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Policy Implementation for Water Resources Protection: Assessing Spatio-Temporal Trends of Results from Process-Based Outcomes of Resource-Directed Measures Projects in South Africa

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Abstract: Governments are continuously developing strategies for policy implementation toward water resource protection. However, little is known about the practical application of such plans to test their effectiveness in policy practice. This study focused on resource-directed measures (RDMs) in South Africa to assess progress made on policy implementation for water resource protection. The study included document surveys and content analysis of the publicly available reports and documents sourced from state departments and government websites. The findings of the study indicated that water resource-directed measures are used as policy implementation strategies for water resource protection in the country. Furthermore, the study revealed that significant progress has been made in this regard, when a multi-sectorial policy implementation practice approach through public-private partnerships ensured that 69% of the catchments have process-based RDM projects completed, while 18% are in progress, and only 13% are outstanding. In addition, it was found that water resource classes (WRC), numerical limits and ecological conditions for water resource reserve, and numerical limits and narrative statements for resource quality objectives (RQOs) are intermediate outputs originating from RDMs projects. The study recommends that outputs derived from process-based policy implementation plans must be applied at the water resource level and monitored to assess the effectiveness of policies for their effects on the status of water resources.

Keywords: policy practice; process-based outputs; resource-directed measures; resource quality objectives; spatio-temporal tend; water resource protection

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1. Introduction

Water is involved, directly or indirectly, in almost all activities and needs required for life sustainability, such as the maintenance of adequate food supply and the productive environment for all living things [1,2]. Furthermore, it has been reported that adequate water supply and appropriate water quality levels are essential in driving social and economic development [3]. However, Refs. [4,5] note that one-fifth of the world's population lives in areas characterized by low rainfall and the limited occurrence of surface water bodies. Consequently, freshwater resources are under threat of excessive utilization and water quality deterioration [6,7]. For example, Ref. [8] noted that even though groundwater is often thought to be relatively well protected from pollution, it is also susceptible to negative impacts, such as declining aquifer heads, groundwater quality deterioration, lower crop yields, and ecosystem degradation due to poor management.

It has been argued that land use changes in urbanization, industrialization, and agricultural processes continue to have a negative impact on water quality and availability at all scales [9]. Such factors have resulted in biodiversity loss and subsequent changes

in the structure and function of the ecosystems, which have wedged humanity in terms of altered ecosystem service delivery [7,10]. As a result, water has been a central issue on the international agenda for several decades [11]. Research has pointed out that to ensure water security and sustained socio-economic development, water resource protection should be considered as the cornerstone for sustained water resource availability and utilization to fast-track achievements of the set target for sustainable development goals (SGDs) [12–15]. It has been argued that water resource protection ensures capacity maintenance of ecosystems to regulate the quality and quantity of water over time, which in turn provides ecosystem services [16]. Such practice is not only promoted in research but is also encouraged and supported by legislation [17–19].

Research indicates that policies directed toward water resource protection are in place in many countries to ensure sustainable water protection and allocation. For example, in Europe, recent policy developments consider the importance of water ecosystems to human wellbeing, hence specific policy targets aimed at protecting water resources have been put forward in that region [20]. The Urban Wastewater Treatment Directive of 1991 ensures that wastewater is collected and treated before it is discharged into the environment, while the EU Marine Strategy Framework Directive (MSFD, 2008/56/EC) ensures prevention of macroplastic and microplastic marine litter [21]. In Mongolia, policies provide prevention directives that are aligned with the interest of different users to protect water resources from degradation and contestation from waterscapes with mining activities [22]. In some cases, policies are developed because of a crisis or a significant event that took place. This is the case in Canada where drinking water source protection policies were developed in response to tragic events in areas of Walkerton, Ontario [23]. Nonetheless, water resource protection policies are a cornerstone in guiding all activities and decisions for long-term water resource use.

In policy practice, several interconnected stages exist, such as policy development, policy implementation, policy monitoring, and policy reporting and review [24–27]. Therefore, success in policy practice for mitigation of identified environmental challenges in the quest to achieve desirable set outcomes depends on the appropriate performance at each stage of the policy implementation process [28]. For example, it would be difficult to develop strategies for implementing policies formulated around unrealistic objectives [29–31]. Consequently, selection of relevant performance indicators or intermediate outputs for policy monitoring may be difficult to achieve [32–35]. Ultimately, appropriate assessment and review of such policies may not be realized [36,37], rendering the evaluation process and its effectiveness difficult. Importantly, successful policy implementation processes and the achievement of policy objectives can only be attained if the outputs of the processes undergone lead to tangible intermediate outcomes required to achieve set goals [38,39]. Whether the application of developed strategies and plans and adherence to processes set for policy implementation for water resources protection in South Africa leads to desirable outputs for effective policy implementation remains uncertain thus far. Therefore, gaining a better understanding of the role of strategies, processes, outputs, and associated challenges within the context of water resources protection can provide insight into improving future decision-making in policy implementation processes in water resources management practice.

