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The South African Polycentric Water Resource Governance-Management Nexus: Parlaying an Institutional Agent and Structured Social Engagement

J. H. Boonzaaier, A. C. Brent

Abstract**—**South Africa, a water scarce country, experiences the phenomenon that its life supporting natural water resources is seriously threatened by the users that are totally dependent on it. South Africa is globally applauded to have of the best and most progressive water laws and policies. There are however growing concerns regarding natural water resource quality deterioration and a critical void in the management of natural resources and compliance to policies due to increasing institutional uncertainties and failures. These are in accordance with concerns of many South African researchers and practitioners that call for a change in paradigm from talk to practice and a more constructive, practical approach to governance challenges in the management of water resources. A qualitative theory-building case study through longitudinal action research was conducted from 2014 to 2017. The research assessed whether a strategic positioned institutional agent can be parlayed to facilitate and execute WRM on catchment level by engaging multiple stakeholders in a polycentric setting. Through a critical realist approach a distinction was made between *ex ante* self-deterministic human behaviour in the realist realm, and *ex post* governance-management in the constructivist realm. A congruence analysis, including Toulmin's method of argumentation analysis, was utilised. The study evaluated the unique case of a self-steering local water management institution, the Impala Water Users Association (WUA) in the Pongola River catchment in the northern part of the KwaZulu-Natal Province of South Africa. Exploiting prevailing water resource threats, it expanded its ancillary functions from 20,000 to 300,000 ha. Embarking on WRM activities, it addressed natural water system quality assessments, social awareness, knowledge support, and threats, such as: soil erosion, waste and effluent into water systems, coal mining, and water security dimensions; through structured engagement with 21 different catchment stakeholders. By implementing a proposed polycentric governance-management model on a catchment scale, the WUA achieved to fill the void. It developed a foundation and capacity to protect the resilience of the natural environment that is critical for freshwater resources to ensure long-term water security of the Pongola River basin. Further work is recommended on appropriate statutory delegations, mechanisms of sustainable funding, sufficient penetration of knowledge to local levels to catalyse behaviour change, incentivised support from professionals, back-to-back expansion of WUAs to alleviate scale and cost burdens, and the creation of catchment data monitoring and compilation centres.

Keywords**—**Institutional agent, water governance, polycentric water resource management, water resource management.

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I. Introduction

A. Background

DESPITE a chronological reverberation of concerns about pressure on natural resources, its continuing degradation due to exploitation for development and livelihood is common knowledge [1]-[4]. This phenomenon, known as the epoch of the Anthropocene [6], [5], refers to the view that humankind is the most important centre of existence. These themes that run through this concerning chronology, were once beyond the grasp from a South African perspective. Many papers from both academics and those in practice, recognise that South Africa is a water scarce country with deteriorating water resources, including changing weather patterns [7] that have significant effects on rural livestock farming [8], and impacts of population growth on agricultural production [9].

The 2003 Millennium Ecosystems Assessment reported a significant deterioration of ecosystems the last 50 years [10]. The World Economic Forum announced that the world water supply crisis presently ranks as the fourth most worrying global risk; firstly, in terms of risk likelihood and secondly, risk impact [11].

Water resources and its management is at the nexus of economics, public policies, nature, ethics, values, beliefs and rational thinking, Priscoli, in [12]. This complex co-existence between human livelihood development and nature is referred to as a socio-ecological-system (SES) [15]. It poses unique challenges to its governance and management for the maintenance of sustainability and resilience [16].

In South Africa, this complexity is currently very sensitive and highly politicised. Commentators ascribe that to a very high turnover of Ministers and Director Generals in the national Department of Water and Sanitation (DWS) and the cloud of bankruptcy to the value of R 6.4 billion [13], [14]. It is in this sense that recent publications in the natural water resource arena sound an urgent reveille regarding an adaption of paradigms to practice [17]; a trans-disciplinary mode as a new mode of governing science [18]; reconfiguring actions towards polycentric thinking against the backdrop of progressing global warming [19], [20]; and mapping out the contours for a more resilient global future [21].

B. The South African Legislative Context

In terms of the South African Constitution and legislation, water is a common pool resource. The main uses are potable

water for society, raw or potable water for industries, and raw water for irrigated food production. Water is to be governed through the national DWS as the governmental authority and the custodian of water resources of the country [22], [23]. The South African National Water Act (NWA) describes the ultimate aim of WRM as being "to achieve sustainable use of water for the benefit of all users and [adds] that the protection of the quality of water resources is necessary to ensure sustainability of the nation's water resources in the interests of all water users" [19]. This description very clearly emphasises the resource as the focal point. Numerous publications noted that South Africa, influenced by international best practices and standards, has of the best and most progressive water laws and policies in the world [24]-[27].

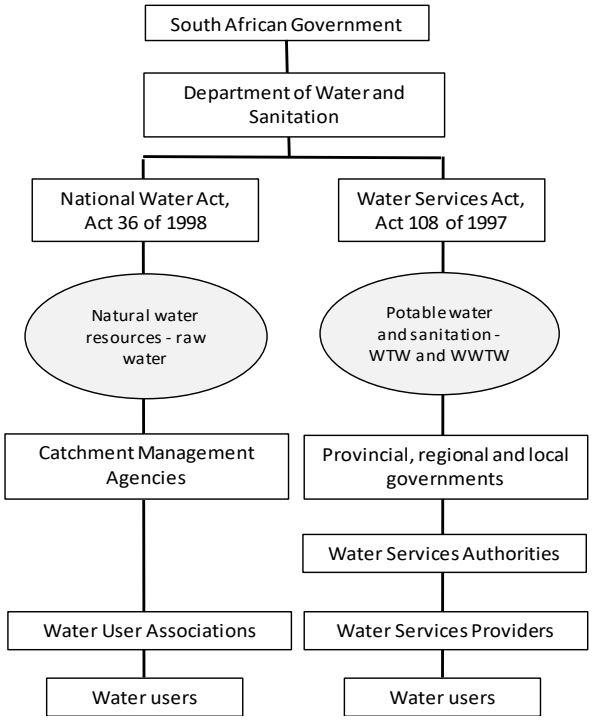

Fig. 1 The hierarchical outlay of the DWS under the two forms of water legislation in South Africa, Redrawn from [28], [29]

In South Africa, under the DWS, two different pieces of legislation regulate two different forms of water resources and related services through different types of water management institutions (WMI) [28]. This hierarchical layout is illustrated in Fig. 1.

1) The Water Services Act, Act 108 of 1997 (WSA) regulates water services by ensuring potable water provision, sanitation and related infrastructure, through Water Services Authorities (WSA) and Water Services Providers (WSP).
2) The NWA, Act 36 of 1998 regulates natural raw water resources and prescribes the requirements for natural WRM through the DWS and two WMI, namely, the catchment management agency (CMA) as a second tier in the institutional framework and water user associations (WUA) as the third tier. The latter supplies raw water for mainly the irrigated agricultural and WSA users.

In order to achieve the WRM objectives this three-tier institutional hierarchy for WRM has been established to devolve power from the DWS to CMAs and WUAs to promote a progressive decentralised participatory and more transparent process. To achieve this, the NWA provides for the establishment of 19 water management areas (WMAs) across South Africa [19], [30]. The entities that were to govern and manage the 19 WMAs are the so-called CMAs [26], [30]. The third tier WUAs, are the WMIs directly in contact with the resource and divergent users. They are meant to execute water management by co-operative user role players on a restricted and local level [23], [28].

Other governmental and provincial government departments that are regulated by other forms of legislation that have direct links to and affect natural water resources, include the Department of Agriculture (DoA), Department of Environmental Affairs (DEA), Department of Mineral Resources (DMR), and Department of Rural Development.

C. Current Concerning Trends in South Africa

Despite the applauded provisions in the South African Constitution, water regulations and law, with the associated principles and tools that hold promise for the coordinated development and management of water resources, the practice of such systems has not yet found definition and application [30] and has had a poor record of successful implementation [28], [31], [32]. Evidence reveals that South African institutional frameworks and water resources are rife with its own serious and perturbing phenomena of a number of deteriorating factors.

As many as 60% of South African water ecosystems are threatened, and of these 25% are critically endangered [18], [33]. Water demand forecasts of the National Development Plan (NDP) for 2030 and the National Water Resources Strategy (NWRS) for 2035 concluded that shortages in South Africa may emerge as the most significant constraint to development. In accordance, [34] further highlighted the significant negative effects of mining pollution and global warming on the projected availability of water by 2035.

Reference [35] reviewed the South African progress for WRM in respect of key challenges for the Africa Water Vision 2025. The findings of [35] revealed many critical shortcomings that are in accordance with many concerns of and challenges identified by other South African researchers and non-governmental organisations (NGOs) in South Africa They report various concerns, such as: a decrease in research funding and a loss of experienced and skilled human resources [36]; increased water pollution and deteriorating water quality [33], [34], [37], [38]; disregard for environmental regulations and protocol, which has resulted in water resource degradation [32], [39]-[41]; and a loss of water services delivery and serious deterioration of water infrastructure [32], [39], [42], [43].

Authors, such as [30], [44], and Sharmer [in 30], concur that in South Africa the current generation of leaders is very poorly prepared to deal with current and future environmental

challenges, and does not efficiently harness multi-stakeholder innovations.

D.Socio-Political Drivers in the WRM Arena

A prominent challenge in the South African Development Community (SADC) is the significant increase in human populations, distribution and settlement of humans in water scarce areas [9], [45], putting immense pressure on water resources and infrastructure development and maintenance.

