related to governmental water strategy goals at the basin level. Thus, the inability to take decisions related to governmental water strategy goals through conducting a systematic peer and grey-literature review at the basin level was defined in this paper as the "water-decision research gap". Although the methodology indicates that the conducted research in the basin aligns with the ministry's water strategy, it does not guarantee that the research affects the strategy, mainly because proper communication between the government and researchers does not exist.

The methodology not only defines the research gaps but also evaluates the relationship between academia and government. In the Azraq Basin, 54 of the 62 peer-reviewed literature documents are led by academic institutions, and approximately 75% of them are conducted without cooperating with any governmental body or non-academic institution. Furthermore, approximately 75% of the peer-reviewed documents published by academic institutions are produced by national universities. This shows the vital role of the national academic institutions in water-related research and the importance of strengthening the relationship between academia and the government.

It is expected that the water strategy would have had a larger impact on the produced research if the goals of the strategy were formed based on the research outputs of each basin individually. This would help researchers to fill the gaps accordingly, and the conducted research would then be more demand-driven. Conversely, if researchers were to explicitly state the goals of the MWI strategy that were targeted in their work, this would help the ministry to update the strategy and develop a living document of the water strategy. The concept of linking the RFAs with the governmental strategy goals would inspire researchers to target the strategy's goals with interdisciplinary and transdisciplinary approaches that address all of the strategy topics. We expect that this link will enhance research production in the basin by reflecting the RFAs across each strategy topic for every goal. This may lead to the creation of innovative and imaginative research and eventually improve the connection between decision-makers and researchers. The government could further profit by conducting a systematic literature review to optimize the allocation of the budget available for future studies.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. List of the analyzed documents, goals, and RFAs.

#	Reference	MWI Goals	Research Focus Areas (RFAs)
1	[22]	not align	Hydrogeological Field Measurement, Socio-Economy
2	[23]	2.f.	Laboratory Water Sample Analyses
3	[24]	2.f.	Laboratory Water Sample Analyses
4	[25]	2.f.	Hydrogeological Field Measurement, Laboratory Water Sample Analyses
5	[26]	2.c., 2.f.	Laboratory Water Sample Analyses, Modeling
6	[29]	2.f.	Modeling
7	[30]	2.a.	Modeling
8	[31]	2.f.	Modeling
9	[32]	1.c.	Modeling
10	[33]	not align	Laboratory Soil Sample Analyses
11	[34]	1.b., 4.d.	Hydrogeological Field Measurement, Remote sensing
12	[35]	4.d.	Agriculture, Hydrogeological Field Measurement, Remote sensing
13	[36]	1.a., 4.a.	Agriculture, Hydrogeological Field Measurement, Socio-Economy
14	[42]	2.b.	Laboratory Water Sample Analyses, Modeling
15	[43]	2.b.	Geophysics, Hydrogeological Field Measurement
16	[44]	1.a., 4.a.	Hydrogeological Field Measurement, Modeling, Socio-Economy
17	[45]	1.a., 4.a.	Agriculture, Energy, Hydrogeological Field Measurement, Socio-Economy
18	[46]	1.b.	Hydrogeological Field Measurement, Modeling, Socio-Economy
19	[47]	1.b., 4.e.	Agriculture, Hydrogeological Field Measurement, Socio-Economy
20	[48]	1.b., 4.d.	Hydrogeological Field Measurement, Remote sensing
21	[49]	1.b., 4.d.	Agriculture, Hydrogeological Field Measurement, Remote sensing
22	[50]	1.c.	Modeling
23	[51]	1.c., 2.d.	Modeling
24	[52]	1.c., 2.a., 2.f.	Agriculture, Modeling, Socio-Economy
25	[53]	1.c.	Modeling
26	[54]	1.c., 2.f.	Modeling
27	[55]	1.c.	Modeling
28	[56]	2.a., 2.g.	Hydrogeological Field Measurement, Socio-Economy
29	[57]	2.a.	Geophysics, Hydrogeological Field Measurement
30	[58]	2.a.	Modeling
31	[59]	2.a.	Modeling
32	[60]	2.a., 2.g.	Agriculture, Modeling, Socio-Economy
33	[61]	2.b., 2.c.	Geophysics, Hydrogeological Field Measurement, Laboratory Soil Sample Analyses, Laboratory Water Sample Analyses
34	[62]	2.b., 2.c.	Geophysics, Hydrogeological Field Measurement
35	[63]	2.b.	Geophysics, Laboratory Water Sample Analyses
36	[64]	2.b., 2.c.	Hydrogeological Field Measurement, Laboratory Soil Sample Analyses, Laboratory Water Sample Analyses, Modeling
37	[65]	2.c.	Modeling

