

# South Africa's Water Research, Development, and Innovation (RDI) Roadmap: 2015-2025

Water Research Commission  
Department of Science and Technology  
Department of Water and Sanitation

WRC Report No. 2305/1/15

ISBN 978-1-4312-0683-4

July 2015



Science and Technology  
Water and Sanitation



**Obtainable from**

Water Research Commission  
Private Bag X03  
GEZINA, 0031

[orders@wrc.org.za](mailto:orders@wrc.org.za) or download from [www.wrc.org.za](http://www.wrc.org.za)

**DISCLAIMER**

This report has been reviewed by the Water Research Commission (WRC), Department of Science and Technology (DST), and Department of Water and Sanitation (DWS) and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the WRC, DST, or DWS, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

## EXECUTIVE SUMMARY

---

The National Water Research, Development, and Innovation (RDI) Roadmap provides a structured framework to focus the contribution of RDI activity to the implementation of national policy, strategy and planning in water resources management in South Africa. The vision of the roadmap is that South Africa is a leader among middle income countries in the development and deployment of water management practices and technologies. It competes with leading countries in providing sustainable solutions.

This has been achieved by means of a National Water Research, Development, and Deployment<sup>1</sup> (RDD) Programme focused on: delivery of at least one breakthrough technology every five years; increasing the number of small and medium sized enterprises operating in the water sector; increasing access to water for rural communities, including provision of sanitation for all in a sustainable manner. Together, this creates significant economic, health, social and environmental benefit.

The contribution of RDD to achieving the vision results from a focus on four key objectives: Increase the availability of water; improve the governance, planning and management of supply and delivery; enable water and sanitation services to operate as a sustainable “business” and increase the efficiency and productivity of water use.

The roadmap was developed through an exhaustive, structured process of eliciting staged responses from the professional community, reviewing the inputs, and assessing their implications.

The roadmapping process included participation, input, review, and revision from key stakeholders in industry, government and organisations within the National System of Innovation. The roadmap provides strategic direction, a set of action plans and an implementation framework to guide, plan, coordinate and manage South Africa’s portfolio investment for the next ten years in seven identified clusters of RDD activity. The investment aspiration and potential return on investment is also mapped out.

The result of this process is a set of seven plans which over the period 2015-2025 develop out pathways to progress from the 2015 situation to a much improved future state, by implementing interventions in research, development, testing, demonstration, and deployment of new technologies and know-how, and demonstration and deployment of emerging technologies.

The seven plans provide itemised, actionable tasks under the following headings:

1. Water supply
  - 1.1. Increase ability to make use of more sources of water, including alternatives
  - 1.2. Improve governance, planning and management of supply and delivery
  - 1.3. Improve adequacy and performance of supply infrastructure
  - 1.4. Run water as a financially sustainable “business” by improving operational performance
2. Water demand
  - 2.1. Improve governance, planning, and management of demand and use
  - 2.2. Reduce losses and increase efficiency of productive use
  - 2.3. Improve performance of pricing, monitoring, billing, metering and collection

Developing, strengthening and embedding South Africa’s water RDD capability and capacity within and between research institutions, academic institutions, industry and government, will enable faster and more effective deployment of context-appropriate technologies and create opportunities for the export of know-how and technology into the African continent and beyond.

This Water RDI Roadmap thus provides a set of Research, Development, and Deployment clusters (focal areas) and associated high level action plans to guide investments over a ten year period, and it also lays out an investment ambition to achieve these plans. This Roadmap is a high level planning tool that facilitates and guides refocusing of research, reprioritization of funds, synergising of existing initiatives and ring-fencing of new resources in order to facilitate a more optimal water innovation system.

---

<sup>1</sup> i.e. Deployment of innovative technologies and new know-how.

## ACKNOWLEDGEMENTS

---

The project team wishes to thank the following individuals for their contributions to the project.

