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Assessing the Application of the Water Institution in the Wonderfonteinspruit Catchment South Africa

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ABSTRACT This paper reviews the water institution: legal framework, water policy and administration, in South Africa with particular reference to the mining areas drained by the Wonderfonteinspruit River. The main aim was to examine the effectiveness in the implementation of the institutional setting for water resources management in the area. This was done by analysing the grey areas in existing policies and their implementation making use of government publications: policies on water resources and mine waste management, literature on water policy, the models applied in other parts of the world and indicators of sustainable water resources management. Findings indicate that the current status is a result of disintegrated implementation mechanisms of the water institution as a result of the weak linkages between the three components of water institution. Based on these findings, a conceptual model on aligning policy and implementation was developed to improve reform and implementation, thereby promoting sustainable development.

INTRODUCTION

Globally the availability of water has been characterized by constraints in the form of uneconomical use of already developed water supplies; exhaustion of groundwater; water pollution thus threatening water-related ecosystems; inequitable access by disadvantaged groups; and threats of transboundary conflicts at national and international levels (Rosegrant et al. 2002).These factors coupled with natural and anthropogenic factors have posed challenges in ensuring an adequate supply of potable water ,that caters for the rapidly increasing demand for water resources. Therefore this has warranted the need for development of effective water management institutions.

Saleth and Dinar (2005) defined water institutions as, the rules that designate action, demarcate action sets, deliver motivations and govern results for individual and collective decisions related to water development, allocation, use and its management. Furthermore water institutions comprise of three main components, water law, water policy and water administration (Saleth and Dinar 2000). IMF 2015, using case studies from various countries, assessed water challenges and various water policy instruments and concluded that sluggish water institutional reforms were a challenge, which was hampering the progressiveness of water resources management. Moreover, Nhira and Mapiki (2005); Namara et al. (2010), alluded, and identified the absence of policies and effective institutional frameworks as the principal reasons for ineffective water management and utilization of water resources in Sub-Saharan Africa.

South Africa is a semi-arid country and is faced with a scarcity of freshwater resources. Water challenges in the country range from security of supply, environmental degradation to resource pollution (Nkondo et al. 2012). This has led to a shift in the water economy from water development and use to allocation and management because of the externalities, increased demand and competition amongst users and amongst other factors. Turton (2009) forecasted that, water policy reform and capacity building will define economic growth of South Africa in the future. South Africa's water management and infrastructure framework is equitably advanced this has created a seeming sense of water security, resulting in degradation and inadequate financing of the water resources (Nkondo et al. 2012).

The area in question (Wonderfonteinspruit catchment hereafter referred to as the WFS catchment) is at the focus of many media reports because of the environmental damage caused by more than a century of gold mining and uranium extraction. Effluent, laden with heavy metals and radionuclides has been shown according to several studies to be migrating from underneath tailings dams of abandoned mines into ground water sources only to resurface in

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the streams and rivers such as Wonderfonteinspruit and Mooi. At major risk are the informal settlements where there is significant use of river for domestic consumption either as an alternative or as a main drinking water source (Marara et al. 2011, 2013).

Researchers have probed this issue from various academic angles, but it is evident that water quality remains a problem. In addition, an estimated 8000 abandoned mines are costing the taxpayers over 100billion rands to rehabilitate (Brown 2007). The *status quo* in the catchment has been largely attributed to pre-1994 government's reactive stance, where instead of acting as a regulator the government was collaborating with mines thus, no closure plans were prepared and dealing with mine residue was not prioritized (Adler et al. 2007; Muller 2012). To date, with the simultaneous water, waste and mine institutional reform and its incremental implementation many questions can be asked: are the water policies being effectively implemented? Are the policies sufficient to address the current problems of water quality? Is there a need for water policy amendment and review?

Objectives

The main aim of this appraisal is to examine the effectiveness in the implementation of the institutional set-up for water resources management in the Wonderfonteinspruit area, relative to the problem of mine waste management. The specific objectives are to: review the government publications on water, mine closure and mine waste management; investigate the vulnerabilities in the content publication and their implementation and establish the current output from these policies and their implementation using the WFS as a case study.

METHODOLOGY

The methodology involved a systematic review of the following documents;

The Constitution of 1996 Act (No.108 of 1996); The National Water act (No. 36 of 1998);

The National Water Resources Strategy 2004; The National Environmental Management: Waste Amendment Act, 2014 (Act 26 of 2014) – GN R 449 of 2 June 2014); White paper on Integrated Pollution and Waste management 2000 and White paper on Minerals and mining policy. Also, a review of the articles publications related to water management in South Africa as well as in other countries from the year 1994 to 2014. The search engines used for this study include Science Direct, Google Scholar, Elsevier using key words ;water institution ,water policy, water resources management; integrated water resources management.