Recently, it has become critical that progress on policy implementation be tracked to establish its effectiveness. Tracking policy implementation progress is likely to initiate the application of adaptive management to ensure that policy objectives are achieved. Such practice is common in the fields of social sciences and public health, however in water resource protection it is not common [40]. Through the adoption of this approach from the social sciences and public health, the study focuses on projects undertaken for water resource protection in South Africa; the study investigates outputs of process-based resource-directed measures projects to track progress on policy implementation for the protection of water resources in the country. For that aim, policy implementation is divided into three components, namely, (i) strategies and plans, (ii) process-based approaches, and

(iii) intermediate outputs. Therefore, three research questions are posed: (1) What are the existing strategies and plans for implementing water resources protection policies? (2) What are the processes followed for implementing policies? and (3) What are the intermediate outputs obtained when existing processes are followed? Are the intermediate outputs achievable?

2. Role of Policy Implementation in Policy Practice

Policy implementation has been identified as a means of translating the goals and objectives of a policy into an action [41]. The author of [42] argues that policy implementation is the hub of the policy process and a cornerstone of policy practice. This argument concurs with the view of [43], who noted that policy implementation is critical to the success of any policy since it constitutes the epicenter of the policy process. Policy implementation is also acknowledged as critical in filling the gap between policy promises and policy outcomes, as it facilitates the process of changing a clearly defined set of legislative targets into reality [44–46]. In this study, departing mainly from [47–50], policy implementation is broken down into three main components: (1) implementation strategies and plans, (2) implementation processes, and (3) implementation outputs. For a summary of these aspects, see Table 1.

Table 1. Summary of different aspects of policy implementation in policy practice (based on [46–49]).

Aspect of Policy Implementation	Context for Policy Implementation
Implementation strategies and plans	Implementation strategies and plans are formulated to guide policy implementation. Strategies and plans are examined with the objective of ascertaining how these plans drive policy implementation for water resource protection. Such examination is critical in diagnosing problems emanating from poor policy implementation associated with a lack of policy implementation plans.
Implementation processes	Policy implementation processes allow for the undertaking of activities using mainly physical, social, and financial resources to achieve goals and objectives set in policy statements. Organizations can only implement policies by following legitimate processes, which can be achieved by relying on transparency and interaction between the implementers and all stakeholders involved.
Implementation outputs	These are considered intermediate results emanating from policy implementation processes. They differ from policy outcomes where the latter are considered policy end-goals. Policy implementation outputs are examined as evidence for assessing policy implementation progress.

2.1. Implementation Strategies and Plans

A policy implementation strategy can be defined as a special comprehensive plan formulated to achieve policy objectives. Such a plan provides clear policy instruments, tools, and procedures to be followed when a policy is being implemented [51]. Such strategies are required to match defined policy goals and to guide production of desired policy outcomes [52]. Several examples of the application of policy implementation strategies in various fields can be cited. For example, strategies have been formulated to guide water recycling policies to combat increasing water scarcity [53], implementation of policies for water supply and demand management to increase water productivity, and maintenance of water resource systems [54,55]. Furthermore, policy implementation strategies have been developed for waste management [56] and for policy implementation toward climate adaptation [57,58].

It has been argued that a lack of policy implementation strategies may result directly in policy implementation failure [59,60]. In the absence of implementation strategies and plans, flaws can happen resulting in policy implementation failure, with resultant impairment on the sustainability of the established systems, such as in the case of Brazil [61]. Therefore, the development of policy implementation strategies is a critical activity in policy practice.

2.2. Implementation Processes

According to [62], policy implementation means carrying out, accomplishing, fulfilling, producing, and completing policy intended activities. It is generally defined as a series of activities undertaken by governments and other entities to achieve the goals and objectives articulated in policy statements [63]. It is critical that policy implementation processes are structured properly to ensure the successful implementation of a policy [62]. Accordingly, Ref. [64] argues that policy implementation is crucial because if it is not undertaken as planned, policy objectives would not be achieved, and the whole policymaking process could result in a total waste of time, energy, and resources. Although policy implementation is considered central in the realization of policy goals [46], it has been argued that without an understanding of the actual policy implementation process and associated factors, policy implementation success in achieving policy goals would be compromised [65].

The authors of [66] argue that success and failure of policies is dependent upon the process of implementation. For example, it has been reported that in Malawi several policies never yield the results they are intended for and most of the policies remain unimplemented or partially implemented with evidence of persistent problems, which were supposed to be addressed by these policies [67]. The author of [68] noted that the process itself is complex and multi-faceted, and it must be well understood to influence policy implementation success. Resources and community involvement are critical in policy implementation because, without such, the implementation of public policies is impossible. For example, involvement of local communities, which is considered as power sharing, has been identified as one of the key factors influencing policy implementation [69]. Procedures in policy implementation processes are introduced to control, set pace, coordinate, schedule timeline, monitor progress, and manage, as they define managerial boundaries, control, logical sequence, and allocation of resources [70]. Therefore, policy implementation could then be defined as carrying out a series of activities that are undertaken using mainly physical, social, and financial resources to achieve the goals and objectives set out in policy statements.