### Reference Group

Ms R Mühlbauer	Anglo American Coal
Ms S Clark	BHP Billiton Energy Coal South Africa Ltd (BECSA)
Mr J Beukes	Coaltech
Dr L Godfrey	Council for Scientific and Industrial Research (CSIR)
Mr I Patel	Department of Science and Technology (DST)
Ms B Ting	Department of Science and Technology
Mr I Maredi	Department of Science and Technology
Mr R Sekwele	Department of Water and Sanitation (DWS)
Mr M Bannister	Department of Water and Sanitation
Mr G Gericke	Eskom
Mr S Moodliar	eThekweni Metropolitan Municipality
Mr M Padayachee	Rand Water
Prof J Maree	Tshwane University of Technology
Dr C Sheridan	University of the Witwatersrand
Mrs N Seetal	WADER
Dr S Mpandeli	Water Research Commission (WRC)
Mr B Madikizela	WRC
Mr C Moseki	WRC / DWS

### Other work session / workshop participants, without whom this roadmap would never have existed:

Agri SA	Limpopo Department of Agriculture
Agricultural Research Council (ARC)	Midvaal Water Company
Amatola Water	Mintails Ltd
Anglo American Coal	National Business Initiative
ARC-Institute for Soil, Climate and Water	National Planning Commission
BHP Billiton Energy Coal South Africa Ltd	Nelson Mandela Metropolitan Municipality
Biomimicry SA	NEPAD Business Foundation
Chamber of Mines	Nestlé
City of Cape Town	Rand Water
City of Johannesburg	SA Association for Water User Associations
City of Tshwane	SA Irrigation Institute
Coaltech	SAB Miller
Coca Cola South Africa	Sappi
Council for Scientific and Industrial Research	Sasol
Department of Agriculture, Forestry and Fisheries	South African Local Government Association
Department of Environmental Affairs	South African National Biodiversity Institute
Department of Science and Technology	South African Weather Services (SAWS)
Department of Water and Sanitation	Stellenbosch University
East Rand Water Care Company	Strategic Water Partners Network (SWPN)
EON Consulting	Trans Caledon Tunnel Authority (TCTA)
Eskom-Mining	Tshwane University of Technology
Eskom-Research & Development	Umgeni Water
Eskom-Technology, Strategy, and Research Management	Umhlaba Consulting Group
Eskom-Water Resources	University of Pretoria
eThekweni Municipality	University of the Witwatersrand
Exxaro	Water Technologies Demonstration Programme (WADER)
Federation for a Sustainable Environment	Water Institute of Southern Africa (WISA)
Golder Associates (Pty) Ltd	Water Research Commission (WRC)
Grain SA	Western Cape Department of Agriculture
Johannesburg Water	Wildlife and Environment Society of South Africa
Land Rehabilitation Society of South Africa	Worldwide Fund for Nature SA

# CONTENTS

EXECUTIVE SUMMARY .....	i
ACKNOWLEDGEMENTS.....	ii
CONTENTS .....	iii
LIST OF FIGURES .....	vi
LIST OF TABLES .....	viii
ACRONYMS & ABBREVIATIONS .....	ix
GLOSSARY .....	x
REPORT ARCHITECTURE .....	xii
<b>CHAPTER 1: CONTEXT .....</b>	<b>1</b>
<b>CHAPTER 2: SOUTH AFRICA'S WATER RDI ROADMAP: 2015-2025.....</b>	<b>5</b>
2.1 STRUCTURE OF THE ROADMAP .....	5
2.2 INCREASE ABILITY TO MAKE USE OF MORE SOURCES OF WATER, INCLUDING ALTERNATIVES .....	6
2.2.1 Cluster definition, scope, and research initiatives.....	6
2.2.1.1 Sector Objective .....	6
2.2.1.2 Target RDD Outcome for 2025.....	6
2.2.1.3 Research Initiatives .....	6
2.2.2 RDD Response: Sources.....	7
2.2.3 RDD Impact: Sources .....	8
2.2.4 Strategic RDD Programme: Sources.....	9
2.2.5 HCD Outline Plans per research initiative (Cluster: Sources) .....	10
2.2.5.1 Needs .....	10
2.2.5.2 Potential.....	12
2.2.5.3 Enablers.....	14
2.3 IMPROVE GOVERNANCE, PLANNING AND MANAGEMENT OF SUPPLY AND DELIVERY.....	16
2.3.1 Cluster definition, scope, and research initiatives.....	16
2.3.1.1 Sector Objective .....	16
2.3.1.2 Target RDD Outcome for 2025.....	16
2.3.1.3 Research Initiatives .....	16
2.3.2 RDD Response: Governance, planning and management of supply .....	17
2.3.3 RDD Impact: Governance, planning and management of supply .....	18
2.3.4 Strategic RDD Programme: Governance, planning and management of supply .....	19
2.3.5 HCD Outline Plans: Governance, planning and management of supply.....	20
2.3.5.1 Required research capacity: Governance, planning and management of supply.....	20
2.3.5.2 Current research capacity per research initiative within Cluster: Governance, planning and management of supply .....	21
2.4 IMPROVE ADEQUACY AND PERFORMANCE OF SUPPLY INFRASTRUCTURE.....	23
2.4.1 Cluster definition, scope, and research initiatives.....	23
2.4.1.1 Sector Objective .....	23
2.4.1.2 Target RDD Outcome for 2025.....	23
2.4.1.3 Research Initiatives .....	23
2.4.2 RDD Response: Infrastructure.....	24
2.4.3 RDD Impact: Infrastructure .....	25
2.4.4 Strategic RDD Programme: Infrastructure.....	26
2.4.5 HCD Outline Plans per research initiative: Infrastructure .....	27
2.4.5.1 Ecological Infrastructure (Infrastructure) .....	27
2.4.5.2 Built Infrastructure (Infrastructure).....	29
2.5 RUN WATER AS A FINANCIALLY SUSTAINABLE “BUSINESS” BY IMPROVING OPERATIONAL PERFORMANCE.....	31
2.5.1 Cluster definition, scope, and research initiatives.....	31
2.5.1.1 Sector Objective .....	31