Theoretical context of the: South African Legislation (Water Management Institution)

South Africa, according to the 1994 constitution, has a directive towards attaining and upholding sustainable development. Thus, the government has had to establish a clear institutional and regulatory framework with quantitative objectives and standards for decision making in terms of mining, environmental and public health protection. The development of laws on water allocation, use and management came with the 1996 constitution having cited the inequities in the ownership and thus the utilization for development, because of the pre-1996 legal framework. The basis of the South African law is thus embedded in the Constitution Bill of Rights Section 27 (1) paragraph (b) which states "the right of every individual to access sufficient water".

National Water Act 1998 (NWA)

The NWA was set out to remedy the uneven distribution of water and scarcity. Under this law, the riparian (private) ownership of water was converted to common ownership. As such, water is a national resource, possessed by the people of South Africa, and is maintained in custodianship by the state (Van Koppen 2010). NWA acknowledges the aim of water resource management; water quality protection and stakeholder involvement, all other aspects of water resources and administration of the law. Other guiding principles to ensure sustainability and equity are used, development, conservation and the control of water resources. NWA has 28 principles some of which include the concepts of user and polluter pays, licensing of water and the registration of water users (Tewari 2009). The NWA also makes a provision for the creation of a National Water Resources Strategy (NWRS) which is supposed to forge framework guiding protection, conservation, use and management of water resources (Tewari 2009).

A stipulation in the act (Section 19) places accountability on persons owning ,controlling ,using or occupying land who has caused or is likely to cause pollution of water to prevent pollution from occurring , continuing or recurring. Section 26 of the NWA also prescribes for the Government Notice No. 704 (GN 704), which states regulations on use of water for mining and related activities aimed at the protection of water resources.

National Water Resources Strategy (NWRS) 2013

The NWRS is an implementation initiative that outlines the ways and plans of action intended to achieve the integrated management of water resources, whereby there is devolution of powers from national levels to local government. The NWRS has its basis in the NWA as well as the Water Services Act of 1997. This strategy is used to achieve sustainable development. To achieve this, there is a provision which emphasizes the need for the establishment of Catchment Management Agencies (CMAs). The CMAs are expected to draw a water resources strategy which should align itself with NWRS. The CMAs are meant to bring about devolution of responsibilities through a bottom-up participatory approach that delegates control at the lowest levels (the CMAs) and makes use of stakeholder participation. The stakeholders are water users who have to be involved in the decision making process in order to achieve the goals set for water resources management by CMAs.

The comprises of an overview water policy, water law and water resources management, and South Africa's water situation and strategies to balance supply and demand. Contained within the strategy are action plans from Policy Implementation Task Teams (PITTs), which were created to identify and overcome constraints from the policy implementation (De Coning 2006). The NWRS maintains the main aim of the water institution i.e. to shift from supply to demand management by enforcing that substantial improvements in water use efficiency are possible if water conservation measures are adopted.

Integrated Water Resource Management (IWRM)

Also incorporated within the NWA is the Integrated Water Resources Management (IWRM) which is described as a "philosophy, process and management strategy to achieve sustainable use of resources by stakeholders at catchment, regional, national and international levels, while maintaining the characteristics and the integrity of water resources at the catchment scale within agreed limits."

IWRM comprises of all aspects of water resources; quality, quantity and aquatic ecosystem quality. In order to achieve IWRM, there are two measures: the resources-directed measures and the source-directed measures .The resources-directed measures are aimed at protecting the receiving environment whilst the source-directed measures are aimed at controlling the impacts at the source.

Mine Management and Closure

There are many legal statutes in South Africa which deal with mine management and closure. One of the aspects set out in the National Environmental Management Act (NEMA) is the need for mining activities to carry out Environmental Impact Assessments EIAs as well as the establishment of closure plans. In the Mines and Minerals Act (MMA) 50 of 1991, as well as the Mineral and Petroleum Resources development Act (MPRDA) 28 of 2002, environmental management is an issue of priority The MMA gives mining companies an obligation of environmental rehabilitation.

The Mineral and Petroleum Resources Development Act 28 of 2002 (MPRDA)

The MPRDA makes provision for the mitigation of the biophysical and socio-economic impacts. Incorporated within the MPRDA are prescribed requirements specifically for mine closure .The MPRDA stipulates the carrying out of an Environmental Risk Assessment (ERA) whereby risks and financial provisions for long term management and monitoring programs are laid down. It also stipulates the development of mine closure plan which has to be approved by the Department of Water Affairs and Forestry (DWAF) as well as Department of Minerals and Energy (DME). In preparation of the mine closure plan, emphasis is made to involve stakeholders especially the DWAF, which has to sign off on any closure certificate.

