

Environmental Water Requirements - Research Impact Assessment

Report to the
Water Research Commission

by

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Executive Summary

Within the key strategic areas of water-linked ecosystems: ecosystem management and utilisation, the WRC has initiated numerous projects focused on the subject of Environmental Water Requirements (EWR). The aim of this project was to provide a concise assessment, using both primary and secondary research, of the impact of the WRC's EWR research investments and products on socio-cultural, economic, environmental and health aspects of South African and international society.

The WRC has completed in excess of 30 projects related to the subject of EWR. These projects include the following subject scopes: water catchment management (2 projects), ecological reserve (6 projects), environmental water requirements (1 project), estuary management (6 projects), instream flow requirements (3 projects), inter-basin transfers (1 project) and river management (13 projects). The WRC research on EWR has had both qualitative and quantitative impacts on South African society.

Economic

EWR research has made a meaningful contribution to South Africa's economy by impacting agricultural activities, fisheries and industry and mining. Tourism and subsistence farming are other economic activities that have benefited. A select example of a report that has had an economic impact includes:

Report	The Role of Estuaries in South African Fisheries: Economic Importance and Management Implications, WRC Report 756 / 2 / 03
Overview	An assessment and quantification of the role of fish, fisheries and estuaries within South Africa's economy
Impact	This report highlights the importance of South Africa's estuaries, fish and fishing industries within an economic context. This information is critical within in the context of valuing and making decisions relating to South Africa's estuaries and the subsistence of communities that depend on them

Environmental

Environmental impacts were reviewed by linking the EWR research findings and management principles with river ecosystem preservation. The influence of this on natural areas and tourism were deemed positive. A select example of a report that has had an environmental impact includes:

Report	Kruger National Park Rivers Research Programme (KNPRRP). WRC Report TT 130 / 00
Overview	The KNPRRP was initiated in 1988 and ran for over a decade in three phases. Broadly, these phases focused on scientifically understanding the environmental requirements of Kruger's river systems. Amongst others, there was focus on water quality and quantity requirements, predicting and monitoring environmental response to different flow regimes and corrective action through stakeholder capacity building
Impact	This programme made a significant contribution to the field of river management and ecological sustainability through the utilisation and development of a range of tools, protocols and methodologies. Some of these included: State of the art hydrological modelling, a new geomorphological model, a new fish model, a riparian vegetation model and an integrated Catchment Information System: It is evident that the KNPRRP made a significant contribution to the field of catchment and river management and to the development of South Africa's environmental water requirement "intellectual capital". With the implementation of these tools and methodologies decision-makers are increasingly empowered to make meaningful and effective water allocation decisions, which will benefit South Africa as a whole

Social

Socially, EWR research has made an impact through the preservation of river ecosystems, which has the knock-on impacts of ensuring access to food, building materials and providing recreational areas. A select example of a report that has had a social impact includes:

Training Course	Introductory course to Estuarine Management in South Africa
Overview	Estuaries have a quantifiable value, however WRC research has shown that these systems are not managed effectively at a local level to leverage and maximize this value effectively. This training course was developed with the aim to empower and train local municipal managers to manage their local estuaries effectively
Impact	The training of local-level managers will build capacity and develop specific estuary-management skills within municipalities. Improved estuary management will have environmental, social and economic benefits. The preservation of estuaries through proper management will improve the sustainability of the system, which will have knock-on effects. Local communities will derive direct recreational (e.g. fishing, boating, birding) and economic (e.g. subsistence fishing, tourism) benefits, while indirect value (e.g.. water purification) can also be derived

Health

Health benefits derived from EWR research can be seen in the form of managing diseases such as bilharzia. By managing instream flow rates, the occurrence of bilharzia can be reduced in areas where it is endemic. Improved bilharzia infection rates reduce treatment costs, improve quality of life and increases productivity. A select example of a report that has had a health impact includes:

Report	The Impact of River Flow Regulation and Manipulation on the Invertebrate Hosts of Malaria, Bilharzia and Liver Fluke Disease, WRC Report No. K5/1589
Overview	This report assessed the impact of different stream flows on the invertebrate hosts of three diseases namely Malaria, Bilharzia and Liver Fluke disease
Impact	The findings from this research provided important insight into the management of these diseases using river flow regulation. Malaria is a poor candidate for flow regulation, the results on Liver Fluke disease were inconclusive, but it was found that bilharzia is a prime candidate for river flow manipulation. Bilharzia is a chronic illness that can be very debilitating within poor communities. The effective management of the invertebrate host through river flow regulation could therefore have an important impact on the livelihoods and health of poor communities in South Africa

The importance of the WRC's EWR research has been highlighted in this report, however, the fact that EWR management principles have been incorporated in South Africa's legislation, alone, highlights the importance of this subject area. The WRC's EWR research has made an important contribution to the various techniques around water resource analysis and classification in South Africa. These techniques have and are being used to help understand the environmental requirements or Ecological Reserve of South Africa's water resources. Once Basic Human Need and Ecological Reserve needs are understood, appropriate allocations can be made to economic water demands.

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1. Introduction

Water is crucial to environmental sustainability. There is a need to utilise available water resources efficiently and effectively to ensure its availability for current and future generations, the economy as well as the environment. Historically, water allocation decisions were based on economic needs; human and environmental requirements were deemed less important. This unsustainable approach to water management and allocation has, through the influence of research conducted in the field of Environmental Water Requirements, since evolved into a more broad-based, sustainable approach.

The research field of Environmental Water Requirements (also known as Instream Flow Requirements and Ecological Reserve) focuses on the management of water resources from an environmental sustainability perspective. The Water Research Commission (hereafter referred to as the WRC), has played an important role in the management, dissemination and implementation of research in the field of Environmental Water Requirements (hereafter referred to as EWR) in South Africa.

As a water knowledge hub, the WRC is committed to ensuring that the publicly funded research under its management provides social, economic, health and environmental benefits to South African society. This is only possible if the WRC ensures that their research activities and outputs provide knowledge that result in groundbreaking innovation that is appropriate for effective and efficient management of water resources.

In an effort to retain and strengthen its position as a “value for money” institution delivering research and innovations that contribute to socio-cultural, economic, political, technical and environmental aspects in South Africa, the WRC has embarked upon research projects to assess and portray the impact of its research programmes and resulting products and their benefits to the country.

With this in mind, the WRC has commissioned this project to assess the impact of its research investment made in support of EWR. The WRC has limited capacity to conduct such evaluations hence it has commissioned international growth consulting company Frost & Sullivan to support on a review of selected research products/programmes one of which is within the area of EWR related research.

1.1 Project Aim and Objectives

Project Aim

The aim of this project is to provide the WRC and its stakeholders with a concise assessment of the impact (to date and future potential impact) of the WRC's *Environmental Water Requirements* research investments and products on socio-cultural, economic, political, technical and environmental aspects of South African and international society.

Project Objectives

To map the full extent of environmental water requirements research funded by the WRC since 1986.

To outline the application (to date and expected future application) of the research and products in South Africa (and internationally if relevant).

To determine the impact of the research and products (as per the project aim).

To relate the outcomes / impact of the developed products to a common measure such as "Rand value of research product impact".

1.2 Project Scope

This section outlines the geographic and technical scope of this project.

Geographic Scope

This project considers the impact of WRC research projects in all regions within South Africa. However, where international applications of WRC research and sales of funded products were apparent, these were also incorporated in the analysis.



Technical Scope

This project considers and evaluates all research projects and products (defined as: reports, guidelines, publications, techniques, methodologies, software, hardware, equipment, plant and registered patents) developed by the WRC since 1986 that relate to EWR.

1.3 Consulting Approach and Methodology

For consulting projects, Frost & Sullivan utilises tried and tested marketing techniques to provide structure to the research and its results, which allows the effective analysis, review and comparison against industry benchmarks.

This project was carried out using primary research (telephone or face-to-face interviews) and secondary (published and online material) research as the principle methods of data gathering.

Frost & Sullivan interacted with the following respondent groups and stakeholders:

Organisation Type	Target Designations	Type of Information
Water Research Commission	Project Managers, Research Managers, Programme leaders	Research projects conducted Products developed Application of products
Research Institutes (Universities / Consultants)	Project Leaders, Researchers and Lecturers	Water research provided Water related products developed
Government Departments	Policy Directors, Environmental Health Directors	Alignment of WRC projects and policy development Impact of research on water management
NGOs	Programme Managers, Environmental Activists	Awareness of WRC research Importance of WRC research to national and local water management
Associations / Other	Industry Specialists, Consultants, Associations	Perceived impact of WRC products Supporting information to substantiate findings

1.4 Overview of WRC

The WRC is a statutory organisation established in 1971 by an Act of Parliament. The organisation represents a dynamic hub for water-centered knowledge, innovation and intellectual capital. The WRC provides leadership for water-related research and development through the support of knowledge creation, transfer and application. The WRC engages stakeholders and partners in solving a wide variety of water related problems, which are critical to South Africa's sustainable development and economic growth.

Funding its projects through levies on national water sales, the WRC faces many challenges including: the creation of appropriate and relevant new water-centred knowledge, the dissemination and application of research, network creation and knowledge building capacity.

1.5 Definitions

Ecological reserve

Refers to the amount of water required to protect and sustain an ecosystem in order to secure ecological sustainability.

Basic human needs reserve

Refers to the amount of water allocated for human consumption before water can be allocated for any other use. This water is predominantly used for domestic purposes and allocated to ensure that people are not overlooked in favour of other uses.

Reserve

Reserve refers to both Ecological Reserve and Basic Human Needs Reserve with an all encompassing focus on sustainability (social, economic and environmental requirements).

Environmental water requirements (EWR)

Ecological reserve focuses on the amount of water required to sustain an ecological system, while EWR provides a much broader view, that is, the sustainable use of ecosystem resources which ultimately leads to human benefit, socially, economically and environmentally.

Environmental (In-stream) flows

Refers to flows that are left in, or released into a river system with the specific purpose of maintaining the rivers ecological integrity.

Base flows

Groundwater seepage into a stream channel is called baseflow. During most of the year, stream flow is composed of both groundwater discharge and land surface runoff. When groundwater provides the entire flow of a stream, baseflow conditions are said to exist.