General agreement and discontent among South African communities have resulted in the development of a "social pathology" [46, p.32] and phenomena of "self-organising networks" [Gooch in 47, p.124-125] and self-governance in society when certain thresholds of perseverance have been exceeded [48].

A popular perception with WRM revolves around socio-political drivers. The field of WRM is, however, much wider and includes the critical primary natural, managerial and engineering disciplines. A number of challenges in four specific disciplines that are incorporated into, and topical in, the WRM domain are presented in Table I. This perception led to a situation that the fields of socio-political sciences are becoming more dominant in WRM than those of environmental and engineering sciences [12], [19]. The result is that the physical care, maintenance of the intrinsic quality, resilience and future sustainability of the water resource falls into neglect. Reference [53] argued strongly that the ability to efficiently manage every available source of water is of primary and urgent importance before one can attempt to improve the socio-economic landscape. It follows logically that institutions or entities, and their leaders and managers, employed to deal with the complexities of the common pool water resources, should match the resource complexities in terms of skills and competence.

E. The Creation of a Critical Void

The decentralised three-tier hierarchy for natural water resources (raw water) between the DWS, the CMAs and the WUAs was hoped to be better and more efficient in many aspects than the state [30], [54], [55]. However, since the promulgation of the NWA in 1998, only 2 of the 19 CMAs have been established and are functional. On 19 March 2012, the DWS approved to decrease the number of WMAs and subsequently CMAs to 9 [56]. On 30 August 2013 the DWS intended to review the NWA, Act 36 of 1998, in which amongst others, indications were raised to disestablish the third tier WUAs [57]. Comments from the public review process suggested that these actions can be challenged based on significant substantive and contentious flaws in terms of sections 33(1) and (3) of the South African Constitution as well as sections 3 and 6 of the Promotion of Administrative Justice, Act 3 of 2000 (PAJA) [58]. Against all odds, a further notice was issued by DWS on 11 September 2017, which indicated that the DWS reconsidered the institutional model and would establish only one CMA to execute WRM for the whole of South Africa. This situation is a reverse back to a centralised position while contemporary thinking prefers decentralised power and transparency [59], [60]. It renders the globally lauded approach to decentralised WRM of the South African water resources and intended linkages between the three tiers inefficient and void. It created high levels of uncertainty especially regarding local WRM and the role and future of WUAs in servicing mainly the irrigated agriculture in South Africa. This void may have detrimental effects on sustainable WRM, water quality and food production in the future. Fig. 2 illustrates the institutional void created by the break in the hierarchical tiers.

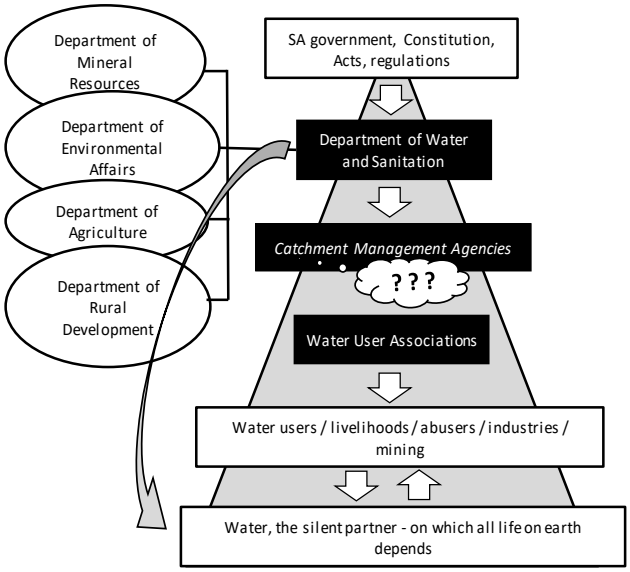

Fig. 2 The void created by the break in the links between the three tier hierarchical relationship of the DWS, the CMA and WUAs in WRM. It also illustrates the involvement of four other governmental departments in water resources

II. Rationale and Objective

It is argued that while perpetual debate and turmoil exist on higher levels of the South African government and its governmental departments, as well as a perceived centralising trend in WRM in South Africa, local WRM structures need to be steadfast and continue to function efficiently to ensure future water resource resilience and sustainability.

The change of paradigms to adjust the practice of science, and its subsequent influence on policy and implementation, can be adequately dealt with through strong governing institutional arrangements on suitable levels [16], [36]. It enhances proper interpretations and creates favourable strategic conditions [19], [59], [61]. It further creates the possibility to employ efficient trans-disciplinary collaborations, as both a tool and an activity [62]. Subsequently, relevant contextual questions may be posed that will lead to the fundamental research question. Firstly, to what extent should there be fragmentation or coherence across the different governance levels that affect the natural water resources domain and support or restrict efficient governance? Secondly, what management instruments and low cost structures will enhance or hinder trans-disciplinary collaboration and natural water-eco-system service delivery?

Thirdly, what institutional arrangement should match the complexity of WRM to cope with the intrinsic governing-management challenges required for WRM on local levels where the water use for livelihood and deteriorations are experienced? Fourthly, what level and scale will be relevant for such a suitable institutional setting relevant to WRM? Finally, does a "face-to-face communication and network" create a sense of collective belonging conducive to efficient WRM in a particular context such as a river basin? Synthesised from these five contextual questions, the fundamental research question sought to determine whether a local institutional agent could be parlayed (Parlay – derived from gambling. To turn or develop an initial stake, advantage or skill into a larger stake or something better.) to efficiently bridge a fragmentation in governmental institutional structures and levels, so as to engage with local stakeholders to execute cost effective and best practice water resource governance and management practices in a polycentric multi-stakeholder local scenario in South Africa. There are two distinct parts to these questions: firstly, the visible and empirical observation that something, an event, is happening (the degrading environment) and secondly, that behaviour may be the cause of the events observed (actions such as leadership, governance or management), or alternatively may resolve the events.

TABLE I
A LIST OF DIFFERENT CHALLENGES IN FOUR DISCIPLINES THAT ARE BEING INCORPORATED INTO THE DOMAIN OF WRM

Socio-political	Natural scientific	Managerial/ Engineering	Policy-regulation
Political transformation	Natural water resource protection	Water abstraction and use	Planning demand and supply
Social development	Measuring and data collection	Water distribution	Policy and regulation
Human land settlement	Water pollution	Trend analysis and future planning	Water allocations
Unemployment	Resource rehabilitation	Trade-offs	Trans-boundary negotiations
Poverty eradication		Infrastructure development	
Social education and awareness		Green economies	
Protection of minorities		Compliance, monitoring, enforcement	
Access to water		Conflict resolution	

Sources: [11], [30], [43], [47], [49]-[52]

To answer the research question, a conceptual polycentric governance-management model is proposed and applied. While the importance of challenges in other disciplines is not negated, this governance-management model application focuses mainly on the environmental, managerial, and regulating domains of local WRM. The unit of measurement is the catchment level, where livelihood development and the resource's use, abuse and deterioration are taking place and being experienced.

Specific guidance on answering the fundamental research question was obtained from three specific authors in five papers, namely, [12], [19], [30], [63], [64]. To evaluate the application of the proposed conceptual model, deductive propositions are set up from the assessment model of [64] and the research paper of [30], presented in Fig. 3.

III. THE PROPOSED MODEL

The "trialogue model of governance", developed by [47], is used as the theoretical basis for departure. It is proposed to improve and expand this triangular model by developing a "tetrahedral" model. The crucial components of the proposed model, illustrated in Fig. 4 describe the proposed framework.

1) Two main clusters of actors in the local water resource environment are added to the "Trialogue model". The actors are operating in the relevant catchment.
2) An institutional agent, as a facilitator, forms the pivoting basis of the model, supporting and driving interaction between the four other main actors.
3) Interfacing between the agent and the four other main clusters of actors take place in terms of polycentric approach.
4) Engagement with role players in the clusters of actors takes the form of a structured process of transdisciplinarity enhancing the governance-management nexus of natural water resources.

The term "polycentrism" refers to the resolution of challenges and conflicts by an interacting transdisciplinary process involving a number of coherent collaborating centres of decision-making bodies that are formally independent of each other [65]-[68]. They may have overlapping jurisdictions but do not stand in hierarchical relationships to each other [64]. As described by [68], the role players engage in a trans-disciplinary relationship and enter into various cooperative undertakings, regardless of having various political or functional jurisdictions. Subsequently, this collaborative trans-disciplinary approach flows through different layers to lower scales of management as well as knowledge deployment and mobilisation. Secondary benefits include transparency and the harnessing of local social power and knowledge, which either could mitigate or cause conflict and trade-offs. It could enhance learning from others in the process, which supports on-the-ground management processes [20], [65], [67]. Ostrom [20] further stated that each unit within a polycentric system exercises considerable independence, but acts for mutual goals. As such, if positioned correctly, a variety of problems affecting livelihood and development could effectively be addressed by employing new scientific information and innovation.

The critical role and value of institutional agents in stewardship, facilitating and democratising change management, and the interfaces between important role players and social learning are well-documented [60], [69], [70]. The important benefit and focus of an institutional agent being positioned amongst the grassroots role players is to win trust and, being from the community and acting to their mutual benefit, take responsibility for its actions [30], [60], as well as to create innovation to promote environmental value [71].