Best Practice Guidelines (BPGs)

The DWAF has recently developed and published Best Practice Guidelines (BPGs). The BPGs define and document best practices for water and waste management focused on attending to all the aspects of mine closure planning process. Thus they provide a logical process that can be applied by both the mines and the DWAF so as to ensure that the mines meet the requirements set for mine closure, and that DWAF is satisfied with the mine closure plans. The BPGs are seen as a planning tool to enable mines to implement mine closure and to better address water related mine closure aspects. In the BPG, listed amongst the primary factors for consideration in the planning for mine closure and post closure, is the sustainable rehabilitation of surface residue deposits which if exposed to oxygen may form AMD. In order to achieve the set objectives, the BPGs bank upon stakeholder and specialists participation, the use of appropriate tools, incorporation of financial costs as well as indicators for efficient mine closure planning.

The National Environmental Management: Waste Amendment Act, 2014 (Act 26 of 2014) – GN R 449 of 2 June 2014

The NEM (WA) lays a foundation for sustainable integrated waste management and emphasizes the need for intergovernmental co-ordination and harmonization of policies, legislation and actions relating to the environment. In general, waste management falls within the mandate of environmental management authorities and agencies, while the mining authorities with little or no specific reference to mining waste address mining (Godfrey 2007). The NEM (WA) sets out the development of a strategy, the National Waste Management Strategy (NWMS). This is an implementation strategy just like the NWRS.

RESULTS

Vulnerabilities in the Policies and implementation

In spite of the modifying of water, waste management, mine management and environmental legislation, many of the changes have not been successfully implemented (Adler et al. 2007). Moreover, Muller (2012) argued that given the fact that many policies within water, waste management, mine management and environmental institutions had not yet been implemented, means the reforms have not been tested. As such the question of effectiveness of these reforms is difficult to tackle. For the water institution it was noted that many of the statutes and other related policy initiatives implementation plans take long to be developed (Muller 2012). For example, the delay in the development of a follow up strategic plan for implementation purposes (National Waste Management Strategy 2011) of the NEM (WA). Muller, 2012 postulated that the slow and incremental implementation approach was purposely used to allow for the different speed of implementation of the water institution in different parts of SA.

Interestingly, various pieces of legislation are constantly being put into place simultaneously or consecutively such that it becomes very difficult for the various stakeholders to adopt and keep up with the implementation of these policy instruments. Schreiner (2013) reiterated that because implementation of the NWA was to be done in phases, the many changes occurring in the water sector have led to water managers trying to implement an array of new functions concurrently. Consequently challenges in the form of limited capacity required in implementation of the institution arise (Schreiner 2013).

Adler et al. (2007) stated that the reasons for non–implementation are the lack of specificity in the legislation and conflicts between the departments due to the duplication of responsibilities amongst other things. In agreement Godfrey (2007) stated that fragmentation and overlapping or vaguely defined roles and responsibilities regarding waste management are characteristic of the United States of America as well as South Africa. For example, mineral residue is not classified as waste and is considered a potential future source of minerals (Godfrey 2007).In a study on the SADC region, assessing environmental sustainability in water resources management it was discovered that although water was utilized by many sectors the legislation was compartmentalized (Hirji and Ibrekk 2001).This leads to the lack of coordination between the various sectors.

Turton (2015) studied the environmental and water resources policy application in South Af-

rica taking into consideration the historical legacy of mining whose impacts have only begun to manifest.Turton (2015) went further to categorize the water policy reform in south Africa in phases, and attributed the *status quo* of degraded water quality and aquatic and related ecosystems to the period around 1975 ,where in a bid to gather more revenue, the South African government nationalized all environmental externalities from mines. However the NEMA (2014) marks a shift from this strategy of nationalizing historical environmental liabilities where it stipulates that all mining operations must offset the externalities by paying a significant amount prior to their operations.

Adler et al. (2007) noted that the South African government continues to be reactive in dealing with environmental issues rather than proactive. For example, in terms of water pollution whereby the Polluter Pays Principle was adopted and is enshrined in the NWA is still maintained in SA and is considered International Best practice (Turton 2015). According to this principle companies are supposed to pay for the contamination arising from their activities. However, the effectiveness of this method has been contested (Komen 2011; de Sadeeler 2012). For instance, questions of identifying the polluter, particularly in the case of diffuse pollution (de Sadeeler 2012). Furthermore, the issues of fine amounts relative to the environmental costs in terms of contamination as well as rehabilitation, the fines were reported to be insignificant such that many governments are looking for other forms of economic instruments like environmental taxes to contribute to the clean-up (Fullerton 2009). To align with principles of precautionary management of natural resources, Johnson 2012; De Lucia (2013); Costanzo (2014) suggested that there is a need to adopt the 4P (Precautionary Polluter Pays Principle). In this system a bond is paid prior to the environmental externalities, thus encouraging prevention over remediation (Perelet et al. 2014) and also counteracting problems associated with scientific improbabilities (Costanza 2014).