1.6 Overview of the WRC's Research on EWR

Research conducted by the WRC in the field of Water Resource Management is guided by the principles and objectives of the National Water Act (NWA) of 1998. These principles focus on maintaining a balance between meeting human and ecological water needs.

The WRC has aimed to support the implementation of the NWA by researching and developing effective tools that will assist and support policy and decision makers when making water resource allocation decisions. In light of this, since 1994, the WRC has funded research projects in the fields of Instream Flow Requirements, Ecological Reserve, Environmental Water Requirements and related water resource management research areas.

Figure 1 below provides an overview of the timing of these reports that were produced by the WRC between 1994 and 2008. The figure below should be read in conjunction with Table 1.

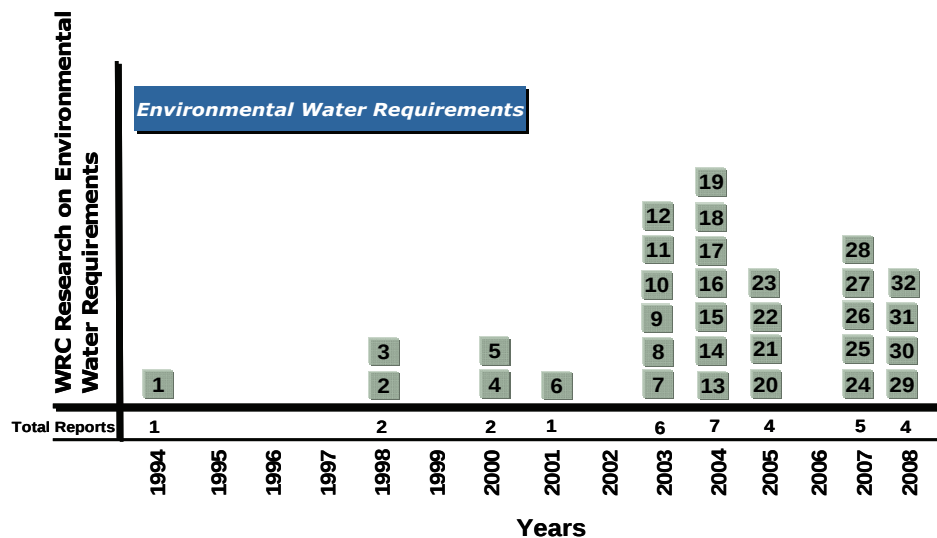


Figure 1: Summary of WRC Environmental Water Requirements Research

To date, the WRC has completed at least 32 research projects within the key strategic area of water-linked ecosystems. These research projects have focused largely on the following areas:

- Water catchment management (2 projects)
- Ecological reserve (6 projects)
- Environmental water requirements (1 project)
- Estuary management (6 projects)
- Instream flow requirements (3 projects)
- Inter-basin transfers (1 project)
- River management (13 projects)

Table 1: Summary of WRC Research

No	Project Code	Title	Authors
Water Catchment Management			
7	TT 220/03	Guidelines for Integrating the Protection, Conservation and Management of Wetlands into Catchment Management Planning	C Dickens, D Kotze, S Mashigo, H MacKay, M Graham
24	TT 301/07	An Introduction to Aquifer Dependent Ecosystems in South Africa	C Colvin, D Le Maitre, I Saayman, S Hughes
Ecological Reserve			
13	TT 245/04	Spatsim, An Integrating Framework for Ecological Reserve Determination and Implementation (Incorporating water quality and quantity components for rivers)	DA Hughes
14	1108/1/04	Early Development of Water Quality Methods and Approaches in Ecological Reserve Assessments	CG Palmer, PA Scherman, WJ Muller, JN Rossouw, HL Malan, S Jooste
16	1174/1/04	Hydraulics for Determination of Ecological Reserve for Rivers	AA Jordanova, AL Birkhead, CS James, CJ Kleynhans
21	1311/1/05	Wetland Water Quality and the Ecological Reserve	HL Malan, JA Day
22	1311/2/05	Assessment of Trophic Status in Aquatic Resources with Particular Reference to the Water Quality Reserve	HL Malan, JA Day
25	TT 307/07	Watermark: The Lasting Impression of the Ecological Reserve	Dr S Liphadzi
Environmental Water Requirements			
23	1414/1/05	Environmental Water Requirements in Non-Perennial Systems	L Rossouw, MF Avenant, MT Seaman, JM King, CH Barker, PJ du Preez, AJ Pelser, JC Roos, JJ van Staden, GJ van Tonder, M Watson
Estuary Management			
1	292/1/94	The Freshwater Requirements of Estuarine Plants Incorporating the Development of an Estuarine Decision Support System	JB Adams, GC Bate
8	756/2/03	The Role of Estuaries in South African Fisheries: Economic Importance and Management Implications	S Lamberth, J Turpie
18	1247/1/04	Contributions to Information Requirements for the Implementation of Resource Directed Measures for Estuaries Vol 1 (Improving the biodiversity importance rating of South African estuaries)	J Turpie, B Clark, D Knox, P Martin, C Pemberton, C Savy
19	1247/2/04	Contributions to Information Requirements for the Implementation of Resource Directed Measures for Estuaries Vol 2 (Responses of the biological communities to flow variation and mouth state in two KwaZulu-Natal temporarily open/closed estuaries)	R Perissinotto, A Blair, A Connell, NT Demetriades, AT Forbes, TD Harrison, K Iyer, M Joubert, I Kibirige, S Mundree, H Simpson, D Stretch, C Thomas, X Thwala, I Zietsman

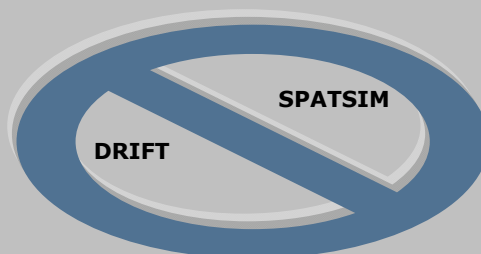
27	1485/1/07	Profiling Estuary Management in Integrated Development Planning in South Africa with Particular Reference to the Eastern Cape Province	L McGwynne, J Turpie, L van Niekerk, C Breen, A Carter, D Hay, S Hosking, T Maswime, M McKenzie, S Mitchell, N Sihlophe, L Schonegevel, S Taljaard, A Wood A Whitfield, G Bate
28	1581/1/07	A Review of Information on Temporarily Open/Closed Estuaries in the Warm and Cool Temperate Biogeographic Regions of South Africa, with Particular Emphasis on the Influence of River Flow on these Systems	A Whitfield, G Bate
Instream Flow Requirements			
15	1159/1/04	Development of Drift, A Scenario-Based Methodology for Environmental Flow Assessments	JM King, CA Brown, BR Paxton, RJ February
3	576/1/98	Development of the Building Block Methodology for Instream Flow Assessments and Supporting Research on the Effects of Different Magnitude Flows on Riverine Ecosystems	RE Tharme, JM King
12	1101/1/03	Determining the Instream Flow Requirement Monitoring Protocol	J Newenham, M.S Chavalala
Inter-basin Transfers			
4	TT 120/00	A Global Overview of Inter-Basin Water Transfer Schemes, with an Appraisal of their Ecological, Socio-Economic and Socio-Political Implications, and Recommendations for their Management	CD Snaddon, BR Davies, MJ Wishart
River Management			
2	TT 106/98	Kruger National Park Rivers Research Programme (Meeting the Water Quantity and Quality Needs of the Natural Environment of Rivers: The Contribution of the KNPRRP)	CM Breen, M Dent, J O'Keeffe, N Quinn, K Rogers
5	TT 130/00	The Kruger National Park Rivers Research Programme	C Breen, M Dent, J Jaganyi, B Madikizela, J Maganbehari, A Ndlovu, J O'Keeffe, K Rogers, M Uys, F Venter
6	856/1/01	Interaction of Reeds, Hydraulics and River Morphology	CS James, AL Birkhead, AA Jordanova, KA Kotschy, CR Nicolson, MJ Makoa
9	849/1/03	Geomorphological Research for the Conservation and Management of Southern African Rivers (Vol 1: Geomorphological Impacts of River Regulation)	AJE du Plessis
10	849/2/03	Geomorphological Research for the Conservation and Management of Southern African Rivers (Vol 2: Managing Flow Variability: The Geomorphological Response)	ESJ Dollar, KM Rowntree
11	1062/03	Principles and Processes for Supporting Stakeholder Participation in Integrated River Management	BW van Wilgen, CM Breen, JJ Jaganyi, KH Rogers, DJ Roux, T Sherwill, E van Wyk, F Venter
17	1181/1/04	Refinement of Geomorphological Tools for the Sustainable Management of the River Environment	RA Wadeson, KM Rowntree
20	TT 238/05	Our Changing Rivers: An Introduction to the Science and Practice of Fluvial Geomorphology	NM Freeman, K Rowntree
26	1405/1/07	Low Flow Hydraulics in Rivers for Environmental Applications	AA Jordanova, CS James

29	TT 329/08	River Ecoclassification: Manual for Ecstatus Determination (Version 2) (Module A: EcoClassification and EcoStatus Determination)	CJ Kleynhans, MD Louw
30	TT 354/08	Environmental Flow Assessments for Rivers: Manual for the Building Block Methodology (Updated Version)	JM King, RE Tharme, MS de Villiers
31	1411/1/08	The Development of a Hydraulic Model for Determining Bed Disturbance Due to Floods in Cobble and Boulder Bed Rivers	J Cullis, M Gazendam, A Rooseboom, G Ractliffe
32	1411/2/08	Flood Disturbance Responses of Invertebrate Assemblages in Two Cobble-Boulder Bed Rivers of the Western Cape	G Ractliffe, J Cullis, A Rooseboom

These research projects encompass a broad array of aspects pertaining to the effective allocation and management of South Africa's water resources.

EWR Assessment Tools

Before water resources can be allocated it is necessary to evaluate current and future water use patterns and their anticipated impact on the natural flow regime. As a result of its research on EWR, the WRC has developed two important tools for assessing in-stream flow requirements: these are **DRIFT** and **SPATSIM**, two computer based systems that are used in the determination and implementation of the reserve.