2.5.1.2	Target RDD Outcome for 2025.....	31
2.5.1.3	Research Initiatives .....	31
2.5.2	RDD Response: Operational performance .....	32
2.5.3	RDD Impact: Operational performance .....	33
2.5.4	Strategic RDD Programme: Operational performance .....	34
2.5.5	HCD Outline Plans: Operational performance.....	35
2.6	IMPROVE GOVERNANCE, PLANNING, AND MANAGEMENT OF DEMAND AND USE.....	36
2.6.1	Cluster definition, scope, and research initiatives.....	36
2.6.1.1	Sector Objective .....	36
2.6.1.2	Target RDD Outcome for 2025.....	36
2.6.1.3	Research Initiatives .....	36
2.6.2	RDD Response: Governance, Planning, and Management of Demand .....	37
2.6.3	RDD Impact: Governance, Planning, and Management of Demand.....	38
2.6.4	Strategic RDD Programme: Governance, Planning, and Management of Demand .....	39
2.6.5	HCD Outline Plans per research initiative: Governance, Planning, and Management of Demand.....	40
2.6.5.1	Governance (Demand) .....	40
2.6.5.2	Planning and Management (Demand) .....	41
2.7	REDUCE LOSSES AND INCREASE EFFICIENCY OF PRODUCTIVE USE .....	43
2.7.1	Cluster definition, scope, and research initiatives.....	43
2.7.1.1	Sector Objective .....	43
2.7.1.2	Target RDD Outcome for 2025.....	43
2.7.1.3	Research Initiatives .....	43
2.7.2	RDD Response: Productive use .....	44
2.7.3	RDD Impact: Productive use.....	45
2.7.4	Strategic RDD Programme: Productive use .....	46
2.7.5	HCD Outline Plans per research initiative: Productive use .....	47
2.7.5.1	Technical Loss.....	47
2.7.5.2	Deliberate Demand.....	49
2.8	IMPROVE PERFORMANCE OF PRICING, MONITORING, BILLING, METERING AND COLLECTION .....	51
2.8.1	Cluster definition, scope, and research initiatives.....	51
2.8.1.1	Sector Objective .....	51
2.8.1.2	Target RDD Outcome for 2025.....	51
2.8.1.3	Research Initiatives .....	51
2.8.2	RDD Response: Pricing, Monitoring, Billing .....	52
2.8.3	RDD Impact: Pricing, Monitoring, Billing.....	53
2.8.4	Strategic RDD Programme: Pricing, Monitoring, Billing .....	54
2.8.5	HCD Outline Plans per research initiative: Pricing, Monitoring, Billing.....	55
2.8.5.1	Cost .....	55
2.8.5.2	Volume.....	56
	<b>CHAPTER 3: RETURNS AND INVESTMENTS .....</b>	<b>57</b>
3.1	ANTICIPATED RETURNS ON INVESTMENT .....	57
3.2	INVESTMENT REQUIREMENTS.....	61
	<b>CHAPTER 4: APPROACH AND PARTICIPATION .....</b>	<b>64</b>
4.1	WHAT DO CUSTOMERS WANT? .....	64
4.1.1	Identify customer needs.....	64
4.1.2	Review needs, and articulate interventions .....	64
4.1.3	Confirm clusters of needs and interventions.....	66
4.1.4	Define Sector Performance Measures.....	71
4.2	SOUTH AFRICA'S RDD RESPONSE .....	73
4.2.1	Articulate and assess RDD Potential.....	73
4.2.2	Research capability mapping.....	77
4.2.3	Articulate strategic intent.....	81
4.2.4	Define RDD Programmes .....	82
4.2.5	Anticipate Programme Impact.....	82
4.3	SETTING UP TO DELIVER SUCCESS .....	83