Despite the above-mentioned vulnerabilities in the policies, the water law in South Africa has been labelled as most comprehensive in the world (Schreiner and Van Koppen 2002; Schreiner 2013). De Coning (2006) reaffirmed that there exists valuable experience in terms of water policy process in South Africa, although there are no clear-cut indicators to determine the effectiveness of the current institutions. Although the constitution and water principles and subsequently the NWA all emphasize the need for conservation of water quality and the mechanisms to determine trends and the status of water quality, there is still a lot to be done regarding water management at the grassroots level.

CMAs for instance, despite several of them being established only two, the Inkomati and Breede-Overberg agencies of the anticipated fifteen as prescribed in the NWRS were fully functional by 2011 (Segal 2009; DWA 2012). The challenges in setting up of CMAs within the Water management areas (WMAs) resulted in the Department of Water Affairs revising its plan in 2012 to set up 19 WMAs and reduced them to 9, this was done citing the challenges related to the technical capacity constraints associated with staffing the CMAs, and the problems likely to emanate from a large number of institutions, to the Department of Water Affairs (DWA) in regulating their performance (Muller 2012). Another question can be raised regarding the reduced number of CMAs whether they can be able to adequately identify and address the pressures and impacts for various specific sites within the vast Water management areas.

Furthermore, Hirji et al. (2002) noted that the lack of clear definition of environmental sustainability criteria for water management has led to limitations in integrating the criteria into the decision making process. For example the NEM (WA) before its amendment in 2014 ironically did not consider mineral residues as wastes. However, according to statistics given out by DWAF (2012), which stated that South Africa produced waste mounting up to 108 million tons in 2011, of which previous reports, DWAF (2001), indicated that 87.7 percent of this waste is actually mineral waste of which 47 percent comes from gold mining activities like those in the WFS catchment. Furthermore there is evidence to the effect that this mineral waste has high uranium content Winde (2006) which also has been shown to migrate into water (Camden-Smith et al. 2015). The government thus decided to prioritize mineral waste and residue in its policy framework and thus incorporated it in the amendment. Nonetheless there is still a borderline between the definitions of mineral residue as waste or as a resource which can thus be reused such lack of clarity can be manipulated to the detriment of water quality and aquatic ecosystems.

Turton et al. (2007) indicated that despite waste management facilities in South Africa being internationally acclaimed, waste management is still currently afforded low priority within all spheres of government, resulting in failing waste management services that negatively affect human health. For example, in a study on policy reform trends in 11 countries South Africa included (Saleth and Dinar 2000), it was noted that one of the best practices incorporated as a strategy in the Brazil institution is the prioritization of regions and sectors relative to their susceptibility to water quality and quantity problems (Saleth and Dinar 2000). In other words, for South Africa, the catchments facing the most serious problems of contamination are prioritized and the stakeholders are targeted to work with government in reducing or alleviating this issue.

In the case of the WFS catchment where there is generation of radionuclides and yet the Hazardous Substances and Articles Act does not encompass radioactive waste. The radionuclide contamination is reduced to a trivial issue yet radionuclides have significant environmental and public health implications (Busby and Schnug 2007; Stephen 2009; Raabe 2010).

In the previous NEM (WA), there was no emphasis on waste minimization initiatives but it allowed for uninhibited waste production and primarily focused on treatment and disposal of waste. This was due to the ignorance on the part of waste generators and shortcomings in the current legislative and regulatory framework. However, the attitude of industry is beginning to change, because waste management is now costly and there are regulations that are more stringent. The amended act now incorporates reuse and waste minimization. Nonetheless the same cannot be said of local government, who are the custodians of the policies on the ground.

DISCUSSION

Walmsley et al. (2001) studied the indicators of sustainable catchment development and catchment management and they defined these indicators to be ideal means by which progress towards a goal (in this case integrated water resources management) can be monitored. Water quality trends is evidently one of the indicators that come amongst others such as ecosystem health, water use and availability, waste produced and the level of compliance. Since these indicators are directly reflective of the policies and administration they can be used to assess the effectiveness of the implementation of the water, waste and mine closure law in the WFS catchment. Furthermore, some of the indicators which were used to assess the sustainability of water management framework at catchment level in Brazil, were adopted of Ioris et al. (2008). The indicators from that study which were adopted in this paper are; water quantity, public participation and institutional preparedness.