Table A1. *Cont.*

#	Reference	MWI Goals	Research Focus Areas (RFAs)
38	[66]	2.c.	Laboratory Water Sample Analyses, Modeling, Remote sensing
39	[67]	2.c.	Laboratory Water Sample Analyses, Modeling
40	[68]	2.c.	Hydrogeological Field Measurement, Remote sensing
41	[69]	2.c.	Geophysics, Hydrogeological Field Measurement
42	[70]	2.c.	Modeling
43	[71]	2.c.	Laboratory Water Sample Analyses
44	[72]	2.c.	Laboratory Water Sample Analyses, Modeling
45	[73]	2.c., 2.f.	Geophysics, Laboratory Water Sample Analyses, Modeling
46	[74]	2.c., 5.b.	Agriculture, Laboratory Water Sample Analyses, Remote sensing
47	[75]	2.c., 5.d.	Laboratory Soil Sample Analyses, Laboratory Water Sample Analyses, Socio-Economy
48	[76]	2.c.	Laboratory Water Sample Analyses, Modeling
49	[77]	2.c.	Geophysics, Laboratory Soil Sample Analyses
50	[78]	2.d., 6.c.	Hydrogeological Field Measurement, Modeling
51	[79]	2.d.	Hydrogeological Field Measurement
52	[80]	2.d., 6.c.	Modeling, Socio-Economy
53	[81]	2.d., 6.c.	Modeling
54	[82]	2.d.	Geophysics, Hydrogeological Field Measurement
55	[83]	2.d.	Geophysics, Hydrogeological Field Measurement
56	[84]	2.d., 6.c.	Modeling
57	[85]	2.d., 6.c.	Modeling
58	[86]	2.d., 6.c.	Geophysics, Hydrogeological Field Measurement
59	[87]	2.d., 6.c.	Hydrogeological Field Measurement, Laboratory Soil Sample Analyses, Modeling, Remote sensing, Socio-Economy
60	[88]	2.d., 6.c.	Hydrogeological Field Measurement, Laboratory Soil Sample Analyses, Modeling, Remote sensing, Socio-Economy
61	[89]	2.d., 4.f., 6.c.	Modeling
62	[90]	2.d.	Modeling
63	[91]	2.d., 6.c.	Hydrogeological Field Measurement, Remote sensing
64	[92]	2.d., 6.c.	Modeling
65	[93]	2.d.	Modeling
66	[94]	2.d.	Laboratory Water Sample Analyses
67	[95]	2.f.	Hydrogeological Field Measurement
68	[96]	2.f.	Modeling
69	[97]	2.f., 2.g.	Modeling
70	[98]	2.f.	Modeling
71	[99]	not align	Hydrogeological Field Measurement
72	[100]	2.f., 2.i.	Modeling, Remote sensing
73	[101]	3.a.,3.b.	Socio-Economy
74	[102]	4.a.	Hydrogeological Field Measurement, Modeling, Socio-Economy
75	[103]	2.g., 4.e.	Agriculture, Hydrogeological Field Measurement, Socio-Economy
76	[104]	6.e.	Energy
77	[105]	2.b., 6.e.	Energy, Modeling
78	[107]	not align	Modeling
79	[108]	not align	Modeling
80	[109]	not align	Geophysics, Hydrogeological Field Measurement
81	[110]	not align	Geophysics, Hydrogeological Field Measurement
82	[111]	2.c.	Geophysics, Hydrogeological Field Measurement
83	[112]	not align	Agriculture, Hydrogeological Field Measurement, Modeling, Socio-Economy
84	[113]	not align	Agriculture, Hydrogeological Field Measurement, Modeling, Socio-Economy
85	[114]	not align	Socio-Economy, Hydrogeological Field Measurment, Agriculture
86	[115]	4.d.	Energy, Hydrogeological Field Measurement, Socio-Economy
87	[116]	2.f.	Laboratory Water Sample Analyses
88	[117]	not align	Laboratory Soil Sample Analyses
89	[118]	not align	Laboratory Soil Sample Analyses
90	[119]	not align	Hydrogeological Field Measurement, Laboratory Soil Sample Analyses
91	[120]	not align	Laboratory Soil Sample Analyses
92	[121]	not align	Laboratory Soil Sample Analyses, Remote sensing
93	[122]	not align	Hydrogeological Field Measurement, Remote sensing, Socio-Economy

Table A1. *Cont.*

#	Reference	MWI Goals	Research Focus Areas (RFAs)
94	[124]	4.d.	Agriculture, Hydrogeological Field Measurement, Remote sensing
95	[125]	2.g.	Hydrogeological Field Measurement, Remote sensing
96	[127]	not align	Modeling, Remote sensing
97	[128]	not align	Modeling, Remote sensing
98	[129]	not align	Hydrogeological Field Measurement, Modeling, Remote sensing
99	[131]	not align	Modeling

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