The Downstream Response to Imposed Flow Transformations (DRIFT)

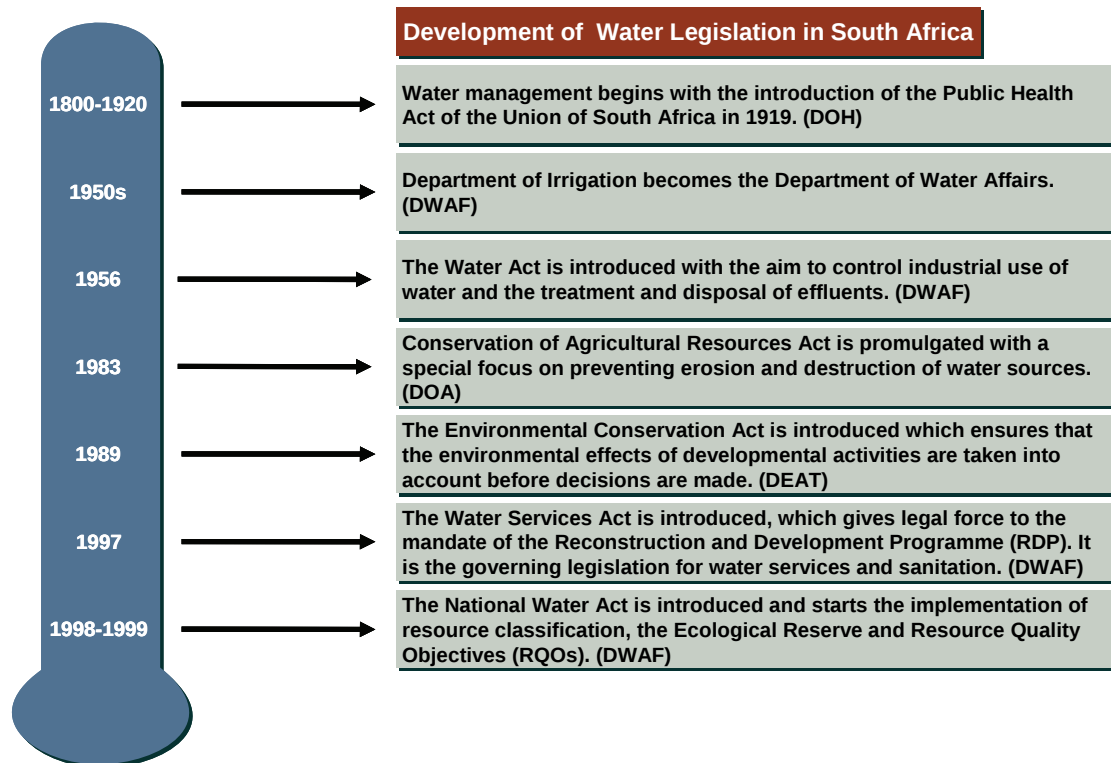
DRIFT is a new methodology for assessing the environmental requirements for the maintenance of rivers that are subject to water developments. This method is currently used by DWAF in the classification of reserves. Previously, assessment tools that were used included Flow-Stressor-Response (FSR) and Building Blocks Methodology (BBM). DRIFT enables predictions of the biophysical state of water resources.

Spacial and Time Series Information Modelling (SPATSIM)

The emphasis of SPATSIM is on the quantity component of rivers and the technical integration of water quality data, tools, techniques and methodologies to facilitate the determination of the ecological reserve. Other Southern African countries have also shown interest in the use of SPATSIM including Tanzania, Botswana, Namibia, Swaziland and Zambia.

South African Water Legislation and the Reserve

Prior to 1998 access to water was not closely regulated in South Africa. No restrictions were placed on land owners who had direct access to water resources. The NWA was put in place to address the inequitable distribution of water and to ensure that water resources are protected within the principles of sustainable development. Figure 2 below outlines the development of water legislation in South Africa.



Source: Watermark: The Lasting Impression of Ecological Reserve, Water Research Commission, TT307/07

Figure 2: Development of South African Water Legislation

South Africa is a pioneer in terms of its water legislation; it was the first country to incorporate the principles of the Reserve into law. Apartheid created marked disparities in terms of access to water resources, hence the NWA was promulgated with a focus not only on equitable allocation within South Africa's population, but also within the principles of sustainability, which includes the Ecological Reserve.

As per the NWA (Act No. 36 of 1998, Chapter 3, Part 3), the Reserve is defined as, "the quantity and quality of water required to satisfy the basic human needs, and to protect aquatic

ecosystems, in order to secure ecologically sustainable development and use of the relevant water resource.”

The following four principles in the NWA relate to the reserve:

Principle 7

The objective of managing the quantity, quality and reliability of the nation's water resources is to achieve optimum, long term, environmentally sustainable social and economic benefit for society from their use.

Principle 8

The water required to ensure that all people have access to sufficient water shall be reserved.

Principle 9

The quantity, quality and reliability of water required to maintain the ecological functions on which humans depend shall be reserved so that human use of water does not individually or cumulatively compromise the long-term sustainability of aquatic and associated ecosystems.

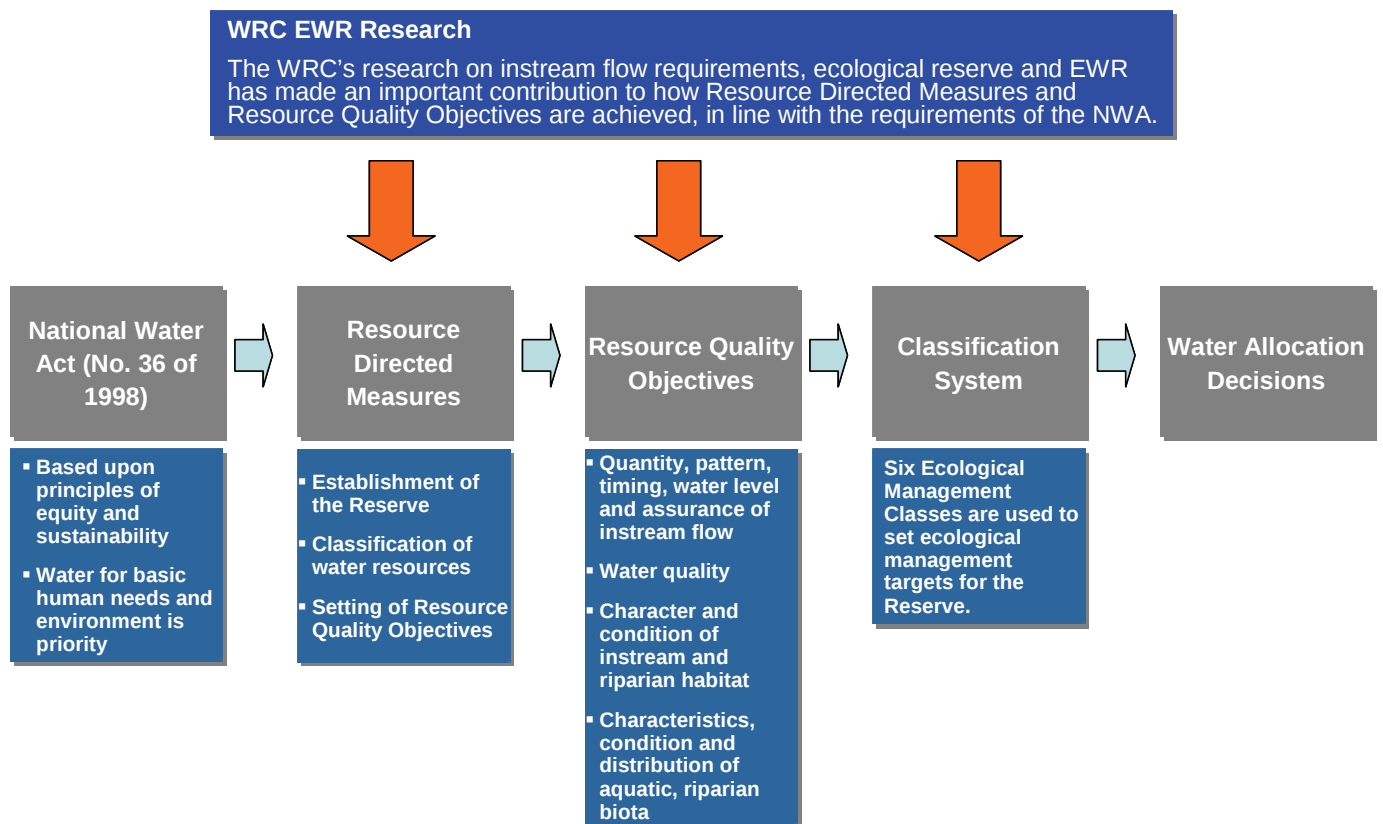
Principle 10

The water required to meet the basic human needs (principle 8) and the needs of the environment (principle 9) shall be identified as “the Reserve” and shall enjoy priority by right. The use of water for all purposes shall be subject to authorisation.

Source: Environmental Water Requirements in Non-Perennial Systems, WRC Report No. 1414/1/05

1.7 Practical Use of EWR Research

The Minister of Water Affairs and Forestry, as per the NWA, is obliged to develop and implement a national water resource strategy that will ensure that water resources are managed and allocated effectively. Important steps within this strategy include Resource Directed Measures, Resource Quality Objectives and the classification of South Africa's water resources. These initiatives are critical for the preservation and correct level of water resource utilisation; without any form of resource measurement or classification it would not be possible to make informed decisions regarding allocation, management and preservation.



Source: Environmental Water Requirements in Non-perennial Systems, 1414/1/05, 2005

Figure 3: Contribution of WRC EWR Research to the National Water Resource Strategy Process

2. Impact of EWR Research

2.1 Impacts

The WRC research on EWR has had both qualitative and quantitative impacts on South African society. Certain impacts are simply defined, assessed and quantified; however, there are particular instances where the assessment and quantification of impacts is more difficult. In cases where a perceived impact is not easily quantified a qualitative assessment is provided.

The impact assessment was classified into 4 main categories, namely economic, social, environmental and health. The diagram below outlines some of the benefits that are expected to be derived from each category.