Compared against the sustainable development indicators, the levels of mineral waste being produced in the catchment are evidently high (Winde 2012). Approximately 6 billion tonnes of tailings have been recorded for the Witwatersrand basin (Winde 2009; Liefferink 2014). Winde (2006, 2013) reported that an estimated 600,000 tonnes of uranium is predicted to be contained within those dumps. Several studies have demonstrated uranium mobilization into water (Coetzee et al. 2005; Winde 2009; Camden-Smith et al. 2015). Nevertheless, the level of compliance is very low and there is poor water quality since many points along the course of the WFS River have been found to exceed the maximum permissible limit for heavy metals and radionuclides (Winde 2006; Coetzee et al. 2006; Marara et al. 2011, 2013).

Another indicator used is the ecosystem health, in this catchment the informal settlement dwellers are evidently at risk of contracting water borne diseases as they lack access to potable drinking water and have to rely on the contaminated WFS river (Marara et al. 2011). Marara et al. (2013) carried out a health risk assessment of drinking water from the WFS catchment and observed statistically significant associations between Arsenic concentrations and skin cancer occurrences as well as Uranium isotopes (235 and 238) concentrations and incidence of kidney cancer. Furthermore, several health effects are documented arising from ingestion of drinking water contaminated with heavy metals and radionuclides, which are rife in this catchment.

In addition, the problem of water pollution from mine waste has not been prioritised in the government's mandate. The ISO 14001 environmental management system should be made mandatory for mining companies so that there is commitment on their part as well as identification, continuous monitoring and mitigation of environmental impacts.

Water quantity in the WFS is an issue, as was clearly indicated in Marara et al. (2011), whereby the availability of potable drinking water is limited for informal settlements. Although the municipality has put up Jojo Tanks, the informal settlements residence complained that, these would go long without being filled up (Marara et al. 2011). As such, informal settlements resort to the use of the highly contaminated WFS river for their domestic uses.

Public participation in the catchment, has been characterized by a high level environmental activism, on the other hand the affected informal settlements are marginalized (Marara 2012) not only in terms of service delivery, but also in terms of participating in water resources management in the catchment. Contrastingly Nhundu et al. (2015) suggested that there is need to encourage stakeholder participation at all levels as well as the incorporation of their inputs in water policy formulation, implementation and review.

Institutional preparedness is a challenge. The aforementioned discussion on vulnerabilities in South African water institution has already demonstrated the lack of institutional preparedness which is characteristic of the WFS. The delayed establishment of CMAs, as a result of capacity constraints. Furthermore, the revised number of WMAs from 19 to 9 is also an additional setback to incremental implementation of the water institution.

Integrated Waste, Water and Mine Management

Contemporary literature has many models which aim at explaining the water institution and the linkages within the institution thereof .Deriving from current literature and results of the review, a model was created (Fig. 1) in an effort to portray the concept of the water institution not existing in isolation, this model proposes that in order to achieve the optimal implementation of the water institution there should be a culture of inter collaboration between water and other related institutions.

The fact that this model is a web illustrates the interconnectedness of the various compo-