2.3. Implementation Outputs

Policy implementation encompasses activities that are undertaken by following prescribed processes. Such activities are also known as inputs; they yield immediate results, known as outputs. Unfortunately, outputs and outcomes are purposefully or mistakenly often used inconsistently [71]. Such inconsistency may lead to confusion and improper application of policy assessment and evaluation approaches. However, Ref. [72] considers outputs as products and other tangible items generated in a collaborative process/project/activity, and outcomes as "effects of outputs on environmental and social conditions". Other authors consider outputs as a measure of efficiency [73]. The application of policy implementation outputs is of key importance in achieving desired policy end goals.

2.4. Progress on Policy Implementation

This study focuses on resource-directed measures as policy implementation strategies for water resource protection, making the processes followed and associated outputs derived when resource-directed measures (RDM) projects are undertaken suitable measures of policy implementation effectiveness. Implementation encompasses the actions undertaken through processes with some form of central "delivery unit" also known as ''intermediate outputs", to track the progress of policy implementation [66,74]. Stakeholder engagement and transparency [75,76] are considered as process indicators in policy practice, and thus they have been used to track activities of policy implementation for water resources protection in the current study.

Water resource classes, water resource reserve limits and ecological conditions, and water quality objectives in numerical limits and narrative statements have been used in the current study as policy implementation outputs to track progress on policy implementation

for water resource protection in the country. The actual monitoring of water resources, as well as whether application of outputs from policy implementation processes lead to water resource status change, are outside the scope of this study.

3. Research Design and Methods

3.1. Methodology

In terms of the methodology, desktop methods were applied for the purpose of data collection. Briefly, data was sourced from policy documents, reports, and similar documents that were available in the government websites. Documents that were observed for the purpose of extracting data included water resource strategies, regulations, and guidelines on water resource protection. In terms of the analysis, the primary data collected was examined using qualitative content analysis methods. Content analysis is mainly used for qualitative analysis [46,63], and this technique was deemed appropriate to use in the current study. The technique is considered as a best method that systematically and collectively processes studies conducted in a specific field [77]. Therefore, the analysis was applied to describe existing policies on water resources protection, strategies used to implement such policies, processes followed in their implementation, and intermediate outputs and indicators to track policy implementation progress. Table 2 provides a summary of collected empirical material to answer research questions.

Table 2. Summary of collected empirical material according to the research question.

Aspect of Policy Implementation	Document Review	Other Material
Implementation strategies and plans	A total of 9 documents pertaining to legislations, policies documents, national strategy documents, regulations, and plans. One document for legislation, One document for policy, Four documents for national strategies, one document for regulation, and one document for a national plan.	Two additional materials related to legislation were obtained from referrals, both documents were related to legislation.
Implementation processes	A total of 17 documents pertaining to policy implementation process for water resources protection.	A total of 6 additional documents related to regulation and water resource classification system volume 1 to 5, and 1 National Regulation.
Implementation outputs	A total no of 66 reports were analyzed. 14 reports for water resources classes, 26 reports for resource quality objectives, and 26 reports reserve determination.	A total of 15 documents related to the government gazettes (for water resources classes and resource quality objectives, and Reserve outcomes).

3.2. Case Study

The study focuses on policy implementation practice for water resource protection in South Africa. The country, South Africa, lies entirely south of the equator between latitudes 22°13.970′ S and 34°47.841′ S, and longitudes 29°41.354′ E and 19°59.584′ E (Figure 1). Policy implementation for water resource protection in the country came into effect in the year 1998 after the promulgation of the National Water Act (Act 36 of 1998). The Act considers the State as the custodian of all natural water resources in the country with the core principles of efficiency, equity, and sustainability [19]. Water resources that are afforded protection according to the Act are rivers and dams, estuaries, wetlands, and groundwater. Policy implementation for water resource protection in the country was initially directed at the previously nineteen (19) catchment areas known as water management areas (WMAs) and now to the nine (9) WMAs (Figure 1). To ensure democratic implementation of the public policy, the processes followed consider the views of the public which is ensured through stakeholder engagement initiatives. In the South African context, water resource protection is fundamentally linked to control, development, use, and conservation [19].