4.3.1	Quantify impact and investment.....	84
4.3.2	Design implementation framework.....	84
APPENDIX A:	WORK SESSION DATA .....	86
APPENDIX B:	ATTRACTIVENESS OF RDD OPPORTUNITIES ACCORDING TO EACH SECTOR, PER CLUSTER.....	97
APPENDIX C:	RESEARCH FOCUS AREAS AND THEIR UNDERLYING DISCIPLINES, MAPPED TO THE SEVEN CLUSTERS OF NEEDS AND INTERVENTIONS .....	104
APPENDIX D:	DEGREE OF DIFFUSION IN RESEARCH FOCUS AREAS, CATEGORISED BY CLUSTER AND SECTOR.....	114
APPENDIX E:	LEVEL OF RESEARCH STRENGTH OF INSTITUTES, CATEGORISED BY CLUSTER AND SECTOR .....	116
APPENDIX F:	IMPACT ANTICIPATED, BASED ON FIVE IMPACT AREAS – SUMMARY .....	118
APPENDIX G:	NATIONAL RESEARCH FOUNDATION VALUES FOR RESEARCH HUMAN CAPACITY ..	121

## LIST OF FIGURES

Figure 1: Organogram of this report .....	xii
Figure 2: Structure and overview of the response for each Cluster .....	5
Figure 3: Research Capacity required each year to carry out RDD Programme, for the Research Initiative “Needs” within the Sources Cluster.....	10
Figure 4: Research Capacity required each year to carry out RDD Programme, for the Research Initiative “Potential” within the Sources Cluster .....	12
Figure 5: Research Capacity required each year to carry out RDD Programme, for the Research Initiative “Enablers” within the Sources Cluster.....	14
Figure 6: Research Capacity required each year to carry out RDD Programme, for the two Research Initiatives “Governance” and “Planning and Management” within the Governance, Planning and Management of Supply Cluster .....	20
Figure 7: Research Capacity required each year to carry out RDD Programme, for the Research Initiative “Ecological Infrastructure” within the Infrastructure Cluster .....	27
Figure 8: Research Capacity required each year to carry out RDD Programme, for the Research Initiative “Built Infrastructure” and “Planning and Management” within the Infrastructure Cluster .....	29
Figure 9: Research Capacity required each year to carry out RDD Programme, for the Operational Performance Cluster .....	35
Figure 10: Research Capacity required each year to carry out RDD Programme, for “Governance” in the Cluster, Governance, Planning, and Management of Demand .....	40
Figure 11: Research Capacity required each year to carry out RDD Programme, for “Planning and Management” in the Cluster, Governance, Planning, and Management of Demand .....	41
Figure 12: Research Capacity required each year to carry out RDD Programme, for “Technical Loss” in the Cluster, Productive Use .....	47
Figure 13: Research Capacity required each year to carry out RDD Programme, for “Technical Loss” in the Cluster, Productive Use .....	49
Figure 14: Research Capacity required each year to carry out RDD Programme, for “Cost” in the Cluster, Price, Monitor, Bill .....	55
Figure 15: Research Capacity required each year to carry out RDD Programme, for “Volume” in the Cluster, Price, Monitor, Bill .....	56
Figure 16: Overview of the investment focus and returns .....	57
Figure 17: Number of additional people entering water-related SET research via the ten year RDI programme, categorised by research seniority .....	59
Figure 18: Investment requirement per year, by cluster, in ZARm.....	61
Figure 19: Total investment requirement, proportion of investment per Cluster .....	61
Figure 20: Investment requirement per year, by investment instrument, in ZARm.....	62
Figure 21: Total investment requirement, proportion of investment per instrument.....	62
Figure 22: Funding by source as % of investment requirement, by year .....	63
Figure 23: Funding by source in total, over ten years in R million (left) and as proportion of total investment requirement (right).....	63
Figure 24: Flow chart of the approach and methodology of the road mapping process .....	65
Figure 26: Evaluation Framework for RDD Potential .....	74
Figure 25: RDD Potential by Nature and Stage in the innovation chain, expressed in % of needs per cluster, all sectors .....	75
Figure 27: Mapping of capacity in underlying science (RFA) required to conduct research for the Cluster: Operational Performance. An RFA in red indicates no capacity identified at academic units or in research institutions. ....	80
Figure 28: Readiness to do Research™ framework.....	80
Figure B1: Increase ability to make use of more sources of water, including alternatives.....	97