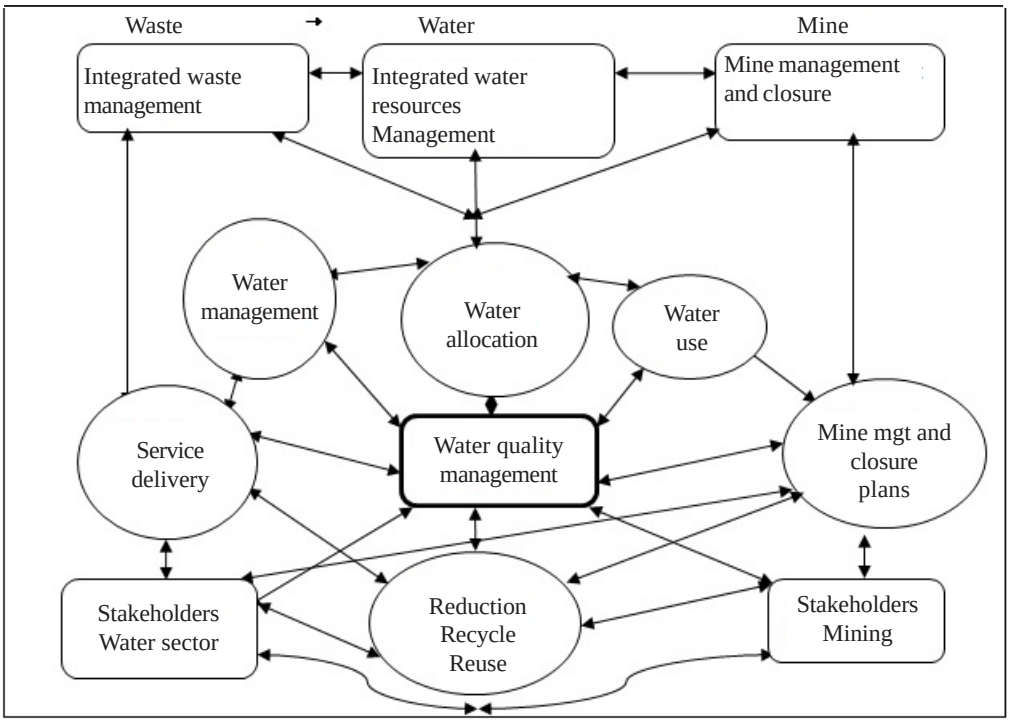

Fig. 1. The integrated water, waste and mine management web
Source: Authors

nents with the water, mine and waste sectors. Symbiotic relationships can be identified, which can only be sustained if the three main sectors are working together as a unit. It can be derived that since the water sector does not exist in isolation, management of the water resources should be approached the in the same manner if the optimal goal of water resources is to be achieved. Thus the model calls for integration of the framework on water, waste and mine management for instance a white paper on integrated water, waste and mine management. The success of optimal water resources management largely relies on a balance between the various sectors whereby, if there is any weakness along the web, the goal cannot be achieved.

CONCLUSION

It can be concluded that although the policies exist, the content is insufficient and unclear. Moreover the implementation is not as effective, as a result of the design of the water institution, which makes use of the incremental implementation approach. Therefore implementation of the water institution and the outcomes have been lagging as evident from the situation in the WFS catchment. Furthermore, another root cause of failed implementation is fragmentation between departments and subsequently duplication of roles. On the other hand the current state of water resources management in South Africa can also be largely attributed to, pre-1994 legislation, which nationalized environmental externalities from mines. The magnitude of these externalities, was not anticipated and incorporated in the policy reform and as such poses serious threats to water resources management in South Africa. Therefore it can be concluded that institutional set up for water resources management in South Africa is not effective.

RECOMMENDATIONS

Using the WFS catchment as a case study, this paper has demonstrated, the grey areas in the South African Water institution and other related sectors which may influence water resources management. As such, government should adopt a precautionary approach in water resources management, rather than the existing system which promotes a reactive stance. There should be development of indicator guidelines for the water sector for the purposes of monitoring, self-evaluation and continuous improvement. To achieve the optimal implementation of the water institution there should be a culture of inter-collaboration between water and other related institutions. There is a need for policy makers in the waste, water and mining sectors to come together and work towards common ground which is water quality management and work towards the alleviation of the problem in their different capacities. There is also a need for further research, on reviewing the water institution in a manner that incorporates and addresses the pre-historic externalities.

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REFERENCES

Adler RA, Marius C, Godfrey L, Turton AR 2007.Water, mining and waste: A historical and economic perspective on conflict management in South Africa. *Economics of Peace and Security Journal*, 2(2): 33-41.

Brown J 2007. Derelict Mines to Cost state R 100Bn, *Business Report*, 23 May 2007, P. 7.

Busby C, Schnug E 2007. Advanced biochemical and biophysical aspects of uranium contamination. In: LJ De Kok, E Schnug (Eds.): *Loads and Fate of Fertilizer Derived Uranium*. Leiden, Netherlands: Backhuys Publishers, pp. 11-21.

Camden-Smith B, Pretorius P, Camden-Smith P, Tutu H 2015. Chemical Transformations of Metals Leaching from Gold Tailings. *10th International Conference on Acid Rock Drainage (ICARD) and International Mine Water Association (IWMA)*, Annual Conference, Chile.

Coetzee H, Wade P, Winde F, Nstume G, Horstmann U, Rademeyer M 2005. An Assessment of Current and Future Water-pollution Risk with Application to the Mooirivierloop (Wonderfonteinspruit). *Report K5/1214*. Pretoria: CSIR.

Coetzee H, Winde F, Wade P 2006. An assessment of sources, pathways, mechanisms and risks of current and future pollution of water and sediments in the Wonderfonteinspruit Catchment. *Water Research Commission, WRC Report*, No. 1214/1, P. 6.

Costanza R, de Groot R, Sutton P, van der Ploeg S, Anderson SJ, Kubiszewski I, Farber SR, Turner K 2014. Changes in the global value of ecosystem services. *Global Environmental Change*, 26: 152-158.

De Coning C 2006. Overview of the water policy process in South Africa. *Water Policy*, 8: 505-528.