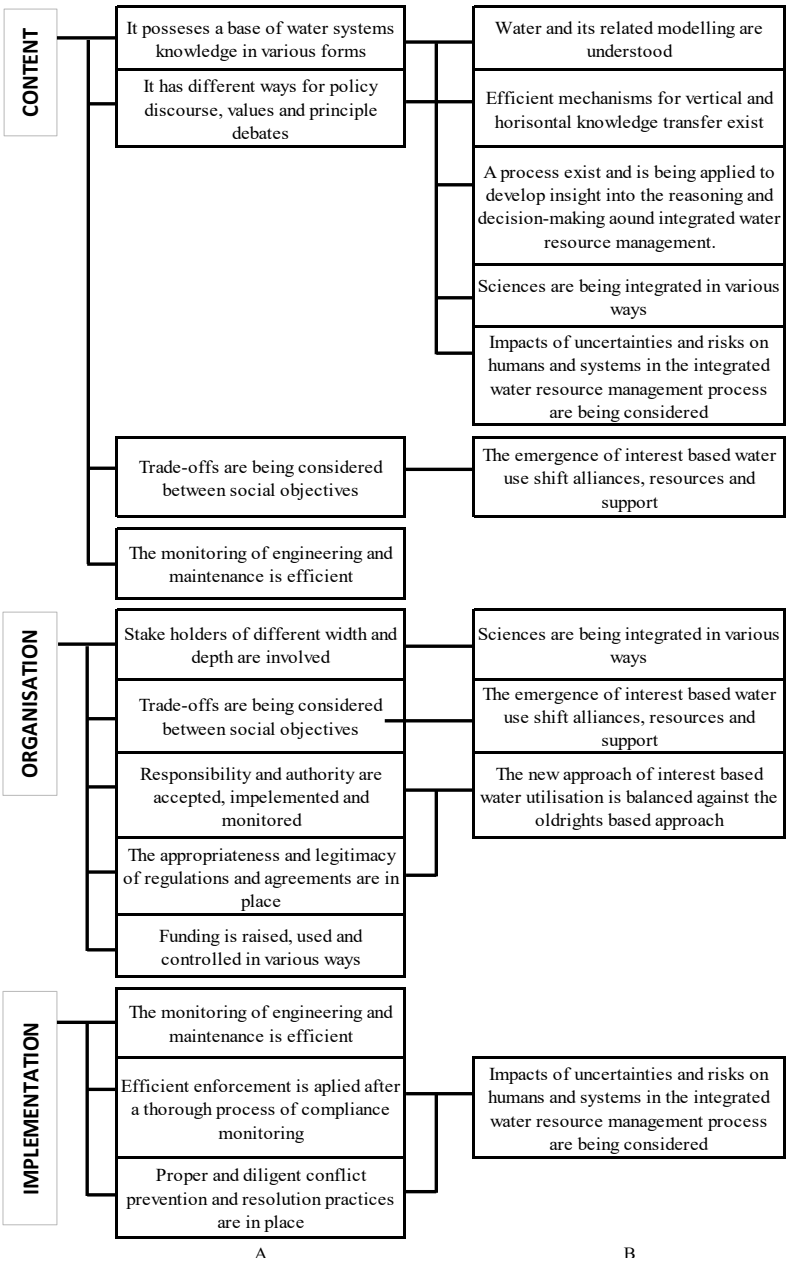

Fig. 3 A list of evaluative deductive propositions for this study, inspired from the studies of [64], depicted (A) and [30], depicted (B), to evaluate and determine the role and efficiency of a local institutional agent in WRM

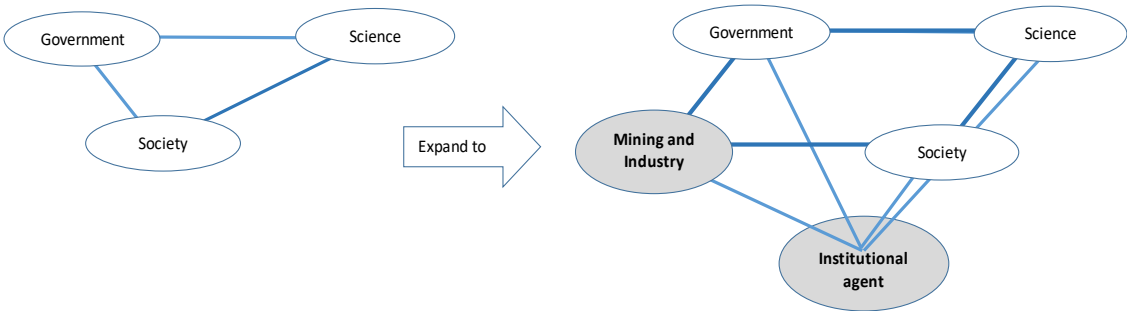

Fig. 4 The expanded development of the proposed governance-management model for local WRM in South Africa. (A) depicts the cluster actors in the Trialogue model of [47]. (B) depicts the extended additional proposed actors in the conceptual model in terms of this study

Empirical experience suggests that real-life tensions, fears, needs, deliberations and an understanding of local issues cannot be experienced on higher levels, on large scales and over far distances [30]. A WUA interacts on local level through a sense of collective, belonging and credible action and social learning, in close proximity with users and stakeholders in a catchment.

IV. Research Method

A qualitative action research case study was conducted from 2014 to 2017. Qualitative case studies are useful to provide an in-depth investigation that relates to a context involving governance and management phenomena and to convince one that such knowledge is applicable and can be generalised [72], [73:192-193], [74].

As the author was deeply embedded in the research content and case, a longitudinal action research was employed. Holwell [in 75:153] regards it as a legitimate research method, through the concepts of recoverability, purposeful articulation of themes, and iteration. Action research allows for personal reflection, contributing to new insights, views and values developed through dialogue and interaction with a situation and role players [75:83-85], [76:15-17].

The critical realist ontology employed, was inspired by the work of Mintzberg and Tsoukas [77]-[79], the critical realist approach in marketing [80], education [81] and founded in the notion of [82] of promoting the extension of reasoning and development of new conceptual arguments other than those which empirical data might justify. Critical realist ontology pairs realist ontology with relativist epistemology and, therefore, provides the opportunity that objectivity and causality that is deterministic can be investigated and used to describe phenomena [80], [81]. It also allows for the emergence of what proposition is required to describe phenomena in open systems that are affected by deterministic reality. In relation to the current study, causality asks, what leads to poor governance or, what cause water resource degradation. The latter are visible empirical outcomes.

According to Bhaskar, as in [79], [80], an empirical event experienced, occurs and is caused because of a mechanism that is active and deterministic in the real domain, illustrated in Fig. 5. In terms of this study, this is argued to be the intrinsic self-deterministic nature of human behaviour, also influenced by social behaviour [80], [81].

To reach sustainable social co-existence, human behaviour is eventually being shaped through human constructs such as governance policies, management and institutions. Consequently, the reasoning may be extended to how it manifests itself to deal with the complex challenges of the natural water resource environment in South Africa by a facilitating agent through multiple stakeholder platforms (MSP) and a polycentric setting. These human constructs should be studied from a constructivist epistemological perspective because the empirical context suggests that emergent and changing properties, such as social learning and adaption within and between the entities, the person and the organisation, exist. The causal relationships between the entities are both necessary and contingent as each cannot exist or function without the other. Triangulated data analysis was conducted according to the model of congruence analysis. A two-step process validated whether empirical evidence is in congruence with a theoretical model. First, specific deduced propositions about the theory under investigation had to be compared with empirical observations. A second step evaluated not only whether the theory and/or its propositions correspond to the empirical observations, but also if it displays better empirical congruence than other rival theories [83]. Toulmin's systematic method of argumentation analysis was utilised to determine the rejection or acceptance of observations or arguments as proof of foundations of knowledge; in this study, the research question [84:87-89], [85].

The delineated unit of analysis or scale of measurement [61], [86:27] was the water basin, or water catchment, of the Pongola River in the northern part of the Kwa-Zulu Natal (KZN) Province, South Africa.

Based on [86:32, 36, 47-50, 185-187], it is argued that this study, has much relevance, since:

1) This case is the playing out of real life phenomena in South Africa that impact on nature and future food production;
2) As it revolves around water in the water scarce South Africa, it will be of public interest and national importance;
3) It is a unique case, because it has attracted little exposure and investigation in South Africa, and deals with current developments,
4) The study is complete as it considers rival entities;
5) The case is typical of a catchment setting and is therefore highly applicable (generalizable) to the other 278 similar institutions in South Africa; and
6) The author is deeply involved in the case and uses intrinsic prior knowledge and experience of current thinking and discourse about the topic.

V. The Case

A. Introduction

In South Africa, irrigation schemes were developed and managed by the State in productive agricultural areas throughout the country, known as Government Water Schemes. These schemes focused on abstraction and supply of raw (natural) water, mainly for agricultural use, but also for domestic use through WSA. As a result of decentralisation of decision-making and responsibilities in DWS, these schemes were transformed into Irrigation Boards (IBs) *circa* 1990 to 1992. After promulgation of the new NWA, Act 36 of 1998 (NWA), all IBs were to be transformed into new entities called WUA. Not all Government Water Schemes transformed into IBs, and not all IBs transformed into WUAs. The current distribution of such WUA/irrigation schemes in South Africa is presented in Table II.

This study deals with the unique case of the Impala WUA located in the central region of the Pongola River catchment.

A. The Pongola River Catchment and the Impala WUA

The Pongola River catchment, south of Swaziland and flowing north-east into Mozambique, is located in tertiary drainage regions W41, W42 and W45. It is delineated in the red block in Fig. 6.

The location of the Impala WUA, delineated with the smaller black circle in Fig. 7, is located on the eastern boundary of the central region of Pongola River catchment, and just south of the Swaziland border.

In terms of this study, only the western region and the central region of the Pongola River catchment (from the headwaters up to the Pongolapoort Dam as shown in Fig. 7), are considered. A number of factors illustrate distinct differences between the western and central regions, presented in Table III.