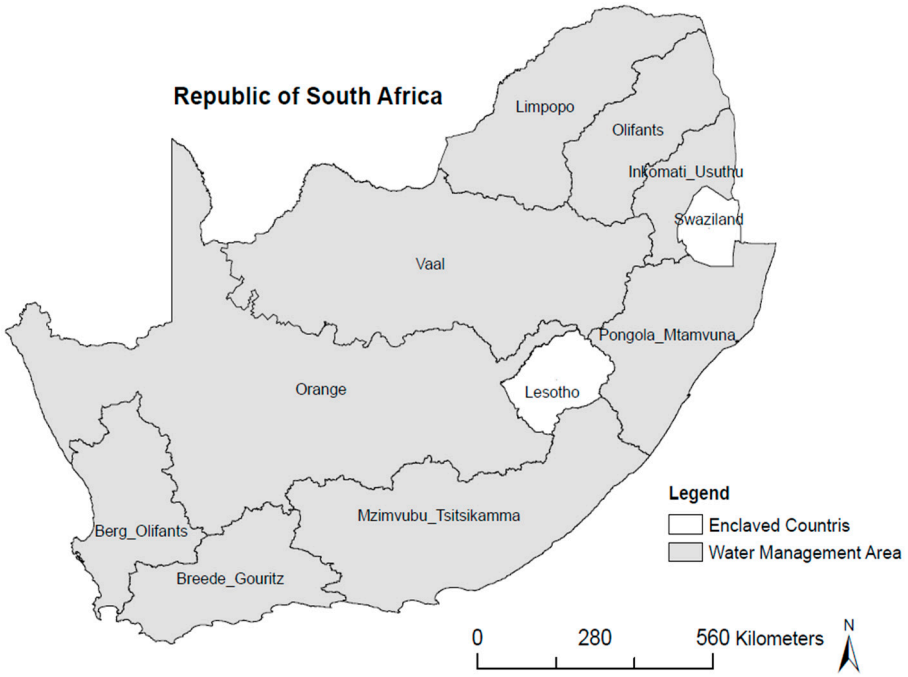

Figure 1. Map showing location of the study area.

Policy implementation for water resource protection in South Africa was chosen because such practice does not only ensure water availability and its sustainable use for current and future generations but also caters for environmental water requirements to sustain ecological ecosystems from which goods and services are derived to support socio-economic development, which is central to human wellbeing globally. The legislative framework in the country prescribes resource-directed measures as strategies for water resource protection to set minimum levels of environmental considerations [13,78]. This demonstrates the importance of resource-directed measures relevant and acceptable policy implementation strategies toward improved and integrated water resources management practice. However, the country is a developing state characterized by semi-arid conditions and climatic changes which has a direct influence on water resources availability with only the southwest region of the country that predominantly receives its total annual rainfall during the austral winter months (April–September) [79,80].

The country has experienced various challenges related to water scarcity, water supply, and deteriorating water resource quality, which pose threats to ecological ecosystems, economic development, and human wellbeing. Such challenges tend to hinder progress on economic development activities, social wellbeing, and food security. For instance, 146 of South Africa's 565 rivers are categorized as having 'very low' flows, while a further 105 are ''low'' and another 88 are moderately low which translates to more than 60% of South Africa's rivers currently being overexploited [81] This observation agrees with findings by [82], who reported that the country's rainfall trend was positive between the years of 1800–1900, while a negative trend was observed in the period 1900–2016. Due to water scarcity challenges experienced in some parts of the country with the recent crisis brought on by the Cape Town's "Day Zero" drought, studies have documented the need for policy intervention, such as strategies to enhance management of water supply and water resource sustainability [83,84]. Challenges linked to water quality deterioration are also prevalent in the country. Apart from influence emanating from anthropogenic activities, changes in river flow regimes have also been linked to water quality challenges [85]. Limpopo, Olifants, and Inkomati are areas that are highly impacted by salinity, agricultural chemicals, urban and industrial effluence, and metals, while excessive sediments and radioactivity are also prevalent in the Vaal area. The Berg-Olifants and Orange areas are dominated by groundwater contamination and radioactivity [86,87].

This makes South Africa a suitable case study to focus on when investigating progress on policy implementation for water resources protection.

4. Results and Discussion

The main objective of undertaking the current study was to investigate progress in water resource protection practice in South Africa. It was hoped that the investigation would be able to ascertain the progress made thus far in the country in terms of policy implementation toward water resource protection. Such exploration would facilitate a better understanding of the effects of having policy implementation strategies, and policy implementation processes which are at the epicenter of policy practice. A better understanding of the progress made toward water resource protection can provide insight into the improvement of decision making for water resource protection practices. The summary of the findings is provided in Table 3, and a detailed explanation of the findings is also provided in Sections 4.1–4.3

Table 3. Summary of results regarding different levels of policy practice for water resources protection.

Aspect of Policy Implementation	Literature Survey	Key Documents/Indicators
Implementation strategies and plans	Resource-directed measures are used as strategies to implement water resource protection policies in the country.	NWP, 1997; NWA, 1998; NWRS, 2004; NGS, 2010; NWRS, 2013; NGS, 2016; NW&SMP, 2018; (NEMA,1998; NEMWA, 2008
Implementation processes	Water resource classification system provides for steps and procedures that are followed when studies and projects on resource-directed measures are conducted.	NWRCS, 2006; Regulation 810 of 2010; NWRCS, 2007a, b, c, d, e
Implementation outputs	Outcomes emanating from studies and projects of resources-directed measures are officially published in the government gazettes as policy implementation outputs for water resource protection.	Reports and Government Gazettes as provided in Appendix A.1

4.1. Policy Implementation Strategies and Plans

The first research question that this study investigated was "what are the existing strategies and plans for implementation of water resource protection policies in South Africa?" The investigation reviewed 11 documents pertaining to environmental and water resource protection. The analysis of the surveyed literature indicates that strategies and plans that support legislation and policies for water resource protection are in place in the country. The White Paper on National Water Policy (1997) states that society needs to develop in a way that can function successfully within the constraints of its natural resource base. The White Paper recommends that society treat the development, use, and protection of the country's water as a common endeavor in the interests of all and in the spirit of a new patriotism rather than as a series of conflicts between different groups [88]. It is in this spirit that the National Water Act of 1998 was written.