Figure B2: Improve governance, planning and management of supply and delivery .....	98
Figure B3: Improve adequacy and performance of supply infrastructure .....	99
Figure B4: Run water as a financially sustainable “business” by improving operational performance .....	100
Figure B5: Improve governance, planning, and management of demand and use .....	101
Figure B6: Reduce losses and increase efficiency of productive use .....	102
Figure B7: Improve performance of pricing, monitoring, billing, metering and collection.....	103
Figure D1: Degree of diffusion in water supply Clusters .....	114
Figure D2: Degree of diffusion in water demand Clusters.....	115
Figure E1: Level of strength in water supply Clusters .....	116
Figure E2: Level of strength in water demand Clusters .....	117

## LIST OF TABLES

Table 1: Mapping of capacity in underlying science (RFA) required to conduct research into “Needs” .....	11
Table 2: Mapping of capacity in underlying science (RFA) required to conduct research into “Potential” .....	13
Table 3: Mapping of capacity in underlying science (RFA) required to conduct research into “Enablers” .....	15
Table 4: Mapping of capacity in underlying science (RFA) required to conduct research into “Governance” (Supply) .....	21
Table 5: Mapping of capacity in underlying science (RFA) required to conduct research into “Planning and Management (Supply)” .....	22
Table 6: Mapping of capacity in underlying science (RFA) required to conduct research into “Ecological Infrastructure” .....	28
Table 7: Mapping of capacity in underlying science (RFA) required to conduct research into “Built Infrastructure” .....	30
Table 8: Mapping of capacity in underlying science (RFA) required to conduct research into “Operational Performance” .....	35
Table 9: Mapping of capacity in underlying science (RFA) required to conduct research into “Governance”	40
Table 10: Mapping of capacity in underlying science (RFA) required to conduct research into “Planning” .....	41
Table 11: Mapping of capacity in underlying science (RFA) required to conduct research into “Management” .....	42
Table 12: Mapping of capacity in underlying science (RFA) required to conduct research into “Technical Loss” .....	48
Table 13: Mapping of capacity in underlying science (RFA) required to conduct research into “Technical Loss” .....	50
Table 14: Mapping of capacity in underlying science (RFA) required to conduct research into “Cost” .....	55
Table 15: Mapping of capacity in underlying science (RFA) required to conduct research into “Volume” .....	56
Table 16: Anticipated RDD Outputs, by Objective and Indicator .....	58
Table 17: RDD Productivity Assumptions .....	58
Table 18: Significant Impact anticipated on five dimensions – Summary .....	60
Table 19: Clustered needs identified by the four sectors, and their summarised interventions .....	66
Table 20: Example Performance Measures created by the water community .....	71
Table 21: Sector Objectives and Performance Measures .....	72
Table 22: Taxonomy of Research Focus Areas (RFAs) .....	77
Table 23: Numbers of different research group members found in average Small, Medium, and Large Research Groups defined according groups described in WRC proposals received from 2009 to 2014 .....	84
Table 24: Total investment plan for the Water RDI Roadmap .....	85
Table A1: Statements of need (unabridged) and interventions provided during work sessions with the four sectors of the water community. ....	86
Table A2: Statements of need grouped into clusters, indicating which sectors expressed which needs. ....	92
Table A3: Assessment of RDD potential according to the stage and nature of each identified opportunity. ..	93
Table A4: Assessment of RDD Performance Measures according to the seven Clusters of Needs, Interventions, and RDD Potential .....	95
Table F1: Impact assessment: Water Scarcity .....	118
Table F2: Impact assessment: Economic .....	119
Table F3: Impact assessment: Health .....	119
Table F4: Impact assessment: Society .....	120
Table F5: Impact assessment: Society .....	120