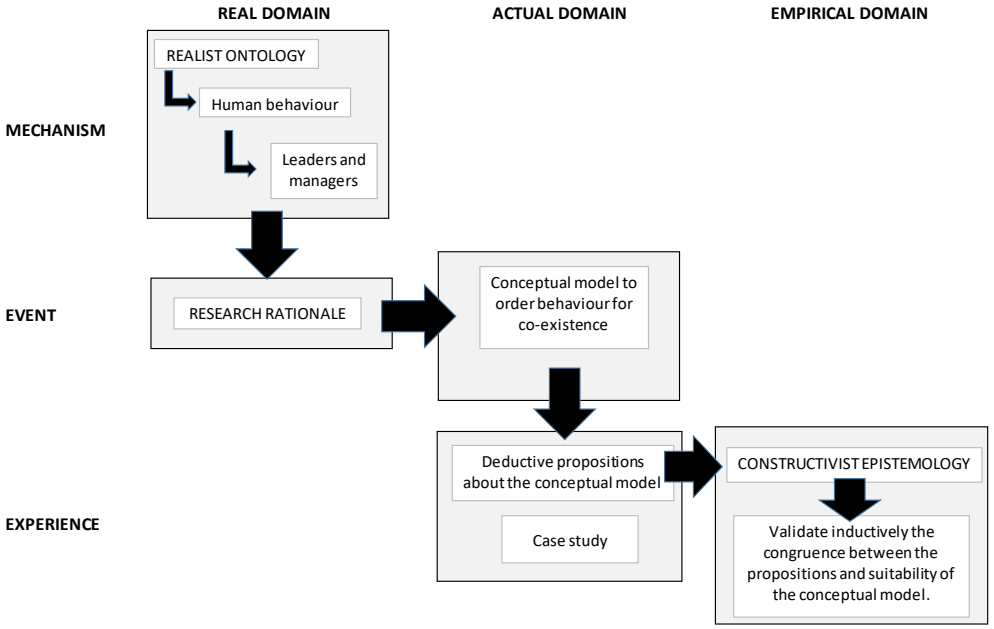

Fig. 5 An illustration of the principle of Bhaskar that empirical events are caused by mechanisms in the real domain [79]

TABLE II
THE CURRENT NUMBER OF DIFFERENT WATER/IRRIGATION SCHEMES IN SOUTH AFRICA [87], [88]

Type of scheme	Number
Government Water Schemes	28
Government Water Control areas	48
Settlement schemes	18
Irrigation Boards	141
WUA	98
TOTAL	**278**

In the western regions of the catchment, 20 abandoned coal mines and 19 new coal mining applications as well as large dense and wide distributions of Black and Silver wattle (*Acacia mearnsii* and *A. dealbata*) aggravate threats of stream quality and flow reduction. Over the catchment, agriculture is to a certain extent associated with unlawful water abstractions, with fertilised nutrients and poor waste management practices flowing back to the water resources in the environment.

Large rural areas of the catchment accommodate human settlements with poorly developed township infrastructure, sanitation and water supply. The latter and the large extent of communal traditional land use practices result in large-scale land erosion and tributary degradation.

The Impala WUA is a well-matured large canal fed and riparian irrigation scheme, located around the town of Pongola. Its sole water source is the Pongola River. It supplies raw water to approximately 17 000 ha of irrigated agriculture and to the WSA, the Zululand District Municipality (ZDM).

The latter provides potable water to rural areas and the five municipalities of Pongola, Nongoma, Ulundi, Vryheid and Paulpietersburg.

The Impala WUA derives its functions and authority from chapter 8 and schedule 5 of the NWA (1998) as well as particular delegations from the Minister of DWS. Due to its statutory authority, Impala WUA has the power to abstract and control water use and supply as well as to monitor compliance in terms of water abstraction and use. Although these functions imply a natural water resource care, WRM functions are particularly the responsibility of the CMAs or the DWS

B. Roll Out of the Study

In the KZN province of South Africa, in which the study area is located, no CMA was established. This led to the fact that neither a CMA, nor the DWS, executed any WRM functions or monitoring in this Pongola River catchment area.

Due to number of significant threatening factors that manifested over the period 2009 to 2017 in the Pongola River catchment, an important focus became the quality and sustainability of the water resource, namely:

1) Between 2009 up to 2014, nine new investigations and applications for coal mining prospecting in the head

waters of the Pongola river system were launched, which grew to 19 in July 2017.

2) A short drought was experienced in the summer of 2011/ 2012 and a very serious drought started in 2015.
3) An unexpected higher silting was observed in the inflow from the Manzaan River into the large surface Bivane Dam of Impala WUA.
4) The World Wide Fund for Nature in South Africa (WWF-SA) approached Impala WUA to participate in a water security project.

Impala WUA, being a downstream water user, is exposed to risks that are created upstream and immediately became involved. Because of a lack of governance and management of the catchment by the DWS or CMA and utilising these conducive factors, successful support was obtained for Impala WUA by the main local role players, to execute WRM functions.

From the assessment of the threatening factors, critical success factors were compiled based on the project management models of [89]. These factors were enhanced by indications regarding the level of existence of the context or level of maturity associated with the factor. Entrance and engagement strategies described by [90] were employed for engagement in the different situations. These consist, firstly, of a description of challenges based on a threat, knowledge and peculiarity of the situation, and, secondly, of employing one engagement approach that is best suited to address the challenge.

The consideration of the relationship dynamics between a challenge, the desired solution and the entities that need to address or support it, is crucial when operating in a multi stakeholder polycentric setting. This is especially decisive when some role players are dominant and powerful, while others carry compelling authority. In this sense an adapted approach of [91] was employed. It describes different suitable response actions to, and between the opportunity, or threat, posed by, an issue, as described in Table IV.

C. Primary and Ancillary WRM Functions

Impala WUA took up specific targeted WRM functions as ancillary functions, to be executed in a polycentric approach in the western and central regions of the catchment. The capacity in terms of manpower, knowledge, transport and networking existed in Impala WUA to deal with these many aspects. The fact that Impala WUA possesses authority as a WMI in terms of the NWA was of significant importance. Financial viability during the period 2014 to 2017 was ensured due to funding approved by the Board of Impala WUA as well as funding and support received via the WWF-SA. These distinctions between the primary and ancillary WRM functions and context are presented in Fig. 8.

IV. Results

A. Evaluation of the Deductive Propositions

Triangulated data, empirical observations and evidence obtained from the case study, were inductively evaluated for congruence with the deductive propositions, depicted in Fig. 3. The propositions and each result are shown in Fig. 9.

Fig. 6 The location of the case study focus in the Pongola River catchment, outlined by the red rectangle, located south of the border with Swaziland. It is a sub catchment of the Pongola – Imzimkulu Water Management Area in South Africa

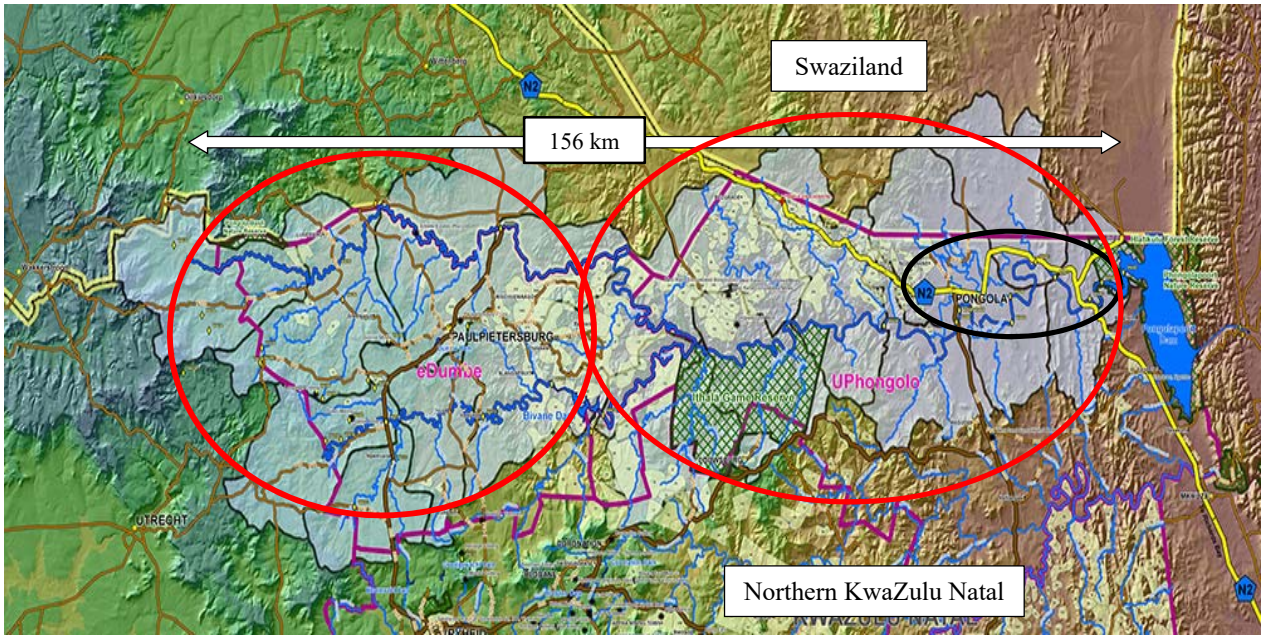

Fig. 7 A map illustrating the western and central regions (red circles) of the Pongola river catchment, (delineated shaded area) from its source in the west only up to the Pongolapoort dam in the northern KZN, just south of the Swaziland and Mozambique borders. The Impala WUA is located in the smaller black circle west of the inflow to the Pongolapoort dam, the 5th largest in South Africa with a capacity of 2 445 million cubic meters