The National Water Act (NWA), (Act 36 of 1998) mandates the protection of freshwater resources such as surface water (rivers, estuaries, lakes, and wetlands) and groundwater resources. This is done to ensure that the nation's scarce water resources are used, developed, conserved, managed, and controlled in ways that consider amongst other factors, promotion of equitable access to water, redress of the results of past racial and gender discrimination, promotion of efficiency, sustainability, and beneficial use of water in the public interest [19]. Furthermore, water resource protection in the country as per the legislative requirement facilitates social and economic development, protection of aquatic and associated ecosystems and their biological diversity and assists in meeting international obligations [19]. Chapter 3 of the NWA prescribes resource-directed measures that include the classification of water resources, setting of the water resource reserve, and establish-

ment of resource quality objectives as water resource protection strategies for all water resources [19]. Such resource-directed measures are instituted under the guidance of the National Water Resources Strategies (NWRS).

The National Water Resource Strategies set out how the nation's water resources should be protected, used, developed, conserved, managed, and controlled in a sustainably and equitably manner [89,90]. Ref [89] recognizes resource-directed measures as the approaches adopted to protect water resources as per the NWA. Furthermore, the importance of water resource protection to support socio-economic development for human welfare and ecosystem sustainability in the country is outlined in chapter 5 of the [90]. The National Groundwater Strategies [91,92] were developed to ensure that environmental legislation, such as the NWA, is implemented successfully, especially when the aspect of groundwater is considered in terms of resource protection and sustainable utilization. The strategies consider groundwater as one of the national water sources requiring an adequate level of protection for groundwater resources to provide and to secure the supply of water of acceptable quality. The groundwater strategies note that the cost of dealing with polluted or contaminated groundwater can involve a considerable hardship to people and the environment, and that groundwater protection is an economic as well as an environmental imperative. The strategies also outline measures for the protection of groundwater and the prevention of groundwater pollution and propose that a resource-directed approach to groundwater quality management by implementing resource-directed measures to protect the reserve and ensure suitability for beneficial purposes must be adopted [91,92].

The National Water and Sanitation Master Plan (NW&SMP) is available, and it was developed with an objective of providing an overall perspective of the situation in the water and sanitation sector and a consolidated plan of actions to improve the current situation to meet the desired future state of the sector, defined by the Government's vision, goals and targets until 2030, such as the National Development Plan (NDP) and Sustainable Development Goals (SDG's) targets [93]. The Master Plan notes that the provision of sanitation services is a key requirement for the establishment of sustainable, healthy communities, protection of the environment, and to meet the human rights of all who live in the country. The Master Plan also notes that continuous over utilization and inadequate protection of ecological systems and infrastructure have led to changes in the characteristics of rivers from perennial to more seasonal in many cases [93]. Legislative backing and tools such as resource-directed measures are promoted to effectively regulate the use of water, the protection of water resources, and the provision of water services and sanitation in the country. For instance, Ref. [93] recommends that water resources must be classified, have RQOs and reserves determined, and be monitored for compliance with the class, resource quality objectives, and reserve requirements. Therefore, the investigation undertaken in the current study provides compelling evidence that strategies and plans are available in the country to implement water resource protection policies.

4.2. Process-Based Policy Implementation

Processes for implementation of water resource protection policies are available and are followed when resource-directed measures projects are undertaken. The country started developing steps and procedures that must be followed when RDM studies are conducted in 2006 when a draft position paper on the development of a national water resource classification system was produced [94]. What followed next was a series of documents named Volumes 1–5 [95–99]. The resultant outcome of these documents was a National Regulation on a water resources classification system, which was published in the Government Gazette number 33541 [100]. The WRCS provides procedures for determining water resource classes, reserve, and resource quality objectives (RQOs) (Appendix A.2). The WRCS defines three water resource classes, reflecting a gradual shift from resources that are minimally used to resources that are heavily used, while taking into consideration the social and economic needs of all who rely on the water resource. The classification of water resources represents the first stage in the protection process and will result in the

determination of quantity and quality of water required for the provision of ecosystem goods and services.

Stakeholder involvement in the policy implementation process is considered as one of the key indicators influencing policy implementation progress [69] Therefore, the current study focused on procedures that involve stakeholder engagements as evidence of policy implementation practices for water resources protection in the country. Stakeholder engagement is a task required in step number 6 of all the three RDM strategies (Appendix A.2). Stakeholder participation is a critical aspect of policy implementation processes to provide transparency and to enhance the acceptability of policy implementation plans where stakeholders become part of such practice [101]. For example, the reserve determination study that was undertaken for the Olifants and Letaba catchments, a stakeholder workshop was held as part of the process. In the workshop, stakeholders wanted to know if their inputs were going to be incorporated into the technical and scientific content of the decision making that informs the outcome of the projects [102]. In another stakeholder engagement workshop [103], stakeholders wanted to know about their role in the monitoring of the set RQOs for resources. Stakeholder participation increases transparency and the satisfaction of being part of public policy practice. The evidence provided is an indication that policy implementation processes are in place, and they are being followed when RDM projects are undertaken. Water resource classes, reserve limits, and RQOs numerical limits and narrative statements are the intermediate outcomes of RDM projects.