De Sadeleer NM 2012. *The Polluter-pays Principle in EU Law-Bold Case Law and Poor Harmonisation.* Pro Natura: Festskrift Til HC Bugge, Oslo, Universitetsforlaget, pp. 405-419.

De Lucia V 2013. Towards an ecological philosophy of law: a comparative discussion. *Journal of Human Rights and the Environment*, 2: 167-190.

Department of Water Affairs 2012.Minister Establishes Nine Catchment Management Agencies.30 March 2012. From <https://www.dwa.gov.za/Communications/PressReleases/2012/Media%20release%20C atchment%20 Management%20 Agencies%20 March %20%2030%202012.pdf> (Retrieved on 16 May 2015).

Fullerton D (Ed.). 2009. Distributional Effects of Environmental and Energy Policy: An Introduction. Distributional Effects of Environmental and Energy Policy. Aldershot, UK: Ashgate. From <http://works.bepress.com/don_fullerton> (Retrieved on 14 August 2013).

Godfrey L 2007. Ecosystem governance and the trialogue debate: An overview of the trialogue relationship and the engagement along interfaces. In: AR Turton HJ, Hattingh GA, Maree DJ, Roux M, Claassen WF Strydom (Eds.): *Governance as a Trialogue: Government-Society-Science in Transition.* Berlin: Springer-Verlag, pp. 319-336.

Hirji R, Ibrekk HO 2001. Environmental and water resources management. *Environment Strategy Papers No.2*. Environment Department, Washington DC: World Bank.

Hirji R, Mackay H, Maro P 2002. Defining and Mainstreaming Environmental Sustainability in Water Resources Management in Southern Africa. – A Summary. SADC, IUCN, SARDC, World Bank: Maseru/Harare/Washington DC From <http://www.sardc.net/waterbook/Summary.pdf> (Retrieved on 27 July 2015).

IMF (International Monetary fund) 2015. Issues in Managing Water Challenges and Policy Instruments: Regional Perspectives and Case Studies. From <https://www.imf.org/external/pubs/ft/sdn/2015/sdn1511tn.pdf> (Retrieved on 27 November 2015).

Ioris AA, Hunter C, Walker S 2008. The development and application of water management sustainability indicators in Brazil and Scotland. *Journal of Environmental Management*, 88(4): 1190-1201.

Johnson AR 2012. Avoiding environmental catastrophes: Varieties of principled precaution. *Ecology and Society*, 17(3): 9.

Komen M 2011. Review of Environmental Assessment and Management. From <http://www.chroniclesa.co.za/index.php?option=com_ contentandview= categoryandlayout= blogandid= 63 andItemid= 88> (Retrieved on 2 April 2014).

Liefferink M 2014. Criminal Investigation by the Department of Environmental Affairs of Blyvooruitzicht Mine's Alleged Failure of Duty of Care pursuant to Criminal Charges laid by Civil Society. Federation for sustainable development. From <http://www. elasa.co.za/uploads/1/1/8/2/11823994/liefferink.pdf> (Retrieved on 14 March 2015)

Marara T, Palamuleni LG, Ebenso E 2011.Access to potable drinking water in the Wonderfonteinspruit catchment. *Journal of Social Sciences*, 29(1): 73-79.

Marara T 2012. *Radionuclide and Heavy Metal Contamination of Drinking Water Sources in the Wonderfonteinspruit Catchment, South Africa*. MSc Thesis, Unpublished. South Africa: North West University

Marara T, Palamuleni LG, Ebenso EE 2013. Chemical and radiological risks of drinking water from communities in Wonderfonteinspruit Catchment, South Africa. *Asian Journal of Chemistry*, 25(16): 9302-9308.

Muller M 2011. *Lessons from South Africa about the Management and Development of Water Resources from Inclusive and Sustainable Growth*. European Report on Development. Overseas Development Institute, Deutsches Institut für Entwicklungspolitik, and the European Centre for Development Policy Management.

Namara RE, Hanjra MA, Castillo GE, Ravnborg HM, Smith L, Van Koppen B 2010. Agricultural water management and poverty linkages. *Agricultural Water Management*, 97(4): 520-527.

Nhira C, Mapiki A (Eds.) 2005. *Regional Situational Analysis Land and Water Management in the SADC Region*. Vol. Workshop Proceedings No.1 2004. Southern African Development Community (SADC) Secretariat, Gaborone Botswana. 164 pp.

Nhundu K, Mushunje A, Aghdasi F 2015. Nature and Role of Water Institutions– Implications to Irrigation Water Management in Zimbabwe. In: MS Javaid (Ed.): Irrigation and Drainage - Sustainable Strategies and Systems. In Tech, DOI:10.5772/59056. From <http://www.intechopen.com/books/irrigation-and-drainage-sustainable-strategies-and-systems/nature-and-role-of-water-institutions-implications-to-irrigation-water-management-in-Zimbabwe>.