TABLE III
DIFFERENCES IN THE WESTERN AND CENTRAL REGIONS OF THE PONGOLA RIVER CATCHMENT

Descriptors	Western region	Central region
Main town	Paulpietersburg	Pongola
Approximate catchment area (ha)	275 500	233 000
Average topographical elevation in meters above sea level	1923m with 1194m, between headwaters and Paulpietersburg.	611m on western perimeter to 252m in Pongola.
Approximate rainfall (mm p.a.)	1500	650
Climatic description	Mild summers and very cold winters.	Extremely hot summers and cool winters.
Main agricultural activities	Dry land maize production. Highly intensive piggeries. Forestry. Feedlot and field cattle.	Irrigated sugar cane, citrus, mangos and vegetables.
Gross agricultural production value dependent on water	R 1 500 million, dry land crops, animal production and forestry.	R 1 200 million highly intensively irrigated cane, fruit, vegetables.
Mining activities	Coal	None
Primary water source	Extensive network of tributary streams of the Bivane and Pongola rivers.	The Pongola river system, buffered by the surface Bivane Dam.
Natural water use control and monitoring	No formal body. Water use to be controlled and monitored from DWS regional office Durban.	Statutory WMI, the Impala WUA.
WRM activities and resource indicator monitoring	To be executed by the CMA, alternatively by DWS regional office Durban. Exposed to activities of Impala from 2014.	Impala WUA from 2014 till to date.

Aiming at answering the research question and substantiating the suitability of execution of polycentric governance-management by a facilitating agent through application of the conceptual model, the propositions are incorporated in three main categories and further sub-categories according to [64], namely: implementation, organisation, and content. *Implementation* revolves around the actual implementation of activities by, and collaboration with, the agent in a polycentric environment. *Organisation* refers the external and inner workings of the agent. It refers to governance and management in terms of acceptance of responsibility, authority, financial matters, care of infrastructure and engagement with stakeholders. *Content* refers to the agent. This reflects to be the deeper and higher levels of knowledge, insight and reasoning of the agent and the embracing of new paradigms in the South African water resource arena

Alternative rival entities were also considered regarding the execution of WRM functions by means of the application of the proposed conceptual model by Impala WUA.

It became clear that a vast knowledge base, presented in Table V, is important to approach WRM functions and to deal with a multiple of divergent stakeholders holistically and systematically. There is a considerable difference in

knowledge between highly educated environmental practitioners and lawyers that act for mining companies, to farmers to rural communities.

It was found that effective WRM cognisance and buy-in require a very specific penetration of knowledge understanding by local role players. Such penetration is needed to catalyse awareness, cognisance and desire to change behaviour in people. It was discovered that a structured inter- or transdisciplinary engagement, education and collaboration increased social resilience over a period of exposure to cope with common resource challenges.

The approach as executed by Impala WUA has proven ways to put communities in a catchment into a cognitive phase to secure their aquatic resource for the future.

B. Governance–Management Nexus

Both governance and management are viewed by [24], [92] and [65] as an exercise of acquired authority. In terms of cognitive meaning, and the execution and sustainability of systems that are subject to leaders, [26] and [54] suggested that a finer distinction of, and between, governance and management on various levels is needed. The concepts of governance and management cannot inherently take place within themselves alone, but involve the behaviour of humans [81], [79].

Four features combine to shape and influence governance and management processes in a sustainable SES environment. They are multi-actors, multi-level organisations, networks and multi-instruments [93]. Therefore, in terms of the workings of organisations, the structure is based primarily on its functions which are shaped by its strategy [77].

Normative measures are subsequently developed that sets values, cognitive frames of reference and power configurations in an organisation. Further, subsequent enabling rules and policies provide the form through and in which the management functions are executed to achieve its objectives.

In a divergent multi actor scenario a simple concise control is unlikely. The complexity and nature of WRM challenges and competitive survival approaches of some actors do not always cater for harmonious co-existence. This is why the polycentric approach relies on the intrinsic individual actor normative measures, and values, enhanced by a shared cognisance of responsibilities among multiple of role players, when collaborating to address a mutual challenge. Governance and management are then a developing dichotomy, an evolving reiterative nexus of interpretation, information and guidance that takes place within and between the actors. The more complex the domain, the more dynamic and reiterative the government-management nexus becomes to interpret circumstances, to guide current and future actions. To facilitate focus, keep track of operational performance, and continuity, a suitable facilitating local agent makes sense.

TABLE IV
READING FROM LEFT TO RIGHT, THIS TABLE PROVIDES A SIMPLE BUT REAL INCIDENT EXAMPLE IN THE APPLICATION OF THE MODELS OF LORANGE AND HILLSON. IT ILLUSTRATES THE INTERACTIONS OF THE DIFFERENT STEPS FOLLOWED TO ADDRESS AN IDENTIFIED POLLUTED RIVER, NAMELY ENTRANCE APPROACH DECISIONS, ACTIONS TAKEN, RESULTING OPPORTUNITIES AND RESPONSES [90], [91]

The issue to be addressed	**The entrance approach** [90]	**Action taken**	**Opportunity offered**	**Risk and opportunity response** [91]
ID a severely polluted river	Pioneering	Determine extent of impact and source	Immediate action at hand	Grab and exploit
Immediate engagement and execution	Dominant execution	Trespass on farm, to take water samples	Rather approach the taking of water samples by utilising a site at a road/river crossing	Mitigate
Contact lab, deliver cooled samples swiftly	Dominance	Separate sample, mark, cool down, pack, drive 240 km	Employ rapid courier services	Share
Interpret results in context	Immediate engagement	Discussion with landowner	Instruct the best orator to persuade	Transfer
Rehabilitate source of pollution	Pioneering	Upgrade facilities and waste control praxis	Insist on stopping further pollution	Avoid
Redesign upgrade facilities	Engage with rapid expansion	Consult with engineers for a facility upgrade	Negotiate optimum design	Enhance

PRIMARY FUNCTIONS	**ANCILLARY WRM FUNCTIONS**	
Finance and Admin	**River and water health**	**Riverbank vegetation and alien invasive**
Administration	Formal river health assessment	Eradication of alien invasive plants
Debtors / creditors	Water quality analysis	
Water Control	**Sound use control and supply risks**	**Education, awareness, mobilizing existing resources**
Water abstraction & supply	Water losses	Farmer's Associations and study groups
Compliance, monitoring, enforcement	Water security dimensions	Catchment Management Forum
Infrastructure maintenance	Civil infrastructure development/care	Zululand District and local municipalities
Infrastructure development		Community schools
Workshop	**Effluent return threats to water quality**	RCL Sugar Mill
Vehicle and machine maintenance	Agricultural effluent	Specialist consultants
Equipment and tool maintenance	Town sewer and grey water effluent	Relevant governmental departments
Bivane Dam surface reservoir	River salinization	NGOs
Dam wall maintenance	Coal mine applications/practices	
Water control and supply	**Land stability, land use practices and soil erosion**	
Infrastructure maintenance	Land degradation and erosion	
Infrastructure development	Indiscriminate dumping of rubbish and waste	
	Injudicious township expansions	

Fig. 8 An illustration of the different primary functions of Impala WUA and the additional ancillary WRM functions embarked upon