4.3. Intermediate Outcomes

Outcomes originating from studies and projects of resource-directed measures are officially published in the government gazettes for public scrutiny as policy implementation outputs for water resource protection (Appendix A.1). A water resource class describes the desired condition of a water resource, ranging from minimal use to heavy use, along with a degree to which it can be utilized. The outcomes of water resource classification processes are water resource classes; class I, II, III. According to [104], a class I water resource indicates that a resource is minimally used or minimally changed from its natural state. Class II indicates a water resource that is moderately used or moderately changed from its pre-developmental condition [105,106]. Class III indicates that the resource is heavily used, and the overall ecological condition is significantly altered from its pre-development condition [107,108]. The water resource reserve is the quantity and quality of water required to satisfy basic human needs and to protect aquatic ecosystems in order to secure ecologically sustainable management of the significant water resource [19]. The reserve therefore consists of two distinct components, which are basic human needs [109] and ecological water requirements [110–113]. Since the promulgation of the WRCS several reserve studies have been completed and gazetted [111,114–119].

The water resource quality objectives are numerical and/or narrative descriptive statements of conditions which should be met in the receiving water in terms of resource quality, quantity, habitat, and biota to ensure that the water resource is protected [119]. The RQOs are intended to give effect to the water resource classes in each significant water resource. When resource quality objectives are determined, resource units are prioritized based on their representation of the catchment in terms of water resource utilization protection requirements [120–124]. Sub-components for resource quality objectives and their associated indicators are selected together with stakeholders [125–127]. Indicators such as numerical limits for water quality, flows, and groundwater levels are finalized and gazetted [128–130]. Therefore, it is evident that there has been significant progress in terms of policy implementation for water resource protection in the country.

In terms of progress on policy implementation for water resource protection, the study focused on the outcomes emanating from RDM projects. Water resource classes, water resource reserve limits and ecological conditions, and water resource quality objectives numerical limits and narrative statements are the intermediate outputs of RDM projects and their publication in the government gazettes marks the finalization of RDM projects.

The indications for undertaking the resource-directed measures projects within the 19 catchments in terms of the old catchment boundaries are presented in Table 4. The indications are that some of the RDM projects have been completed and some are underway, while in a few catchments the studies are yet to be undertaken—at least at the time when data collection for writing this paper was undertaken (August 2022).

Table 4. Summary of the catchments where water resource classification, reserve determination and resource quality objectives projects have been completed, are in progress, and are outstanding.

Status	Water Resource Classification	Reserve for Water Resources	Resource Quality Objectives
Completed	Lower Vaal; Middle Vaal; Upper Vaal; Olifants_Doorn; Olifants; Inkomati; Mvoti to uMzimkhulu; Crocodile West & Marico; uThukela; Berg; Breede_Gouritz; Mzimvubu to Keiskamma; Part of Levhuvhu & Letaba; Part of Limpopo	Olifants_Doorn; Olifants; Inkomati; Mvoti to uMzimkhulu; Crocodile West & Marico; Lower Vaal; Middle Vaal; Upper Vaal Levhuvhu & Letaba; Mzimvubu to Keiskamma; Part of Limpopo 1	Lower Vaal; Middle Vaal; Upper Vaal; Olifants_Doorn; Olifants; Inkomati; Mvoti to uMzimkhulu; Crocodile West & Marico; uThukela; Berg; Breede_Gouritz; Mzimvubu to Keiskamma; Part of Levhuvhu & Letaba; Part of Limpopo
In Progress	Usuthu to Mhlathuze; Fish to Tsitsikamma; Part of Levhuvhu & Letaba	Berg; Breede_Gouritz; Fish to Tsitsikamma; Upper Orange	Usuthu to Mhlathuze; Fish to Tsitsikamma; Part of Levhuvhu & Letaba
Outstanding	Lower Orange; Upper Orange	Usuthu to Mhlathuze Thukela; Part of Limpopo 2; Lower Orange	Lower Orange; Upper Orange

Temporal aspects of process-based RDM projects at national level are summarized in Table 5 and shown spatially in Figure 2a–c. The results show that significant progress has been made in terms of policy implementation for water resource protection using the tools of RDM. The significance in terms of policy implementation progress for water resource protection is inferred by 69% of the catchments having RDM projects completed, with 18% in progress, and only 13% outstanding. This revelation suggests that RDM are appropriate tools for implementing policies directed toward water resource protection. The findings of the current study are comparable with the findings of [131], who used a similar approach to investigate changes in accessing free drinking water in California public schools after the implementation of the 2010 federal and state school water policies. Their study revealed significant increases in public schools meeting the criteria for excellence in free drinking water access, after school drinking water policies were implemented. This revelation suggests that implementation of the 2010 federal and state school water policies in California was monitored for its progress, and this practice is advocated by the current study. Contrary to the findings of the current study, when a similar approach was applied to investigate policy practice for flood management in Switzerland [132], despite the increase in the number of flood related policies over time, it was found that the occurrence of floods had not decreased, suggesting that policies have not been effective in mitigating flood events. This indicates that the approach adopted in the current study is capable of tracking progress of policy implementation.