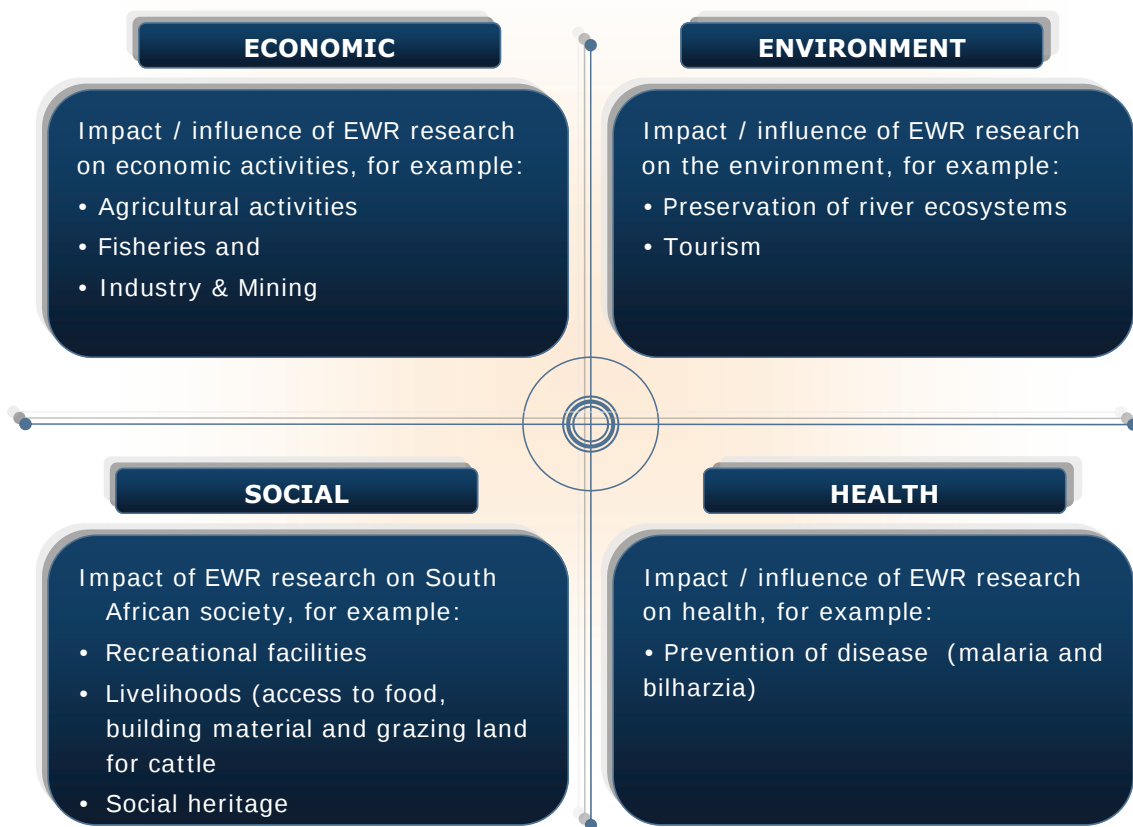
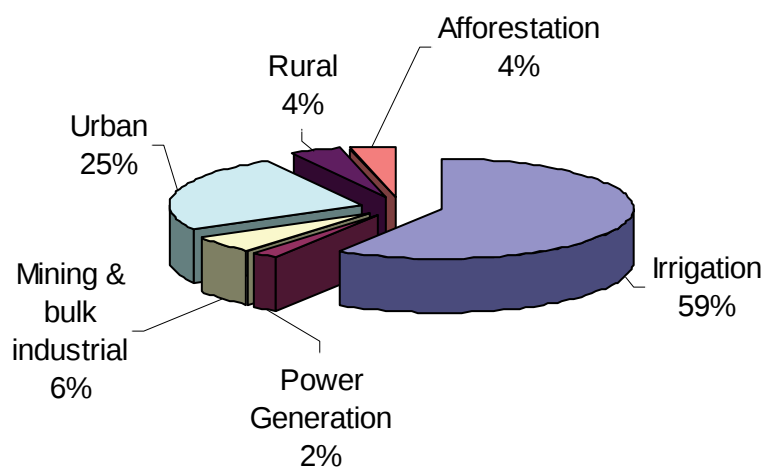


Figure 4: Overview of Key Impact Areas

3. Economic Impacts

3.1 Introduction

Water is the backbone of the economy and its availability can be a limiting factor for economic growth. Mining, agriculture, power generation, industry and manufacturing are key contributors to South Africa's GDP and are also large consumers of water. Without a consistent supply of water, critical economic functions such as energy supply and mining would not be able to function effectively. The Department of Water Affairs and Forestry, through the "Water for Growth and Development framework," is increasingly focused on water availability and allocation issues.



Source: Watermark; The Lasting Impression of the Ecological Reserve

Figure 5: Water Utilisation by End User Group

In the context of EWR and the WRC's research in this field, the water allocation decisions that are based on EWR data, research and water management principles, will have a direct impact on South Africa's economy. Select examples of WRC research projects that have, directly or indirectly, made a contribution to South Africa's economy include:

Report	Environmental Flow Assessment for Rivers: Manual for the Building Block Methodology, WRC Report TT 354 / 08
Overview	The development of an holistic approach to assessing the environmental water requirements of a river; different flow scenarios, which are closest to the natural flow regime, are utilised to determine the most appropriate flow regimes for a river system
Impact	This research has ensured that environmental flow methodologies encompass all components of a river system. This allows more accurate measurement of environmental flow requirements, which culminates in better water allocation decision-making. This will directly impact water allocation decisions within the economy
Report	The Role of Estuaries in South African Fisheries: Economic Importance and Management Implications, WRC Report 756 / 2 / 03
Overview	An assessment and quantification of the role of fish, fisheries and estuaries within South Africa's economy
Impact	This report highlights the importance of South Africa's estuaries, fish and fishing industries within an economic context. This information is critical within in the context of valuing and making decisions relating to South Africa's estuaries and the subsistence of communities that depend on them
Event	International Conference on Implementing Environmental Water Allocation: promoting the sustainable use of rivers, wetlands, estuaries and groundwater
Overview	The primary objective of the conference was to critique global trends in the implementation of environmental water allocations, specifically: policy and legislation, integrating ecosystem protection with socio-economic development, defining and involving stakeholders, decision making for sustainable use, operational management of water allocations, sharing knowledge and skills
Impact	Delegates from around the globe discussed key topics including: Integrated water management and utilisation; institutional mechanisms around water management; decision-making and trade-offs relating to water utilisation and allocation; delivering environmental water and monitoring and adaptive management. The initiation of EWR conferences by the WRC helps position them as a world authority on the subject. Events such as this encourage the communication of new ideas, the development of key strategic relationships with global EWR academics and authorities and ensures that the WRC remain at the cutting-edge of EWR thinking. South Africa is at a critical point where water allocation decisions will impact directly on the sustainability of the environment, development of the economy and social development. Conferences like this make a significant contribution to the understanding of complex EWR issues within South Africa and help ensure that organisations like DWAF make effective water allocation decisions.

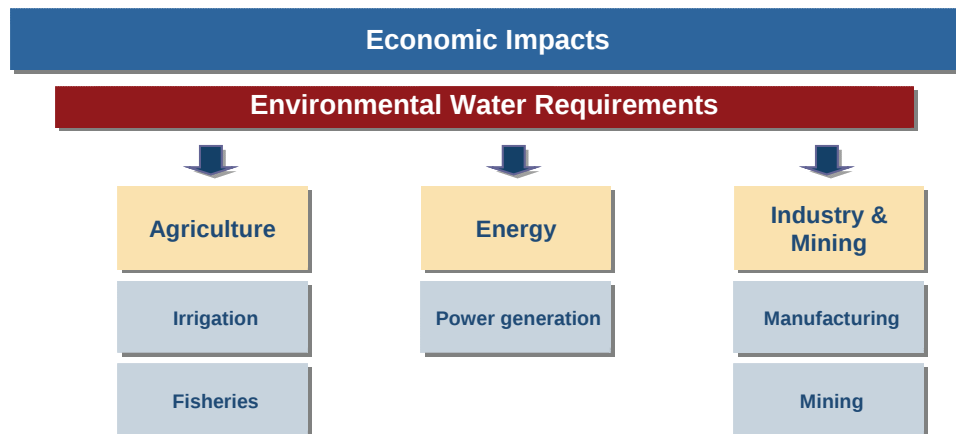
These reports represent a sample of EWR research projects that have an influence on water allocation and management within South Africa's economy.

Maintenance of South Africa's water resources' ecological integrity is critical for the continued supply of water to South Africa's economy. The WRC's EWR research may not have a clear, direct impact on South Africa's GDP. However the management of South Africa's water resources, as outlined by the WRC's EWR research, has a direct influence on water supply to key sectors of South Africa's economy.

This section of the report will explore the impacts that the WRC's EWR research has or will have on South Africa's economy.

3.2. Impact Assessment

As outlined above, key sectors within South Africa's economy are dependent on a sustained supply of water. The economic impact assessment portion of this project will focus on economic impacts across agricultural, power generation, industry and mining activities.



Agriculture

South Africa's agriculture sector, despite only contributing 4.0 per cent to GDP, is a critical component of the economy. Primary agricultural production makes a small GDP contribution, however the sector employs a significant number of the working population (9%) and it contributes significantly to the agro-industrial processing sector, which makes an important GDP contribution (15%). Further, the subsistence farming sector is the primary pursuit of South Africa's rural population and is the backbone of the rural economy.

The agricultural sector is also the largest consumer of water (59%) in South Africa. The success of commercial agriculture is dependent on the consistent availability of water; without water commercial farmers can not operate, which will have significant knock-on effects for revenue and employment levels.

The water management areas outlined in table 2 below provide a snapshot of key areas where agriculture is a fundamental economic activity. Without a secure and sustainable supply of water each of these regions would not be able to continue making a contribution to their Gross Geographical Product. In addition, there would be significant negative knock-on effects in terms of employment.