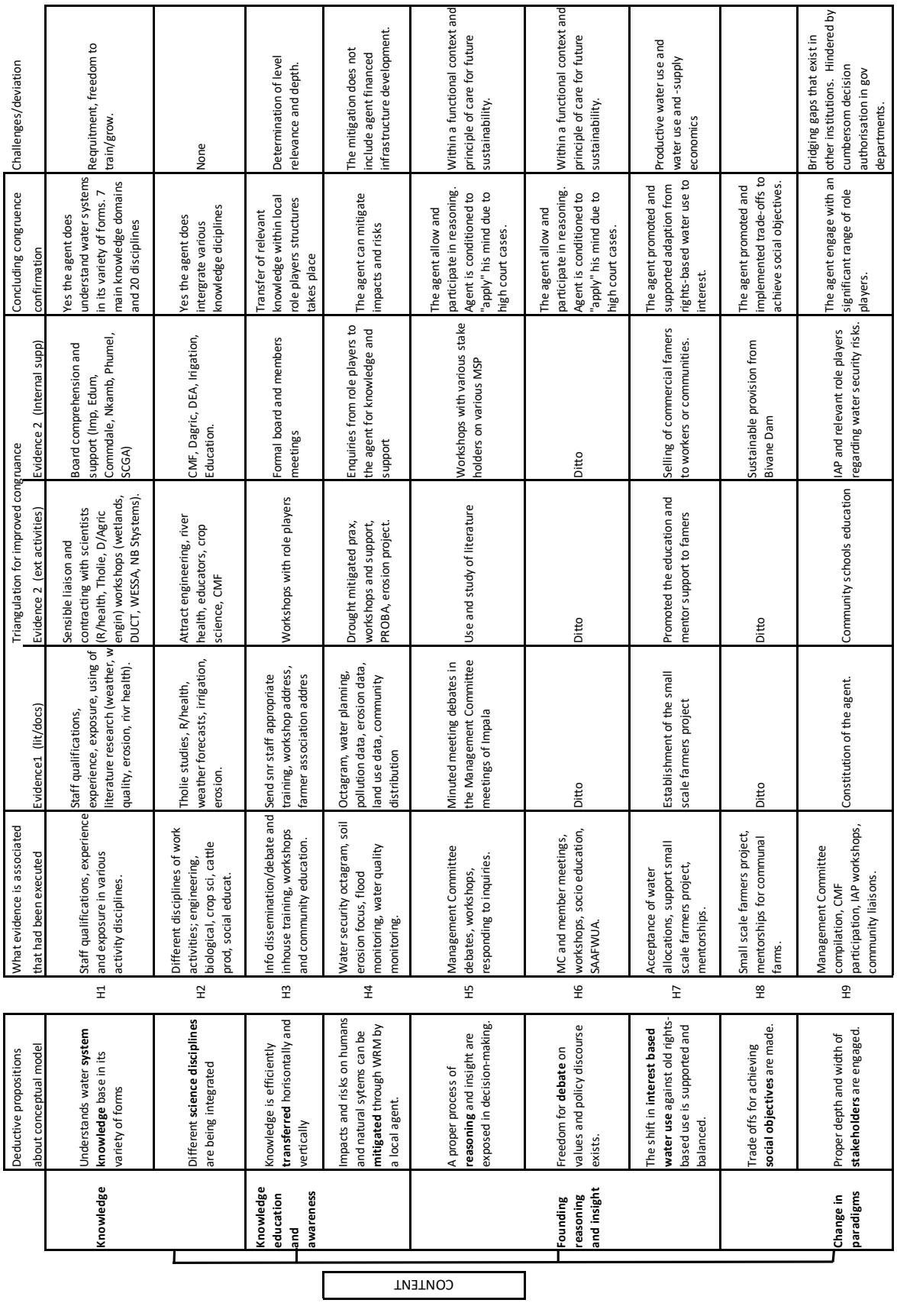

Fig. 9 (a) The triangulated congruence of the propositions, within the category, CONTENT, against empirical sources of evidence compiled from the case study

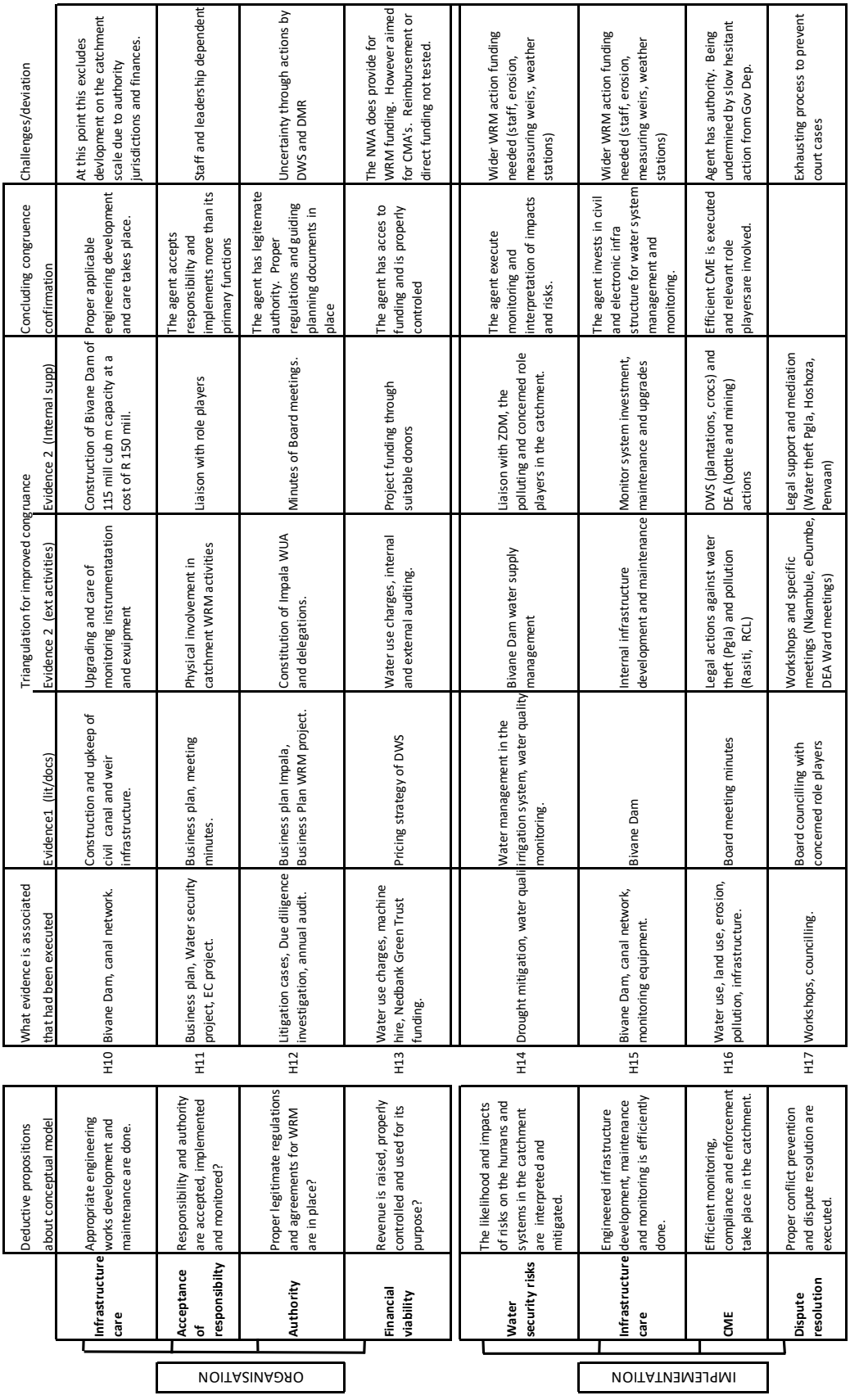

Fig. 9 (b) The triangulated congruence of the propositions, within the categories, ORGANISATION and IMPLEMENTATION, against empirical sources of evidence compiled from the case study

TABLE V
AN INDICATION OF THE DIFFERENT KNOWLEDGE DISCIPLINES NEEDED AND APPLIED IN THE EXECUTION OF TARGETED WRM FUNCTIONS

1	Management and economics
2	Water and chemistry
3	Natural and biological sciences
4	Engineering
5	Compliance, monitoring and enforcement
6	Agricultural sciences
7	Social sciences

C. Polycentric Stakeholder Engagement

The engagement with all the different role players of the various stakeholder clusters confirmed the notions of [63], [94], [95] that stakeholder participation is no panacea and does not guarantee constructive actions. Acceptance of shared responsibilities and co-operation is difficult. Integrating many stakeholders on a local or catchment scale around an issue is very challenging. It was experienced that stakeholders utilise manpower, resources and available time very much to focus on their own core business and tend to participate on their perceived value of a challenge, threat or an activity. One needs to differentiate between the intrinsic characteristics of stakeholders during the normal course of life. High-level industry and mining operates under highly competitive forces to achieve shareholder wealth by exploiting resources. Highly educated professionals work only where they are being contracted by external parties to fulfil the contracted functions in the shortest and quickest periods of time available. Other type of role players, such as farmers and rural communities, do not possess either the knowledge, administrative capacity, or privilege of taking time as often as they wish, to attend to WR challenges in a sustainable manner. They tend to act if the challenge emerges as a threat experienced in direct or close proximity.

On a scale of 0 to 3 (low to high), the extent of collaboration of each individual with whom engagement took place by Impala WUA, was quantitatively assessed on the basis of the impressions and behaviour experienced in terms of their depth of prominence and the profile of drive. Depth of prominence evaluates the importance of an individual in his or her sphere of operation. It reflects two crucial aspects. First, the impact that the person's decision or opinion, and secondly, the extent of penetration that the person might have to influence other people in his or her domain of work. The profile of drive is an indication of the individual's comprehension of the concept and interlinkages of water security, the support provided, and the extent of participation.

From Fig. 10 it can be observed that the low score role players comprise two groups: 8% role players that only paid lip service or were incapable of participating, and 47% that merely talked or may have been restricted in participation, a total of 55%. A total of 45% provided constructive background support (29%) and a core group (16%) were active in support to achieve the various objectives related to their circumstances at that time.

Dealing with the local and farming communities is complex and time consuming. Continuous deliberations with mining organisations, relentlessly driven to achieve their mining goals, are intensive. Discussions with the various role players, revealed the following:

1) The relative disorganisation among the general civilian communities when compared with the diligence and in-house knowledge and capacity of some mining houses;
2) A total lack of knowledge in environmental, mining, administrative and legal matters;
3) Lack of continuity in dealing with the matters mentioned above, as this is not a normal and core activity;
4) Mistrust by members of the public regarding motives if financial contributions are required towards action campaigns;
5) Fear and reticence concerning financial obligations if actions may result in litigation; and
6) Gullibility of local communities towards unrealistic promises of some mining organisations.

It was realised that the possession of power to exercise statutory authority was very important. In its execution, structured engagement is the intentional design of activities to capitalize on the interactions between various stakeholders. It comes down to a balancing of the concept of "carrot – stick – loyalty", which hinges around communication, the perceived value of the participant, the perceived threat for the participant, authority, and the importance of own core business and time. The systematic engagement of the appropriate stakeholders in communities concerned in the planning process, to solicit buy in, is difficult but critical. It was shown that continuous informing and educative consultation with the local role players, as well as service users and the broader group of stakeholders to enhance understanding, became a learning process, both for the community of resource users, and for the resource managers themselves.

Collaborations were conducted in a polycentric inter- or transdisciplinary approach, which entailed the following components:

1) A polycentric collaboration relates to specific challenges identified and proceeds with specific related content.
2) Only relevant role players were attracted for participation to address particular challenges.
3) Once the participation of each role player begins to result in comprehension, effort to dissect and synthesise possible options and exercising or influencing own jurisdictions to resolve a matter, it becomes a truly polycentric transdisciplinary event.
4) Each role player acknowledged his or her jurisdiction and authority, then undertook and strive to carry out the necessary activities to achieve the determined objectives.