Table 5. Summary of resource-directed studies undertaken at national level presented in percentage terms (August 2022).

Status	Water Resource Classification	Reserve for Water Resources	Resource Quality Objectives
Completed	74% (14 of 19)	58% (11 of 19)	74% (14 of 19)
In progress	16% (3 of 19)	21% (4 of 19)	16% (3 of 19)
Not yet done	10% (2 of 19)	21% (4 of 19)	10% (2 of 19)

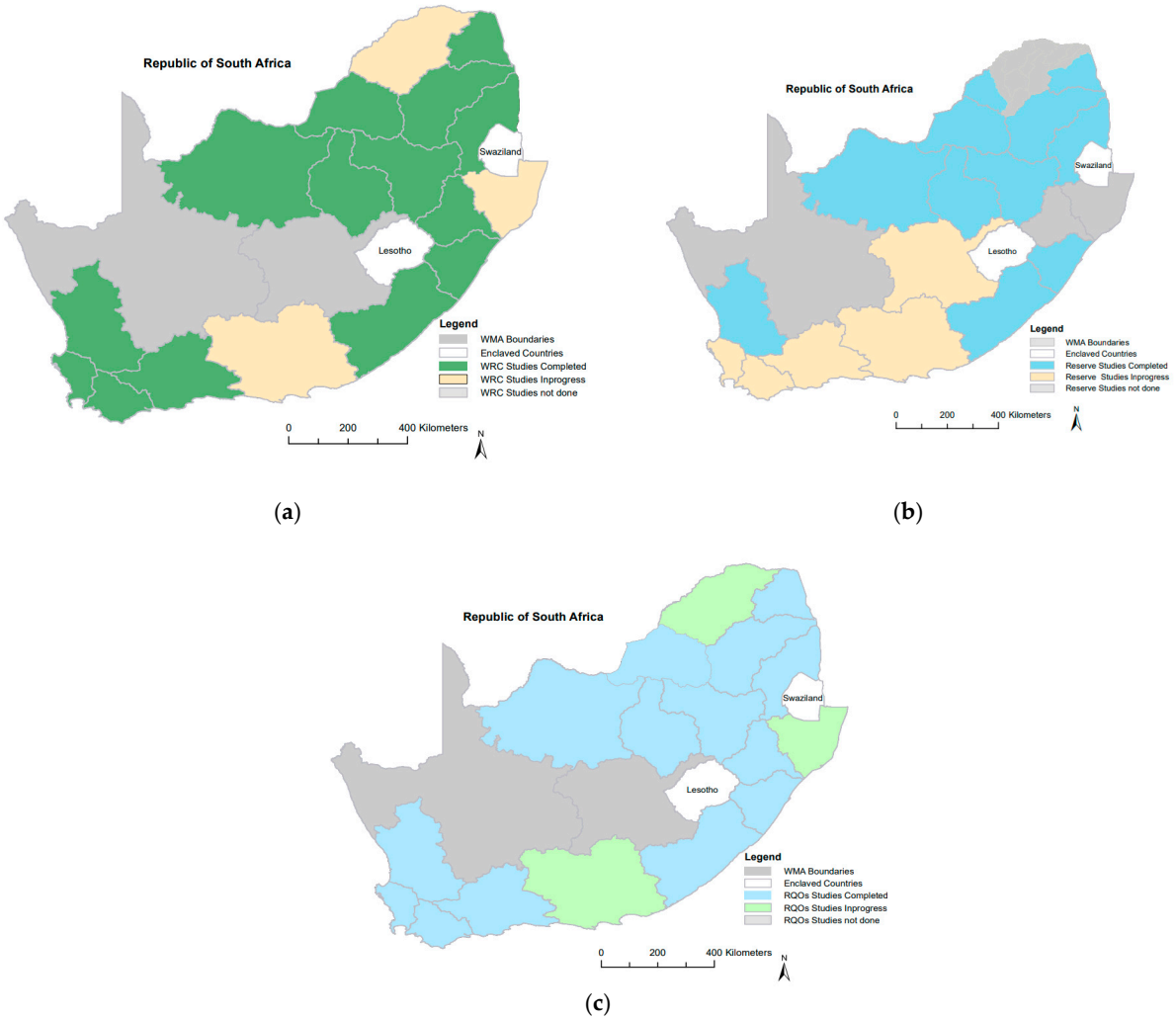

Figure 2. Maps showing catchments where RDM studies have been completed, are in progress, and are not yet done, (**a**) water resource classification, (**b**) reserve determination, (**c**) resource quality objectives.