Table 2: Some of South Africa's Water Management Areas and Associated Agricultural Activities

Catchment Area	Overview	Crops	Economic Contribution
Berg River	Approx. 30 000 ha under irrigation	Lucerne, Grapes, Deciduous Fruit & Vegetables, Wheat, Pasture	Agriculture made a 38% contribution to the regions Gross Geographic Product (GGP)
Breede River	95% of total water demand is from the agricultural sector	Wheat, Fruit, Wine, Ostriches,	Agriculture made a 32% contribution to the regions Gross Geographic Product (GGP)
Inkomati	Tropical region suitable for frost-sensitive crops.	Bananas, Avocadoes, Pawpaws, Mangoes, Sugar Cane, Pulp & Paper	Agriculture made a 18.6% contribution to the regions GGP
Lower Orange River	Produce high value crops. Dry region, but sources water from Orange River	Table Grapes, Dates, Raisins, Wine, Flowers, Vegetables, Grain	Agriculture made a 15.9% contribution to the regions GGP
Olifants-Doring	Dry region, dominated by livestock farming, but suitable for high value crop production	Wine, Table Grapes, Rooibos Tea, Citrus, Deciduous Fruit, Wheat, Potatoes, Flowers, Livestock, Fisheries	50% of the formally employed labour force works in the agricultural sector in this region.

The water catchment areas outlined above represent a fraction of South Africa's total agricultural production, but they provide an indication of the economic contribution that this sector provides in terms of revenue generation (on a local and national scale) and job creation. Should poor EWR and water allocation decisions be made in these regions there would be a significant negative economic impact.

Case Study: Olifants-Doring River EWR Determination

Background

The Olifants-Doring river is an example of a catchment whose economic output is dominated by agricultural activities. The agricultural sector in this water management area contributes significantly more to the economy compared to the national average for South Africa. As a result, the resources of the Olifants-Doring River have largely been regulated with the idea that most of the water is used for irrigation.

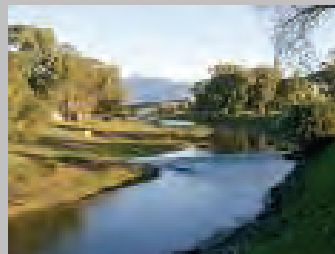
EWR Determination for the Olifants-Doring Estuary

The recommended EWR for the Olifants-Doring estuary was defined as a run-off scenario that represents the highest reduction in river inflow that can still protect the aquatic ecosystem of the estuary. Simulated runoff scenarios were used and these represented realistic future modifications in flow (incorporating future dam development or water abstraction strategies) in the system.

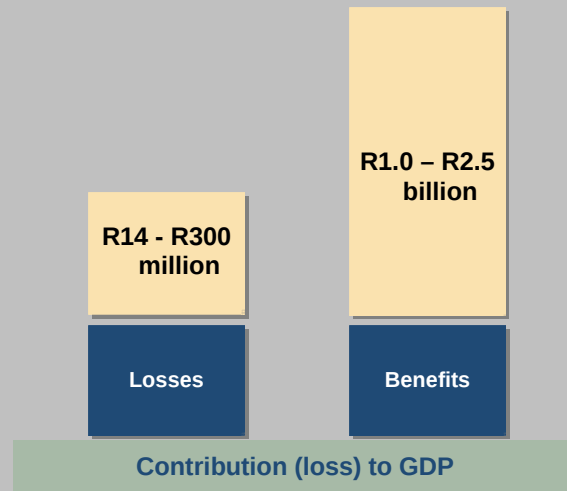
Seventeen possible scenarios with different permutations of water resource developments and compliance to the EWR (quantity) for the river were identified for the Olifants-Doring estuary. The main criterion used in the selection of scenarios was that the permutations chosen were to be realistic approximations of possible future inflows to the Olifants-Doring estuary and to be linked to the distribution of the flows reaching the estuary.

Impact Assessment

The results of the EWR assessment predicted that the economic losses and gains under the different scenarios due to changes in water use in the agricultural sector are significant. Two scenarios from this assessment resulted in losses of GDP from agriculture of approximately R14 million to R300 million, whereas other feasible scenarios predicted gains ranging from R1 billion to R2.5 billion.



Impact of Flow Scenarios on Agricultural GDP



Impact on Low-income Households (R millions):

Scenarios	Present Day	Scenario 2	Scenario 7	Scenario 5	Scenario 17	Scenario 10
Low income households	R199	-R36.84	-R5.01	R192.73	R237.77	R350.04

Further, the different EWR scenarios predicted for the Olifants-Doring system could have a significant impact on low income households in the region ranging from reduced overall income of R36 million to increased overall income levels of R350 million.

Conclusion

What is evident from this case is the influence that different EWR flow scenarios can have on the agricultural economics of a region. A change in flow patterns could have a significant negative or positive impact on revenues and employment levels. This case clearly indicates the importance, in an economic sense, that the field of EWR research has in water resource management.

Source: Brown, (2006)

Case Study: Role of Estuaries in South African Fisheries

Introduction

South Africa's estuaries play an important role in the recreational and subsistence fishing industries. Approximately 80 species of fish have been recorded in estuaries along South Africa's coastline and these areas also provide important nursery areas for breeding marine species. Careful management of South Africa's rivers and estuarine habitats, in terms of EWR, is important to ensure that these valuable resources are sustained for future generations.

Economic Value of Estuarine Fish

Estuarine fish species hold significant economic value. There are approximately 255 estuaries in South Africa and the total estimated catches from these estuaries is approximately 2 482 tonnes per annum.

Total Yield and Value of South Africa Estuarine Fisheries

	Annual Yield	Revenue Generation
255 Estuaries	2, 482 tonnes	R433 million

Total estimated revenue derived from estuarine fish within South Africa is R433 million per annum. Approximately 99.0 per cent of this value is derived from recreational angling and the remaining 1 per cent from subsistence fishing. There are at least 72, 000 recreational anglers in South Africa.

Conclusion

As outlined above, estuaries contribute significant value to the South African economy. The flow rate and EWR requirements of estuaries is very important because freshwater characteristics influence fish species distribution, composition and abundance levels. Without the careful management of South Africa's rivers and estuarine habitats, in terms of EWR, these valuable resources are negatively impacted. Further, the WRC has had an important impact to the understanding of this economic contribution by funding this research.

Source: Lamberth & Turpie (2003)

Power Generation

The energy: water nexus is well documented. Energy cannot be created without water, which is a challenge for South Africa's power utility, Eskom. At least 95% of South Africa's base load generation capacity is produced from coal, which requires substantial amounts of water for

cooling purposes. Eskom has a high dependence on wet-cooled power stations, which currently comprise approximately 64 per cent of total power output. Wet-cooled power stations (50 million m³ of water/annum) use significantly more water than dry-cooled plants (3.5 million m³ of water/annum).

As a result Eskom is South Africa's largest individual consumer of water (2%). Without a secure supply of water Eskom would not be able to produce power, which would add to their current generation capacity woes.

Eskom Water Security Initiatives

Eskom works closely with DWAF to ensure that they are allocated sufficient water resources to maintain sufficient operating levels within their power plants. These memorandums of understanding have the following aims and objectives:

Aims:

- Negotiating a memorandum of understanding with DWAF on water conservation and water demand management for five years.
- Develop a strategic partnership with DWAF to foster water conservation and demand management in the power generating sector.

Objectives

- Share, inform and guide regulatory initiatives on water management within the power generation sector;
- Exchange information regarding policies, strategies and developments in the field of water use and conservation and climate change;
- Joint research, co-operation and agreement in the areas of best water management practice and water use performance improvement;
- Promote, encourage and support good water management practices;
- Develop benchmarks for the power generation sector and implement plans to meet set targets;
- Explore synergies between Eskom's Energy Efficiency and Electricity DSM Programme and DWAF's WCWDM Programme.

Reference: Eskom, Energy and Water Conservation, 2007

Some of the water catchment areas in which Eskom's power stations were built are water scarce, which requires that water is transferred from other catchment areas. It is important that the implications of inter-basin transfers are well understood to ensure that each basin's water

requirements are managed sustainably. The WRC has commissioned specific research focused on this issue:

Report	A Global Overview of Inter-basin Water Transfer Schemes, with an Appraisal of their Ecological , Socio-economic and Socio-Political Implications and Recommendations for their Management, WRC Report TT 120 / 00
Overview	A review of the impacts (ecological, socio-economic and socio-political) of inter-basin water transfers on a global scale
Impact	Globally, little is known about the impacts of inter-basin transfer schemes. Inter-basin transfers are critical to the supply of water and the functioning of South Africa's economy, hence this report will make an important impact within the context of planning and managing these schemes in South and Southern Africa

Case Study: Energy Production Water Demands in Upper Vaal Catchment

Upper Vaal catchment area

There are several large power stations in the Upper Vaal catchment area that consume large volumes of water. Tutuka (near Standerton), Majuba (near Volksrus) and Lethabo (near Vereeniging) are three large coal-based power plants. In addition there are also power stations at Sasol Secunda and Sasolburg. Eskom competes with Rand Water and Sasol for water allocations in the Upper Vaal catchment area.

The significance of the WRC's EWR research, within the context of power generation, is important in terms of water security and allocations. For example, the poor management of flow levels or general EWR requirements within the Upper Vaal catchment area would have a significant impact on Eskom and Sasol's power plants.

Industry and Mining Impacts

South Africa's economy was built on mining and heavy industry. The mining and industrial sectors collectively contribute approximately 31 per cent to South Africa's GDP and consume 6 per cent of total water. In the bulk industrial sector water is utilised for purposes such as processing, cleaning, dilution, and cooling. Major water-using industries include steel, chemical, paper and petroleum refining. Use of water in the mining sector includes the extraction of naturally occurring mineral solids such as coal and ores; liquids, such as crude petroleum; and gases, such as natural gas.

Case Study: Examples of Industry and Mining Water Demand on Catchment Areas

Berg River Water Management Area: Saldanah Steel

The largest industry in the Berg River management area is the Saldanah Steel plant. This facility abstracts approximately 1.5 million m³ per annum from the Langebaan Road lower aquifer. Wheat farmers in the region are suggesting that this is impacting negatively on the upper aquifer, a source of irrigation water for them. In addition, Saldanah Steel, in line with expansion plans, has iterated that they will likely require an additional 2-3 million m³ per annum.

Solutions that have been suggested for this increased demand include:

- Artificial aquifer recharge
- Possible use of alternative aquifers
- Development of additional surface water yield

Olifants Water Management Area: Mining

Mining is an important economic activity in the Olifants River water management area, contributing approximately 22 per cent to the GGP. Coal is by far the dominant mineral group in the region, however copper, chrome, platinum, vanadium and phosphorus are also mined.