The number of engagements that took place with divergent role players in the four actor clusters active in the catchment. are indicated in Table VI. The divergent role players engaged with in the actor clusters, are shown in Fig. 11.

Following the notion of Bhaskar, an illustration was drawn up, depicted in Fig. 12, to describe a real incident application of the critical realist approach, followed in this study. It shows the progression from intrinsic individual self-deterministic

behaviour as a cause, through collaborative action and learning by means of group behaviour towards the necessity of polycentric collaboration, resulting in the adaption of a practice and achieving a WRM objective.

D. Institutional Agent and Rivals

The ability of the Impala WUA to execute constructive polycentric WR governance and management functions, as a facilitating agent, was compared with WRM functions compiled by [19] and two other possible rivals that are active in the catchment. These were environmental NGOs and the DWS or the CMA. The results are presented in Fig. 13.

E. Generalisability

Interviews with CEOs of other WUAs and large IBs, confirmed that they are very similar in organisation, the environment exposed to, and primary functions if compared to the Impala WUA. They did differ in the willingness, knowledge base and higher-level support to expand their own functions in the way that Impala did. It was, however, in principle agreed that these institutions can all theoretically play a very valuable and strategically role in local WRM activities and protection of the natural resource for sustainable future water supply [96]. The generalisability of local WRM functions to the other 278 WUA or IBs across South Africa, depicted in Table II, and its role as a facilitating agent in a polycentric multi role player role is therefore possible. It is strategically well positioned to fill the institutional void and offers a cost effective solution on
a local level.

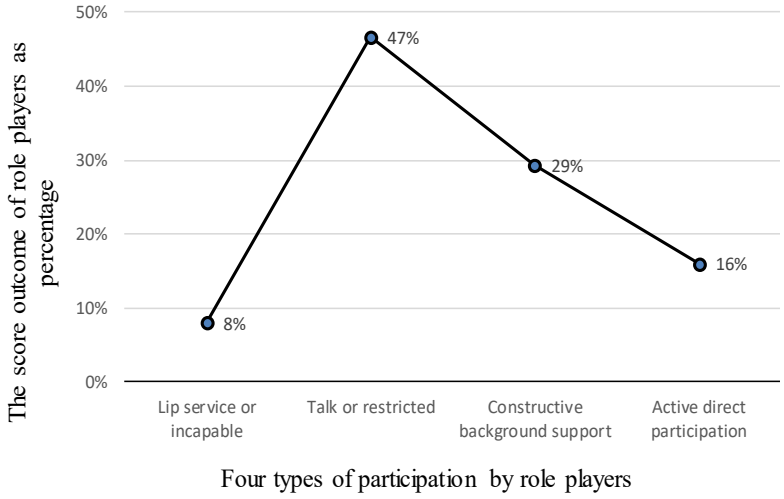

Fig. 10 A summary of the extent of participation of all 75 role players engaged with by Impala WUA, expressed as a percentage score per collaborative type

VI. Conclusions

It is concluded that the Impala WUA, as a mature self-steering local WMI, showed the ability and laid a foundation to execute a facilitating polycentric water resource governance management role. The Impala WUA applied a conceptual polycentric model that offered a practical approach towards WRM on a catchment base. It has proved to be a cost-effective use of existing institutions and structured engagement with stakeholders.

The study showed that a suitable strategic positioned facilitator can execute multi-disciplinary problem identification and analysis, and initiate and facilitate constructive integrated solution synthesis. Such an agent, though not always popular among users due to issues such as making or enforcement of user regulations, creates a sense of belonging and credible collective action for mutual benefit. A polycentric approach, acknowledging the different role player's own jurisdictions, creates a stable and efficient operating base for communication, collaboration, support and monitoring. It balances varying levels of power and knowledge.

In terms of current constraints in the South African water governance context, however, the WUA is a neglected third tier in the current institutional framework. It therefore needs to be parlayed in specific ways, to ensure the execution of such a role and function. A list that contains the important aspects from the experience of the Impala WUA is provided in Table VII.

The study concludes with a final test of the elements by way of the systematic method of argumentation analysis devised by Toulmin [85].

The claim the author wishes the audience to draw is that a WUA can execute polycentric WRM functions in a catchment cost effectively as a facilitating institutional agent.

The data provided is the case study and research work of the WRM activities and experience of the Impala WUA, as well as the proximity to the resource and stakeholders.

The warrant, as the rational link of the data to the claim, is explicitly the fact that the Impala WUA is a well-established mature WMI operating in the catchment, comprising divergent stakeholders all dependent on the natural water resource for a sustainable livelihood.

Backing is provided by a substantial volume of peer reviewed scientific studies expressing concerns about:

1) the deterioration of the natural water resources in a water scarce South Africa;
2) the concerns about poor leadership from DWS;
3) the institutional gap created by DWS in the execution of WRM; and
4) the need for more practical on the ground solutions.

The claim is qualified as undeniably true, based on the careful considerations of the strategic positioning of a WUA in the catchments of South Africa, and the way in which Impala WUA conducted WRM functions in the Pongola River catchment. This is important if seen against the empirical facts that critical WRM functions and monitoring that should have been carried out by governmental departments, such as DWS and Environmental Affairs, were not done.

TABLE VI
THE NUMBER OF STAKEHOLDER ENGAGEMENTS BY IMPALA WUA FROM 2014 TO 2017 IN THE FOUR CLUSTERS

Cluster	Total number of engagements
Civil society	63
Science and knowledge	41
Mining and industry	91
Government and municipalities	27

In countering a rebuttal of the claim, it is required that the following parlaying conditions must be met, namely:

1) The WUA must be well established and matured regarding its administration, operations and capacity to conduct complex functions and liaison;
2) The staff must possess good capacity and competency; and
3) Funding must be rerouted from the WRM charges received by the state from South African water users.

Therefore, the study successfully answered the fundamental research question in that:

1) An existing WUA can act as an institutional agent;
2) There is a necessity to parlay the institutional agent;
3) The agent is very well positioned in the catchment and is able to engage through polycentric inter- or transdisciplinary collaboration;
4) Governance-management takes place internally and "protrudes" externally towards, and during, polycentric collaboration when a joint activity is implemented; and
5) The WUA as an agent possesses statutory and delegated authority according to which compliance, monitoring and enforcement can be executed.

This project and the diligence of Impala WUA proved that key elements of WRM activities could be executed and were possible through the facilitation and mobilisation of groups with common challenges and striving to achieve the same objectives. This proposed conceptual polycentric model is indeed in the context of what [51] suggested, that basin role players identify challenges and collaborate to find appropriate solutions, and attempt to implement them. It further conforms to a large extent to the notion advocated by Ostrom, that water, as a common pool resource, can best be managed in terms of "common property regimes" by users who have a direct interest in sustaining the resource [19].

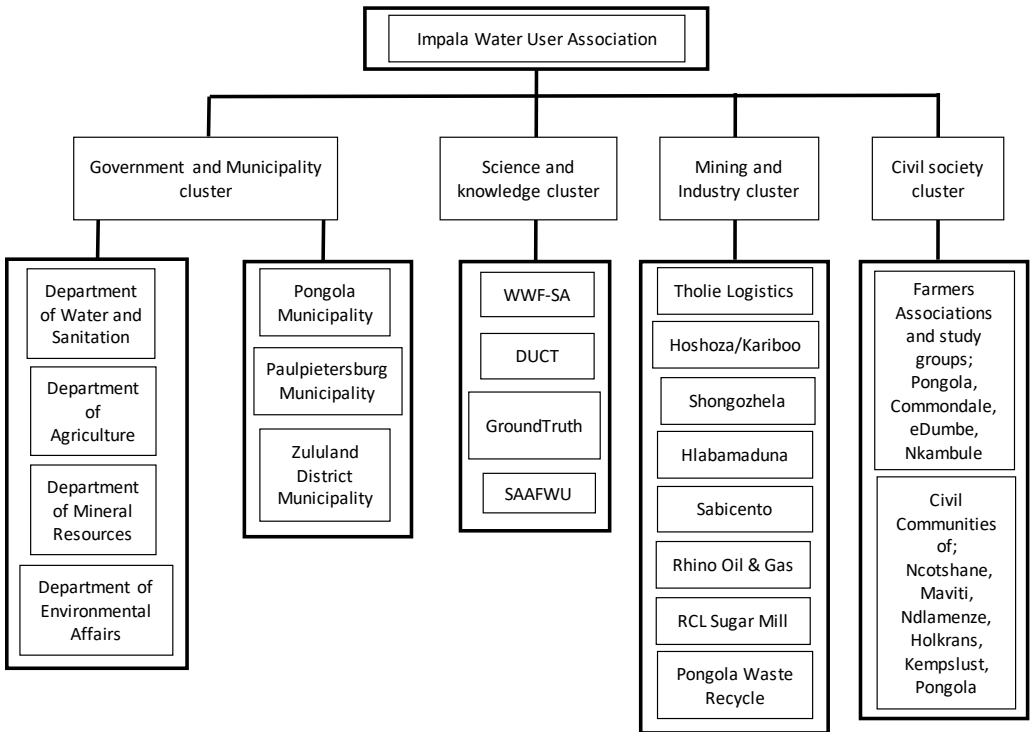

Fig. 11 The different role players in the catchment within the 4 actor clusters that were active and engaged with by Impala WUA as a facilitating agent in a polycentric approach