5. Conclusions

Given the very critical status and nature of water resources, it is vital that policies developed for their protection and management are implemented to ensure the sustainability of aquatic ecosystems and water supply for current and future generations. However, mere implementation of policies without tracking progress on such actions is not appropriate for assessing policy impact. Given the state of South Africa's water resources, whether policies set and implemented for their protection lead to desirable outputs for effective management of water resources remains uncertain thus far. Therefore, gaining a better understanding of the progress made on policy implementation within the context of water resource protection can provide insight into improving future decision-making in policy implementation processes for water resource management practice in the country.

The aim of this research was to explore current practice and assess progress made in terms of policy implementation for water resource protection in the country. The investigation scrutinized the publicly available reports and documents sourced from state departments and government websites, it was found that strategies and plans that support legislation and policies on water resource protection are in place in the country. Such a revelation suggests that structures and plans are set up to facilitate the implementation of policies for the protection of water resources. The National Water Resources Strategies, (NWRS, 2004; NWRS, 2013) and the National Groundwater Strategies (NGS, 2010; NGS, 2016), together with the National Water and Sanitation Master Plan (NW&SMP, 2018) are

some of the key documents supporting utilization of RDMs as policy implementation tools for water resource protection.

In terms of the processes followed for policy implementation to protect water resources, the study found that water resource-directed measures projects are undertaken by following procedures as prescribed in the water resource classification system which was gazetted as Regulation 810 in the year 2010. The procedures involve seven steps for undertaking water resource classification studies, eight steps for undertaking reserve studies, and seven steps for establishing resource quality objectives, suggesting that guidance on how RDMs projects should be conducted to ensure that policy implementation for water resource protection is both realized and available. Furthermore, the study revealed that 69% of the catchments have process-based RDM projects completed, while 18% are in progress, and only 13% are outstanding, suggesting that significant progress has been made in terms of policy implementation using RDMs.

The current study demonstrates how South Africa can translate the abstract of a legislation into practice using process-based projects of RDMs applied in policy implementation for water resource protection. Such a demonstration shows that it is possible for water resources managers and policy makers to track progress on policy implementation activities for evidence-based interventions. The current study contributes immensely to the subject of policy practice, especially as far as water resource protection and management are concerned. The current study recommends applying result-oriented monitoring of intermediate outputs from RDM projects to assess the effectiveness of policy implementation within the context of integrated water resources management, which could help to improve policy practice.

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Appendix A

Appendix A.1. Summary of Analyzed Documents

Appendix A.1.1. Legislations, Policies, Strategies, Regulations, and Plans

1. National Water Act (Act 36 of 1998), (NWA, 1998)
2. National Environmental Management Act (Act 107 of 1997), (NEMA,1997)
3. National Environmental Management Waste Act (Act 59 of 2008), (NEMWA, 2008)
4. White Paper on National Water Policy of 1997 (NWP, 1997)
5. National Groundwater Strategy, 1st Edition (NGS, 2010)
6. National Groundwater Strategy, 2nd Edition (NGS, 2016)
7. National Water Resource Strategy of 2004 (NWRS, 2004)
8. National Water Resource Strategy of 2013 (NWRS, 2013)
9. National Water Resource Classification System, Draft discussion document, (NWRCS, 2006)
10. Regulations for the Establishment of a Water Resource Classification System, (Regulation 810 of 2010)
11. National Water and Sanitation Master Plan, 2008 (NW&SMP, 2018)

Appendix A.1.2. Reports, and Referral Materials

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Appendix A.1.3. Government Gazettes

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Appendix A.2. Gazetted Steps for Classification, Reserve, and Resource Quality Objectives

Water Resource Classification Steps	**Resource Quality Objectives Steps**	**Reserve Determination Steps**
Step 1: Delineate the Integrated units of analysis and describe the status quo of the water resources Step 2: Link the socio-economic and ecological value and condition of the water resources Step 3: Quantify the ecological water requirements and changes in non-water quality ecosystem goods, services, and attributes Step 4: Determine an ecologically sustainable base configuration (ESBC) scenario Step 5: Evaluate scenarios within the integrated water resource management process Step 6: Evaluate the scenarios with stakeholders Step 7: Gazette and implement the class configuration.	Step 1: Delineate the integrated units of analysis and define the resource units. Step 2: Establish a vision for the catchment and integrated units of analysis. Step 3: Prioritize and select preliminary resource units for RQO determination. Step 4: Prioritize sub-components for RQO determination and select indicators for monitoring. Step 5: Develop draft resource quality objectives and numerical limits. Step 6: Agree on RQOs and numerical limits with stakeholders. Step 7: Finalize and gazette RQOs.	Step 1: Initiate the basic human needs and ecological water requirement assessment Step 2: determine eco-regions, delineate groundwater resource units, select sites and, where appropriate, align with step 1 of the water resource classification procedures Step 3: Determine the reference conditions, presents ecological status and the ecological importance and sensitivity of each of the selected sites Step 4: Determine the basic human needs and ecological water requirement for each of the selected sites and, where appropriate align with step 3 of the water resource classification procedure Step 5: Determine the operational scenarios and their socio-economic and ecological consequences Step 6: Evaluate scenarios with stakeholders and align with step 6 of the water resource classification procedure Step 7: Design an appropriate monitoring program Step 8: Gazette and implement the reserve

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