Mines in this region compete with irrigation, rural, urban and commercial forestry demand for water allocation. A historical water demand study completed in the region revealed the following water demand patterns:

Sector	Description	Annual Net Water Demand (Mm ³)
Irrigation	110 000 ha of land are under irrigation	511
Mining	There are 93 active mines in the region	77
Rural	Includes stock watering and subsistence irrigation	74
Urban	Includes industrial, commercial, institutional and municipal water requirements	28
Commercial forestry	Afforestation impacts the hydrology of the catchment area	54

Evaluation of Historic, Current and Future Water Demand in the Olifants River Catchment, South Africa, 1995.

Crocodile River Water Management Area: Platinum Mining

The Crocodile River water management area is an important region for mining. The dominant mining activities in the area include platinum, palladium, gold, chrome, manganese, iron ore, diamonds, granites, mineral sands, vanadium, limestone and andalusite mining.

All of these mining activities have increased the demand for bulk water supply significantly. Consequently, mines have been approaching Rand Water for the supply of bulk supply from the Vaal River System.

Another challenge for water users in this region is the dewatering of these mines. Local farmers, who compete for water allocation in this region, believe that their groundwater supplies have been depleted because of mine dewatering activities.

Implications

What these mining and heavy industry examples highlight is the central role that water plays in their operational activities and how, in certain areas, they compete with other ecological or social water demands. It is of critical importance that the environmental requirements of these catchment areas are understood so that sustainable water allocation can result.

Additional Economic Impact Areas

Apart from the economic impacts highlighted above, there are also other activities that contribute to South Africa's economy.

Subsistence farming:

It is evident that primary agricultural activities make an important contribution to South Africa's economy, but subsistence farming is also critical. The majority of South Africa's rural population relies on some form of subsistence farming for food and an income. The poor management of South Africa's water resources could have a negative impact on the sustainability of subsistence farming and the livelihoods of South Africa's rural population. Subsistence farming also has important social benefits; hence this subject will be discussed more extensively in the social impact chapter.

Tourism:

The tourism sector has experienced significant growth since 1994. International visitors are drawn to South Africa's extensive natural areas, which are underpinned by our rivers and water catchment areas. The management of these river systems, within EWR principles, is critical if these natural areas are to be preserved and if South Africa is to remain a top tourism destination. The impact of tourism, in relation to EWR, will be discussed more extensively in the environmental impact chapter.

Conclusion

The impact of the WRC's EWR research on economic aspects of South African society is clear. Across the agricultural, energy, industrial and mining sectors the availability of a sustained supply of water is critical. Limited or a lack of water to these sectors would cripple activity and have significant impacts on South Africa's economy. Not only would the impacts be direct revenue losses, but extensive indirect impacts such as job losses would also occur.

The management of South Africa's water resources, as outlined in the WRC's extensive EWR research project-base, will ensure that adequate water is provided for the environment, thereby securing the sustainability of these water resources and future economic supplies.

4 Environmental Impacts

4.1 Introduction

South Africa is known for its extensive network of protected areas and abundance of natural resources. When decision-makers are faced with sustainability dilemmas, deriving economic and social metrics is relatively simple; environmental metrics are typically more complex. Common approaches utilised range from calculating a value from the sale of natural resources to quantifying the revenue derived from visiting tourists to these natural areas. Tourism-based revenues were utilised in this project to ascertain the impact that EWR catchment management has on the environment.

Tourism is a significant generator of revenue for South Africa. Each year thousands of people visit natural areas across the country; in 2007 just over 9 million tourists visited South Africa (DEAT, 2008).

Central to many of these natural areas is water resources, which need to be correctly managed and protected in terms of EWR principles. Specific research that the WRC has completed within the context of the management of rivers in protected areas includes:

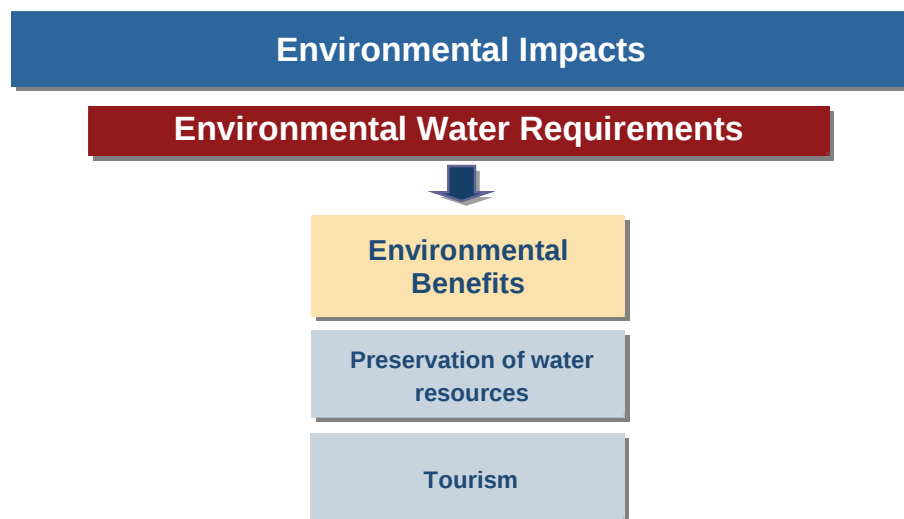
Report	Kruger National Park Rivers Research Programme (KNPRRP). WRC Report TT 130 / 00
Overview	The KNPRRP was initiated in 1988 and ran for over a decade in three phases. Broadly, these phases focused on scientifically understanding the environmental requirements of Kruger's river systems. Amongst others, there was focus on water quality and quantity requirements, predicting and monitoring environmental response to different flow regimes and corrective action through stakeholder capacity building
Impact	This programme made a significant contribution to the field of river management and ecological sustainability through the utilisation and development of a range of tools, protocols and methodologies. Some of these included: <u>State of the art hydrological modelling</u>: Two cutting edge hydrological modelling systems were implemented: Agrohdrological Modelling System and the Hydrological Simulation Programme Fortran <u>A new geomorphological model</u>: A qualitative rule-based geomorphological model was developed, which can predict the changes in selected sections of a river <u>A new fish model</u>: A qualitative rule-based KNPRRP fish model was also developed, which predicts the response of fish to different flow conditions <u>A riparian vegetation model</u>: A qualitative ruled-based riverine vegetation model was developed, which predicts the response of riverine vegetation to changes in the form of a river <u>Integrated Catchment Information System</u>: The KNPRRP pioneered the development of a catchment management information system. In 1988 the Integrated Catchment Information System (ICIS) had already been installed at 18 research and government institutions It is evident that the KNPRRP made a significant contribution to the field of catchment and river management and to the development of South Africa's environmental water requirement "intellectual capital". With the implementation of these tools and methodologies decision-makers are increasingly empowered to make meaningful and effective water allocation decisions, which will benefit South Africa as a whole

This particular research programme, which spanned a decade, made an important contribution to the understanding and management of the Kruger National Park's rivers. Without this initiative and the resulting intellectual capital and tools that were developed, the management of the park's rivers would be far more difficult and not based on sound empirical research. Further, this research programme made an important overall contribution to the field of EWR through the development of key assessment tools.

4.2 Impact Assessment

The primary focus of EWR research, along with ensuring an equitable balance between societal and economic needs, is the sustainable management of water resources. The link between the WRC's EWR research and environmental impacts is clear, however quantifying this relationship can be challenging.

The impacts outlined in this section of the report focus on the preservation of water resources and tourism. Both of these areas are closely linked and will be discussed in unison. With the preservation and effective management of water resources, the ecological integrity of natural areas is maintained, which has a positive impact on tourism.



Preservation of Water Resources

EWR management principles ensure that sufficient quantities of water are left within a river system or water resource to maintain its ecological integrity. To be more exact:

- The quality, quantity and timing of water flows required to maintain the components, functions, processes and resilience of aquatic ecosystems which provides goods and services to people (Trans-Caledon Tunnel Authority, 2009)

The adoption of these principles ensures that the ecological sustainability of the system is maintained, which has knock-on impacts for industries like ecotourism, where significant value is placed on pristine and well managed water resources and natural areas.

Implementation of EWR principles impacts both the quality and quantity of flow, which influences the preservation of riverine species and habitats.

Flow Quality and Quantity

Water quantity and quality can not be managed in isolation of each other. The quantity of water in a river system has a direct impact on its quality. The underlying factor behind the Reserve is both the quality and quantity of water required for basic human needs as well as the system's ecology. Human activities such as agriculture, mining and recreational activities have impacted negatively on the quality of our water resources. The consequences of irrigation, the leaching of fertilisers, and more importantly the leaching of salts from deeper soil horizons can render both land and the receiving rivers unsuitable for use.

By adopting EWR management principles, the importance of releasing more suitable quantities of water from dams for diluting saline water in downstream areas is prioritised, which creates acceptable water quality levels as well. The WRC has completed several studies that focus on the issue of flow quality and quantity, but one particular project example includes:

Report	SPATSIM, an integrating framework for ecological reserve determination and implementation: incorporating water quality and quantity components for rivers, WRC Report TT 245 / 04
Overview	SPATSIM represents a computer-based decision-making tool to quantify and assess the ecological reserve of a river, specifically incorporating quality and quantity components
Impact	The utilisation of computer-based decision-making tools allows for the more accurate assessment ecological reserve, which will ensure that better water allocation decisions are made

Preservation of Rare Species and Habitats

Adequate protection and management of water resources will ensure that riparian species and habitats are given sufficient protection.

Estuaries and wetlands are some of the water resources that have been threatened by human activities. Some of the river ecosystems have already been declared protected areas by DWAF. The Olifants Estuary, for example, is one of the largest and most diverse estuaries in South Africa. It also has a high functional importance in terms of its role as a nursery area for marine

fishes on the West Coast. The estuary has been targeted as a 'Desired Protected Area' by the Resource Directed Measures Directorate in DWAF (DWAF 2004).

The WRC has completed numerous projects focused on the preservation of riverine species and habitats. Below is an example:

Report	The Freshwater Requirements of Estuarine Plants Incorporating the Development of an Estuarine Decision Support System, WRC Report No. 292/1/94
Overview	This research project aimed to establish an understanding of the manner in which estuarine plants respond to varying freshwater regimes such as salinity, water level and flow velocity. This data was used in formulating guidelines and as a decision-making tool for the management of estuarine ecosystems
Impact	The study revealed that estuarine plants are sensitive to both salinity and water level changes. The freshwater variations are caused by limiting normal freshwater catchment discharges. This project made an important contribution towards the understanding of the freshwater requirements of estuarine plants, their management and preservation.