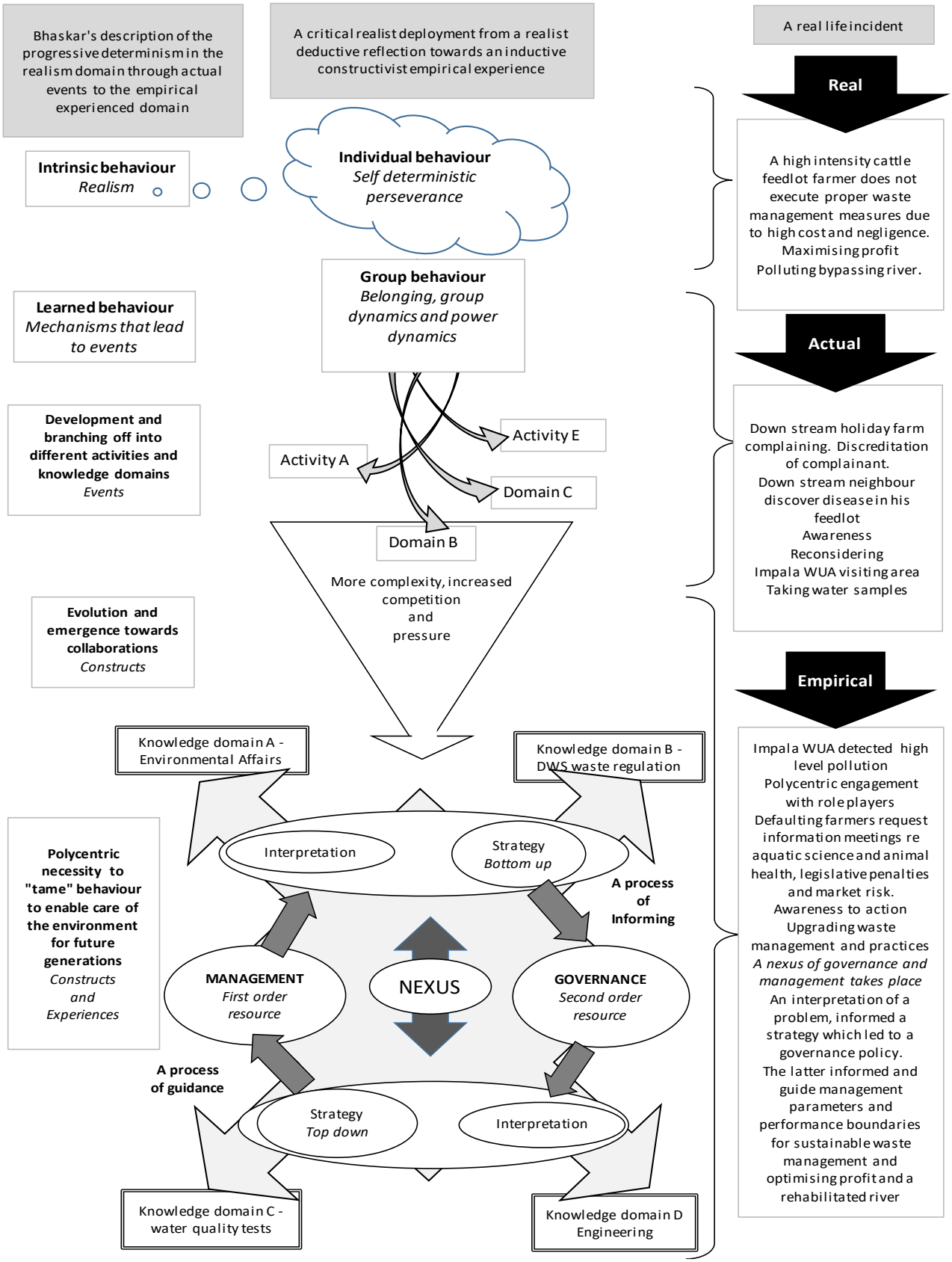

Fig. 12 The illustration of a real incident following the critical realist approach and the notion of Bhaskar from a self-deterministic behaviour, group behaviour soliciting various reactions and change to the principle of interpretation and strategy in the polycentric governance-management nexus to achieve a WRM objective

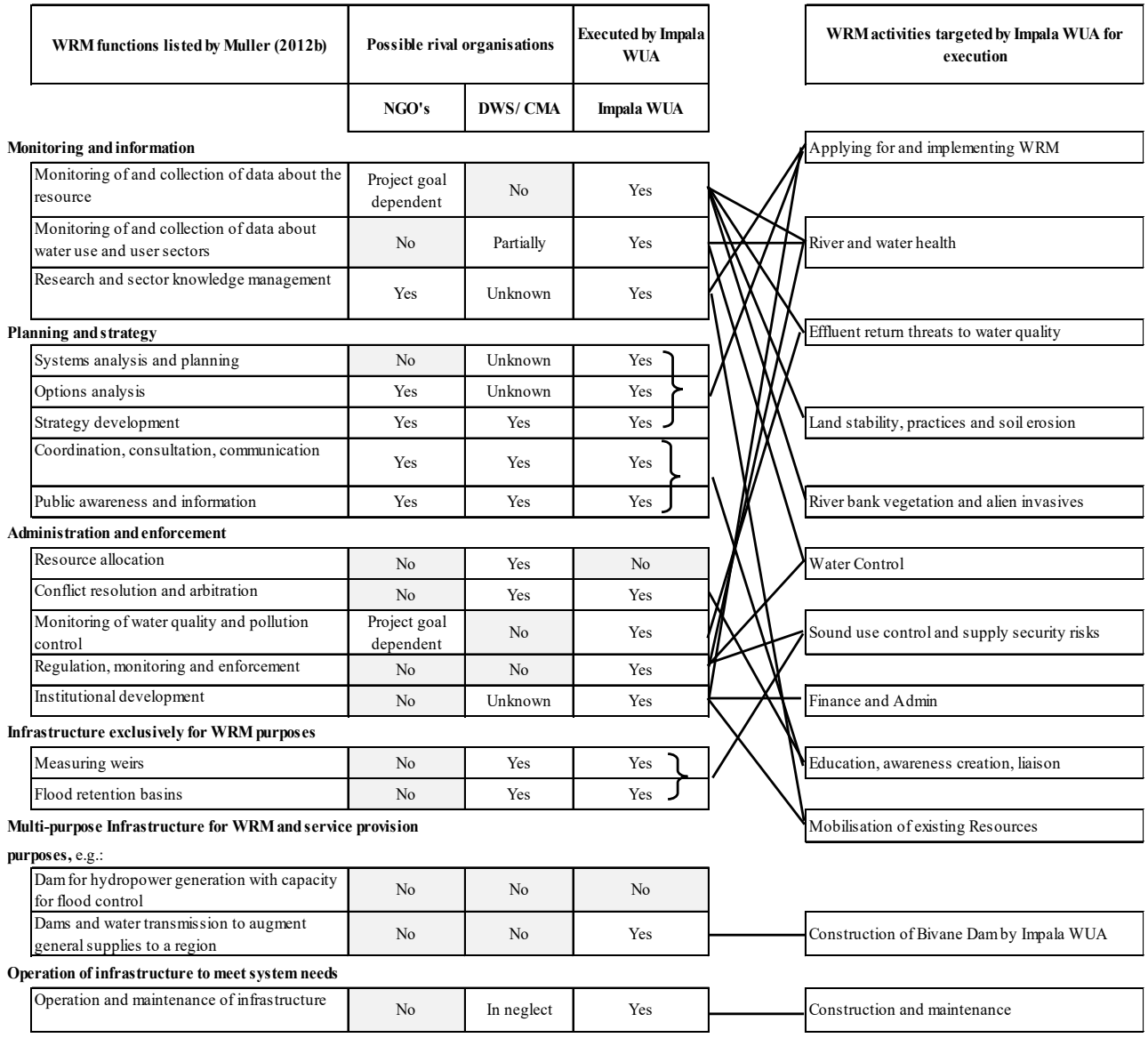

Fig. 13 A summary of WRM functions described by Muller, compared to the execution of WRM functions by the Impala WUA and by two possible rival organisations Source: Adapted from [19]

TABLE VII
A LIST OF ASPECTS THAT NEED TO BE IMPLEMENTED TO PARLAY A WUA AS AN AGENT TO ENABLE EXECUTION OF WRM FUNCTIONS, DRWN FROM THE IMPALA WUA CASE STUDY EXPERIENCE

Functional division	Parlaying aspect	Motivation and description
Statutory arrangements.	Authority and power to be expanded and legalised	The first question most role players, especially rural communities ask, is "who you are and what is your authority?". Statutory authority is extremely important as friendly persuasion is not possible in all circumstances. In a WRM context, the agent must be able to gain access to areas/properties, do assessments and if needed, issue directives
	Locus standi	The statutory position and role in a catchment to act for benefit of the environment and current and future generations
Finance and administration	Access to operational funding	WRM functions can be grouped into two categories. One comprises the operational aspects in terms of assessments, meetings, research, sampling, collecting and working with data. The other is *in situ* rehabilitation projects of whatever challenge might present itself. The former is an in house cost that the agent needs on a continuous basis. The latter may be extremely expensive and may be obtained in the form of a project reimbursement from government
	Sufficient suitable staff	The nature of WRM activities varies considerably. Staff must have the competency and nature to work with people in friendly and in hostile circumstances and to be comfortable in remote difficult terrain
	Fixed accessible address	It creates certainty and becomes a communication hub and reference point of communication and engagements
Operations	Suitable vehicle, working equipment.	To be able to drive to and transport equipment in rough terrain and difficult areas and equipment for monitoring and surveying

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