Nkondo MN, van Zyl FC, Keuris H, Schreiner B 2012. Draft National Water Resource Strategy 2 (NWRS-2). From <https://www.dwa.gov.za/nwrs/Link Click.aspx? fileticket= M8Npr ZjscYw%3 D&tabid=72&> (Retrieved on 28 November 2015)

Perelet R, Mason P, Markandya A, Taylor T 2014. *Dictionary of Environmental Economics*. London: Earthscan.

Raabe OG 2010. Concerning the health effects of internally deposited radionuclides. *Health Physics*, 98(3): 515.

Rosegrant MW, David-Poblete S, Dawe D, Elliot H, Kaosa-ard M, Meinzen-Dick R, Palanisami K, Pingoli P, Somad M, Swallow B, Wolf A 2002. Policies and Institutions for Sustainable Water Resource Management: A Research Agenda. Challenge Progress on Water and Food Background Paper 5. Colombo, Srilanka: CGIAR Challenge Program on Water and Food, pp. 161-196.

Saleth RM, Dinar A 2000. Institutional changes in global water sector: Trends, patterns and implications. *Water and policy*, 2(3): 175-199.

Saleth RM, Dinar A 2005.Water institutional reforms; theory and practice. *Water and Policy* 7: 1-19.

Schreiner B, Van Koppen B 2002. Catchment management agencies for poverty eradication in South Africa. *Physics and Chemistry of the Earth*, 27: 969-976.

Segal N 2009. Does South Africa Face A Water Crisis? A Report to Business Leadership South Africa. From

<http://99.198.119.130/~infrastr/wp-content/uploads/Does-South-Africa-face-a-water-crisis.pdf>. (Retrieved on 23 September 2015).

Stephen R 2009. Nuclear Accidents and Food Contamination. Part II. Radionuclides and Health Effects. In: R Stephen (Ed.): Disaster Response, Food, and Public Health. From <http://elements.healthspace.com/?p=540> (Retrieved on 17 February 2015).

Tewari D 2009. A detailed analysis of evolution of water rights in South Africa: An account of three and a half centuries from 1652 AD to present. *Water SA*, 35(5): 693-710.

Turton A 2015. Untying the Gordian Knot: Unintended consequences of water policy for the gold mining industry in South Africa. *Water International, No. Ahead-of-Print,* pp. 1-21.

Turton AR, Hattingh GA, Maree DJ, Roux M, Classen Strydom WF (Eds.) 2007. *Governance as a Trialogue: Government-Society-Science in Transition.* Berlin: Springer-Verlag.

Turton AR 2009. South African water and mining policy: A study of strategies for transition management. In: D Huitema, S Meijerink (Eds.): *Water Policy Entrepreneurs: A Research Companion to Water Transitions Around the Globe.* Cheltenham, UK: Edward Elgar Publishing, pp. 195-214.

Van Koppen B 2010. Water rights in informal economies in the Limpopo and Volta Basins. *CPWF Project Report.* Colombo, Sri Lanka: Challenge Program on Water and Food.

Walmsley J, Carden M, Revenga C, Sagona F, Smith M 2001. Indicators of sustainable development for catchment management in South Africa- Review of indicators from around the world. *Water SA*, 27(4): 539-550.

Winde F 2006. Challenges for sustainable water use in dolomitic mining regions of South Africa – a case study of uranium pollution, Part II: Spatial patterns, mechanisms and dynamics. *Physical Geography*, 27(2): 379-395

Winde F 2009. Uranium Pollution of Water Resources in Mined-out and Active Goldfields of South Africa-A Case Study in the Wonderfonteinspruit Catchment on Extent and Sources of U-contamination and Associated Health Risks. *Anonymous Proc. 2009 International Mine Water Conference,* 2009.

Winde F 2010.Uranium pollution of the Wonderfonteinspruit, 1997-2008. Part 1: Uranium toxicity, regional background and mining-related sources of uranium pollution. *Water SA*, 36(3): 240-256.

Winde F 2012. Challenges in assessing uranium-related health risks: Two case studies for the aquatic exposure pathway from South Africa–Part I: Guideline and toxicity issues and the Pofadder case study. In: BJ Merkel, M Schipek (Eds.): *The New Uranium Mining Boom.* Berlin, Heidelberg: Springer, pp. 529-538.

Winde F 2013. Uranium Pollution on Water –A Global Perspective on the Situation in South Africa. *Vaal Triangle Occasional Papers*: Inaugural Lecture 10/2013.