Case Study: Vulnerable River Systems

Overview

A combination of habitat degradation and invasion by alien species has significantly contributed towards the decline in endemic fish populations in the Olifants-Doring River basin. The Olifants River is extremely important from a conservation perspective. Firstly, the Olifants River contains remnant populations of eight species of endemic fish, the highest number of endemic fish south of the Zambezi River; its upper reaches flow through a unique gorge area, which is widely recognised for its aesthetic and recreational appeal. Possible historical links with the Orange River also make the river important from a scientific point of view.

The Doring River is also important from a conservation point of view. It is inhabited by nine indigenous fish species, seven of which are endemic to the river system. Of these, the main stem of the Doring River is most important for the larger species. The reaches upstream of the Tankwa River are vital breeding areas for the sawfin, the Clanwilliam yellowfish and the Clanwilliam sandfish. The latter two are classified as rare Red Data species, while the sawfin is regarded as vulnerable (Skelton, 1987).

Source: Brown (2006)

Tourism

Tourism is a significant contributor to South Africa's GDP; it is one of the fastest-growing industries and government considers it to be a key sector to boost the country's economic growth. Ecotourism in particular is a major revenue generator for South Africa's national parks and game reserves.



Eco-tourist centre, KwaZulu-Natal

Water resources are central to South Africa's natural areas; inadequate water supply as a result of poor catchment management would negatively impact tourism numbers and resultant revenue levels. The application of sound EWR management principles to catchment regions is integral to ensuring natural areas are adequately protected.

Case Study: The Value of River Ecosystems Derived Through Tourism

Background

The Kruger National Park (KNP) is a popular destination for both local and international tourists. Tourists are attracted to the KNP by a variety of river attributes which form part of the total package for which they are willing to pay. Visitors and safari guides to the KNP have indicated that a number of river attributes have attracted them into spending time along rivers. Wildlife and various game species along the river, the appeal of the river-scape, large river trees and riverine birds were some of the river attributes that were cited as important.

Valuation of River Ecosystems

Because of the inter-dependency between river features, species and habitats, it is difficult to separate the values of each component. Although wildlife may be the main attraction to visitors, they are dependent on river ecosystems for their survival. Thus, it is important to stress that rivers are viewed as ecosystems containing wildlife, rather than as the water that sustains wildlife.

Between March 1999 and February 2000, 41 442 people were brought to the southern KNP by private safari operators. This represents figures for the five gates within the Komati Basin area, but accounted for almost all private safari vehicles entering the park. The KNP generates an annual turnover of R3 063 840 from private safari companies in entrance fees.

Private safari operators generated a gross income of R12.5 million from game drives in the KNP during the 1999/2000 financial year. In comparison, KNP-run game drives generated R4.6 million during the 1999/2000 financial year, from a total of 66 507 visitors.

Table 3 below outlines estimates of the total tourism value of rivers based on expenditure in KNP (on-site costs), off-site expenditure (including money paid to safari companies), and consumer surplus:

Table 3: Tourism value of rivers

	Expenditure		Consumer Surplus	Total Value
	On-site costs	Off-site costs		
Kruger Park	R41 210 518	R41 987 765	R301 200 000	R384 398 000
Komati Basin	R25 013 106	R27 309 779	R183 732 000	R236 055 000
Crocodile Catchment	R8 921 613	R9 740 784	R65 962 800	R84 625 000

Based on percentage of time spent at rivers, it was estimated that approximately R3.2 million of the revenues generated outside the KNP for safaris into the park can be attributed to rivers. Based on the measure of satisfaction, R41 million of KNP revenues and R80 million of overall expenditure (on-site and off-site attributed to KNP) by tourists could be attributed to rivers for the whole of the KNP.

Conclusion

This research revealed that consumers' willingness to pay can be impacted by the change in the quality of a river ecosystem. People derive more satisfaction from an amenity that is in good or natural condition. Therefore it can be concluded that the sustainable management and use of river ecosystems will assist in the preservation of river species, features and habitats, which will in turn have knock-on effects on social, economic and environmental aspects of the society. The Kruger National Park Rivers Research Programme (outlined above) made an important contribution to the management of the park's rivers, which has created significant value in the form of ecotourism revenues.

Conclusion

The WRC's EWR research encapsulates the principles of sustainability (social, environmental and economic needs), but it is primarily focused on the environmental requirements of water resources. As a result, the impact on environmental aspects of South African society is

substantial. Programmes such as the Kruger National Park Rivers Research Programme have made both a significant impact on the management of the park's river systems, which has contributed positively to ecotourism, but also contributed, through the development of new assessment and management tools, to the field of EWR as a whole. There are also key examples where WRC reports on specific aspects of river systems (flow quality and quantity, preservation of riverine species and habitats) have had a noteworthy impact.

5. Social Impacts

5.1 Introduction

The South African Constitution states that every citizen has a right to potable water access. This is enforced through the NWA and the provision for the Basic Human Need Reserve, which is currently set at 25 litres/person per day. No water may be allocated before this Basic Human Need Reserve has been met, after which environmental and economic requirements may be addressed, in that order.

The South African government has made significant headway in providing access to water and sanitation services. The maintenance of these services will however require a sustained and reliable supply of water from key water resources. The EWR research conducted by the WRC is focused on the environmental sphere of the sustainability equation. By effectively managing South Africa's water resources, through EWR management principles, this will help ensure that a sustainable supply of water is available for South African society. Specific research that the WRC has completed within the context of social impacts includes:

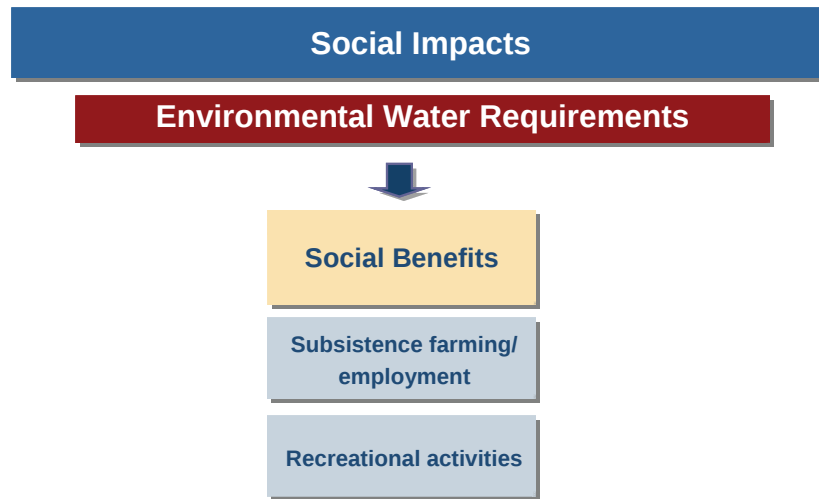
Training Course	Introductory course to Estuarine Management in South Africa
Overview	Estuaries have a quantifiable value, however WRC research has shown that these systems are not managed effectively at a local level to leverage and maximize this value effectively. This training course was developed with the aim to empower and train local municipal managers to manage their local estuaries effectively. Key focus areas included: Why do we value our estuaries; how does an estuary work, activities threatening estuaries; legal mandate; governance and finally management and supporting management tools
Impact	The training of local-level managers will build capacity and develop specific estuary-management skills within municipalities. Improved estuary management will have environmental, social and economic benefits. The preservation of estuaries through proper management will improve the sustainability of the system, which will have knock-on effects. Local communities will derive direct recreational (e.g. fishing, boating, birding) and economic (e.g. subsistence fishing, tourism) benefits, while indirect value (e.g.. water purification) can also be derived The roll-out of this training programme will have significant influence on the sustainability of South Africa's estuaries and the social or economic benefit that can be derived

5.2 Impact Assessment

Broad-based impacts, such as access to water and sanitation services, are important to South African society, but they are typically difficult to quantify, hence this portion of the report will focus on more specific examples such as subsistence farming and related impacts.

Subsistence fisheries and farming are localized activities, and they involve very low values in terms of revenues, however these activities are important within the context of peoples'

livelihoods and overall wellbeing. In addition, South Africa's water resources present significant value in terms of recreational activities, but these can be difficult to quantify.



Subsistence Fisheries

Communities who live within the radius of a river system are likely to be affected by any change in the river's ecosystem. Rural communities located close to river systems are typically reliant on them for their livelihoods. Subsistence farming and fisheries are some of the benefits that people derive from river systems in South Africa. This has been an important tool to alleviate poverty among many rural communities that are located close to river systems.

Case Study: Ebenhauser Community Employment and Subsistence Fishing

Introduction

Research in the Olifants-Doring water management area revealed a strong link between the livelihoods of rural communities in this region and the areas water resources. Different communities within the region are reliant on the Olifants – Doring rivers in varying, but important, ways. Within the context of this case study, the estuarine portion of this catchment area supports approximately 200 households through subsistence fishing.

Impact Assessment

Research into different instream flow rates indicated that variation in flow will have a direct impact on the fish stocks in the estuary, which will have an impact on the wellbeing and nutritional security of fishing households in the Ebenhaesar community. Forty per cent of these households obtain more than 75.0 per cent of their income from fishing, and 64.0 per cent of households eat fish at most meals.

Conclusion

The careful management of the instream flow rates in the Olifants-Doring catchment will have a direct impact on the livelihoods of 200 households in Ebenhaesar. This case highlights the importance of the WRC's EWR research into the effective management of water resources. An insufficient knowledge base around the importance of maintaining specific instream flows would directly impact this community negatively.

Source: Brown (2006)

Raw Material Collection and Basket Manufacture

South African river systems are also an important source of raw material for rural communities. Reeds are harvested from nearby rivers and woven into baskets, mats, roofing material and other useful tools. The sale of these products can be an important source of income for women that reside in rural areas. Further, riparian vegetation provides building materials for rural communities.