## **ACRONYMS & ABBREVIATIONS**

---

ARC	Agricultural Research Council
ASSAf	Academy of Science of South Africa
CoC	Centre of Competence
CoE	Centre of Excellence
CSIR	Council for Scientific and Industrial Research
DAFF	Department of Agriculture, Forestry and Fisheries
DHS	Department of Human Settlements
DoH	Department of Health
DST	Department of Science and Technology
DWS	Department of Water and Sanitation
HCD	Human Capacity Development, or Human Capital Development
HEI	Higher Education Institute
KG	Knowledge generation
M&E	Monitoring and evaluation
NBI	National Business Initiative
NEPAD	The New Partnership for Africa's Development
NGO	Non-government organisation
NIPMO	National Intellectual Property Management Office
NPC	National Planning Commission
NRF	National Research Foundation
NSI	National System of Innovation
NWRS2	National Water Resources Strategy 2
PSP	Professional service centre
R&D	Research and development
RDD	Research, development, and deployment
RDI	Research, development, and innovation
RFA	Research focus area
RP	Research programme
SALGA	South African Local Government Association
SANBI	South African National Biodiversity Institute
SAWS	South African Weather Services
SET	Science, engineering, and technology
SOE	State-owned enterprise
SWPN	Strategic Water Partners Network
TAC	Technical assistance centre
TCTA	Trans Caledon Tunnel Authority
TIA	Technology Innovation Agency
TRP	Targeted research programme
WADER	Water Technologies Demonstration Programme
WCDM	Water conservation and demand management
WDCS	Waste discharge charge system
WESSA	Wildlife and Environment Society of South Africa
WHO	World Health Organization
WRC	Water Research Commission
WUA	Water Users' Association
WUE	Water use efficiency
WWF-SA	Worldwide Fund for Nature South Africa

## GLOSSARY

Centre of Competence	Pre-commercialisation instrument positioned downstream in the NSI of a CoE, and immediately before commercialisation.
Centre of Excellence	CoEs are physical or virtual centres of research that concentrate existing research excellence and capacity and resources to enable researchers to collaborate across disciplines and institutions on long-term projects that are locally relevant and internationally competitive in order to enhance the pursuit of research excellence and capacity development.
Cluster definition	A definition of the Cluster with its constituent Research Initiatives, together with the associated water sector objective and RDD Outcome for 2025, in support of the Cluster objective.
Customer and Partner Relationship Management	Recognises that the need to engage with customers, partner and investors – to engage, understand needs, secure buy-in, participation and commitment to collaborate, invest or commercialise requires explicit resource that is other, or incremental to those that are principally involved in conducting research itself. This may require a dedicated function, such as a desk
Customer needs	Statements of need expressed by ‘Customers’, who in this context were members of the water community of professionals, which were divided into four sectors: Agriculture, Industry, The public sector, and Environmental protection.
HCD Outline Plan	A summary of the research capacity required for each Cluster – at the level of Research Initiative – as well as the current level of competence in the associated Research Focus Areas (RFAs). This indicates the potential for realisation of the intended RDD Programme. It also provides a basis for more detailed investigation of requirements for HCD interventions.
Human Capacity Development, or Human Capital Development (HCD)	Honours and graduate students (not Masters or PhDs) supported as part of building a pipeline of RDI Capacity. In the investment model, masters and doctoral studies are catered for under Research Capacity because these students contribute to research activity as part of Research Groups. Investment is also required in the Bachelors and Honours part of the pipeline. This is provided for in the HCD component of the Investment Model.
Impact Assessment Framework	The Impact Assessment Framework used required assessment of anticipated impacts in a set of nine sub-areas in five broad areas: <i>Water Scarcity, Economic, Health, Society, and Environment</i> .
Interventions	Actions required or corrective measures that can be taken to satisfy a need, without prescribing a solution in terms of how, or when, such action could be taken.
Knowledge Diffusion	The extent to which knowledge about a specified topic has diffused from research into practice. The degree of KD is estimated on a scale of 0 (initial research, no implementation), through field testing and pockets of implementation, to 5 (research translated into full adoption).
Professional Service Centre (PSC)	A PSC is a market-facing unit that delivers services or technical offerings to a defined set of customers, on a commercial basis (though not necessarily as a for-profit enterprise).
RDD Impact	A high level summary of the potential impact anticipated, based on successful performance of the RDD Programme, in relation to five areas defined in the Impact Assessment Framework.
RDD Opportunity	An identified set of actions which would allow RDD activity to provide for interventions to satisfy needs.