An example of WRC research focused on riverine reed species includes :

- **Interaction of Reeds, Hydraulics and River Morphology, WRC Report No. 856/1/01**

Reeds were not the sole focus of the research project ; their relationship with river hydraulics and morphology were analysed in detail. Reedbed expansion and contraction, phenology and propagation modes and reed life history characteristics were some of the key areas that were focused on. The knowledge acquired through this research project, and similar projects, can be leveraged to manage reedbeds and raw materials effectively to ensure that communities can sustain their livelihoods.

The mismanagement of river systems could negatively impact the occurrence of raw materials, which would impact these rural communities negatively.

Recreational Activities

There is a strong link between the WRC's EWR research and recreational activities. South Africa's water resources are used for numerous recreational pursuits. Poor management of these resources would negatively impact the activities.

Case study: Recreational Facilities:

Dusi Canoe Marathon

Recreational use of water resources takes many forms. Some of the activities can however have direct impact on the water resource. Activities such as power-boating, sailing and swimming which can have pollution impacts on the resource. Far more significant in terms of both quantity and quality is the release of water to allow for canoeing and other water sports downstream. These activities can result in significant economic benefits to the water management area concerned. Where water releases can be accommodated, it is important to align it with the needs of the ecological Reserve or other downstream users.

Some of the rivers in South Africa have become sites of significant canoe races. These include the Fish, Berg, Crocodile rivers and several others in KwaZulu-Natal. The biggest race that has captured public interest is the Dusi Canoe Race. This race has attracted thousands of participants and has become a proving ground for top South African paddlers.

In order to stage the Dusi Canoe Marathon and the three related events the KwaZulu-Natal Canoe Union (KNCU) requires an assurance that the required flows will be granted. The combined value to the regional economy of the four races which depend upon the releases from the Inanda Dam is estimated by the KwaZulu Canoe Union at R41.4 million per annum. Tourism authorities have estimated the marketing value of the Dusi Canoe Marathon to the country at R120 million.

Since 1990, the Dusi Canoe Marathon cannot be staged without guaranteed water release from Inanda Dam. There are three lesser but related canoeing events in December, January and in February, which also require water releases from Inanda Dam. The KNCU submits a schedule of the desired water releases to the responsible authorities on an annual basis. The releases on which these races depend amount to 8.7 million cubic.

While these releases have been tolerated for the continuation of a high value recreational activity, they are in fact exactly aligned with the environmental flows that would be required if the Reserve had been determined. The releases for these events therefore have a dual effect, serving both environmental and recreational purposes at the same time.

Source: Still et al (2009)

Conclusion

There is a clear-cut link between the WRC's EWR research and impacts on South African society. Apart from the indirect impacts related to employment levels and water supply in the industrial sectors that were covered in the economic section of this report, there are also significant social impacts linked to subsistence farming and fishing.

Rural communities located near to water resources can be reliant on these systems for food and income. Poor management of the instream flows in these catchment areas could negatively impact these vulnerable communities.

Finally, numerous recreational activities derive benefit from South Africa's water resources. The Dusi canoe marathon would not operate if the instream flows were not carefully managed within the catchment, which could result in a significant loss of income for the region.

6. Health Impacts

6.1 Introduction

Water-linked diseases are commonplace throughout Africa and have significant health implications for those infected. Bilharzia and malaria are two serious illnesses that are linked to water and have major health impacts on South African society. Both of these diseases are reliant on invertebrate hosts that breed in aquatic habitats.

Recent research conducted in conjunction with the WRC has indicated that it may be possible to control water-linked diseases, such as bilharzia and malaria, by managing the instream flows of specific rivers where these diseases are prevalent.

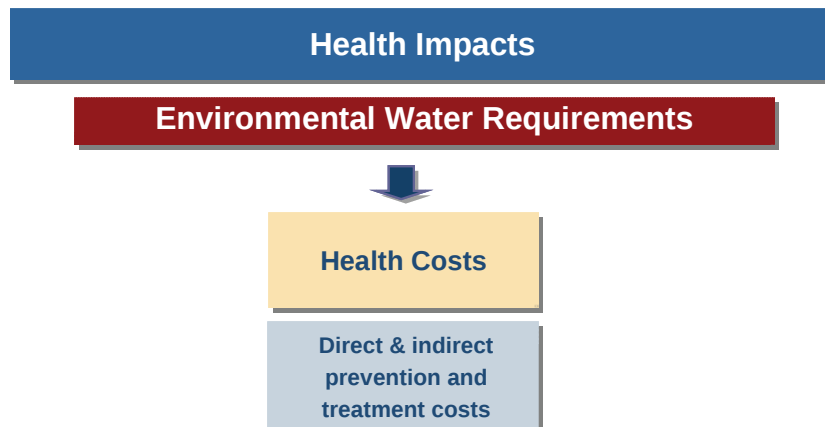
This section of the report will review the impact of the WRC's EWR research on health aspects of South African society, specifically focusing on the management of water-linked diseases through the manipulation of specific rivers' instream-flow requirements. The specific report that the WRC is busy compiling that will impact health aspects of South African society is titled:

Report	The Impact of River Flow Regulation and Manipulation on the Invertebrate Hosts of Malaria, Bilharzia and Liver Fluke Disease, WRC Report No. K5/1589
Overview	This report assessed the impact of different stream flows on the invertebrate hosts of three diseases namely Malaria, Bilharzia and Liver Fluke disease
Impact	The findings from this research provided important insight into the management of these diseases using river flow regulation. Malaria is a poor candidate for flow regulation, the results on Liver Fluke disease were inconclusive, but it was found that bilharzia is a prime candidate for river flow manipulation. Bilharzia is a chronic illness that can be very debilitating within poor communities. The effective management of the invertebrate host through river flow regulation could therefore have an important impact on the livelihoods and health of poor communities in South Africa

6.2 Impact Assessment

The quantification of health-related impacts can be difficult. A common approach focuses on collating costs associated with an illness. Health costs typically include both direct and indirect costs; the former including specific treatment regimes to cure the disease while the latter could include disease prevention programmes or a loss of income for a patient.

The water-borne diseases discussed below are reviewed in terms of both direct and indirect costs.



Water-related Disease Management with Instream Flow Rates

Introduction

Both malaria (Plasmodium) and bilharzia (Schistosomes) are parasitic diseases that rely on invertebrate hosts as a disease vector.

Malaria requires a mosquito of the genus Anopheles to fulfill an intermediate host role and pass the parasite onto a human who is the definitive host. Similarly, an aquatic snail transmits bilharzia. The Anopheles mosquito requires standing water (small pool) to breed, while the bilharzia snail can be found along the edges of streams and wetlands.



Findings from the research project, “The Impact of River Flow Regulation and Manipulation on the Invertebrate Hosts of Malaria, Bilharzia and Liver Fluke Disease,” which was conducted in collaboration with the WRC (WRC project K5/1589), indicate that it may be possible to manage these diseases through instream flow requirement manipulation. Numerous of South Africa’s major rivers are dammed, which would allow for the manipulation of the flow regime.

Before determining whether the alteration of a river’s flow regime will reduce the occurrence of bilharzia or malaria invertebrate hosts, it is important to review the impact of these diseases.

Disease costs

Limited research has been conducted on the economic cost of specific diseases, however a project completed in 1998 determined that malaria cost South Africa approximately R124.5 million in that year (Trend, undated, www.malaria.org/tren.html). This value includes costs attributed to malaria control programmes, treatment costs and loss of income. More recent data from 2006, which does not include prevention programme costs, quotes a figure of R140 million based on current infection rates (WRC Project K5/1589).

Estimating the cost of bilharzia is trickier as this disease is generally not well documented. However, approximately 2.5 million people are said to be infected with the disease at any one time in South Africa. Extrapolation of two localised projects conducted in the Crocodile and Lower Thukela catchments indicate that once-off treatment costs could equate to R363 million per annum and loss of productivity costs could be as much as R275 million per annum (WRC Project K5/1589).

Management of malaria and bilharzia with instream flow manipulation

The two species of *Anopheles* mosquito that transmit the disease in South Africa breed in different habitats. *Anopheles funestus* breed in the quite backwaters of rivers, while *Anopheles arabiensis* are opportunistic breeders choosing temporary pools of rainwater. The larval stage of the breeding cycle of both species is very short. The research conducted in conjunction with the WRC concluded that instream flow manipulation will not likely have any significant effect on the breeding habits of *Anopheles* mosquito.

The fresh water snails that transmit the bilharzia parasite prefer permanent and still or slow flowing water bodies. Variations in flow have a negative impact on the success of fresh water snail populations; hence a key finding from the research conducted is that by manipulating the flow rates within a river the occurrence of bilharzia can be reduced.

Conclusion

A key finding from this research is that the occurrence of bilharzia can be controlled by manipulating the instream flow rates of key rivers in South Africa. Bilharzia is found in the eastern parts of South Africa where prevalence rates have exceeded 80 per cent among children in the rural areas of eastern lowlands of Limpopo, Mpumalanga and Kwa-Zulu Natal. The costs associated with the treatment of the disease are significant, but equally critical is the loss of productivity and associated income.

As per these research findings, if flow management regimes are implemented effectively this could have a significant impact on the occurrence of bilharzia in South Africa, which will improve the livelihoods of the rural populations most impacted by this disease.

7. Conclusions

The importance of the WRC's EWR research has been highlighted in this report, however, the fact that EWR management principles have been incorporated in South Africa's legislation, alone, highlights the importance of this subject area.

As demand for water increases, allocation decisions are going to become increasingly challenging for managers. Without accurate data on the state of South Africa's water resources it would be near-impossible to make informed allocation decisions. The WRC's EWR research has made an important contribution to the various techniques around water resource analysis and classification in South Africa. These techniques have and are being used to help understand the environmental requirements or Ecological Reserve of South Africa's water resources. Once Basic Human Need and Ecological Reserve needs are understood, appropriate allocations can be made to economic water demands.

The WRC's EWR research has also had significant direct impacts on South African society. The adequate management of South Africa's water resources, as a result of WRC EWR research, ensures that sufficient water is available for economic, environmental social and health aspects of South African society. These impacts are far-reaching and range from direct, revenue generating influences to less obvious indirect impacts, such as job creation.

The continued implementation of key EWR management principles, as outlined by the WRC's research in this field, will ensure that South Africa's water resource Ecological Reserve requirements are met and consequently ensure that all aspects of South African society prosper.