*Water Research, Development, and Innovation Roadmap*

RDD Outcome	Describes our ambition, i.e. what – ideally – will have been achieved at the successful conclusion of the Programme.
RDD Potential	The potential that resides in South Africa to undertake RDI and RDD activity, as a product of current research capability and strength, and existence of opportunities.
RDD Programme	Defined in immediate, short-, medium-, and long-term timeframes. The <u>immediate</u> phase is typically time-limited to one year in which to explore and further clarify the RDD Opportunity and plan an appropriate research response.
RDD Response	A high level summary of the planned RDD Programme planned for each Cluster based on identified Customer Needs and the opportunity to develop and deploy solutions in satisfaction of such needs through R&D.
RDI / RDD Objective	RDD Objectives distil and summarise the Needs and Interventions documented. Sets out at a high level the ambition and focus of the RDI Programmes that underpin the contribution of RDI to achievement of the vision.
RDI Infrastructure	Facilities and equipment required to perform RDI activity
RDI Success Factor	Success Factors are things that are required to enable achievement of the RDD Objectives.
Research Capacity	Research Groups, whether at a particular location or in the form of a distributed network, including masters and doctoral students that are associated with, and supervised by this Research Capacity. Capacity Outline Plan: forward needs summarised.
Research Chair	Research Chairs may be publicly or privately funded. They are held by a university in partnership with a private partner or a public research institution. The main goal of Research Chairs is to strengthen and improve research and innovation capacity of public universities for producing high quality postgraduate students and research and innovation outputs. The South African Research Chairs Initiative (SARChI) is designed to attract and retain excellence in research and innovation at South African public universities through the establishment of Research Chairs at public universities in South Africa with a long-term investment trajectory of up to fifteen years.
Research Focus Area	Areas of research expertise were defined both by the underlying academic discipline (e.g. microbiology) and the research focus area (RFA), or area of interest (e.g. potable water quality). The full list of RFAs is shown in Appendix C.
Research Strength	The number of people active in an RFA, with recognition of their length experience and depth and breadth of their capabilities. Research Strength is gauged on a scale of 1 to 8. The ideal situation is one in which 20% of research groups in a certain focus area are below level, 50% at levels 5-6, and 30% at level 7 or 8.
Sector Objective	The Target Objective for a sector.
Seeding	Covers investments made at the Exploratory Phase, as well as investment to enable a change in state in the course of the overall timeframe
Target Objective	The Target Objective sets out an intended end-state, in terms of a capabilities, products, and state of commercialisation for these key areas or contribution.
Targeted Research Programme (TRP)	A Research Programme (RP) designed specifically to satisfy a particular Need or Cluster of Needs.
Technology Development	Human resource investments associated with the development of technology (and service) components, platforms, systems, process improvements

# REPORT ARCHITECTURE

This report does not present the roadmap in chronological order.

It contains the ten year roadmap for water research, development, and innovation (RDI) itself, in Chapter 2, and additionally contains the rationale (Chapter 1), the level of investment in water RDI required to carry out the plans set out in Chapter 2 (Chapter 3), and finally an explanation of the methodology used to create the roadmap (Chapter 4).

The diagram below depicts the architecture of the document.

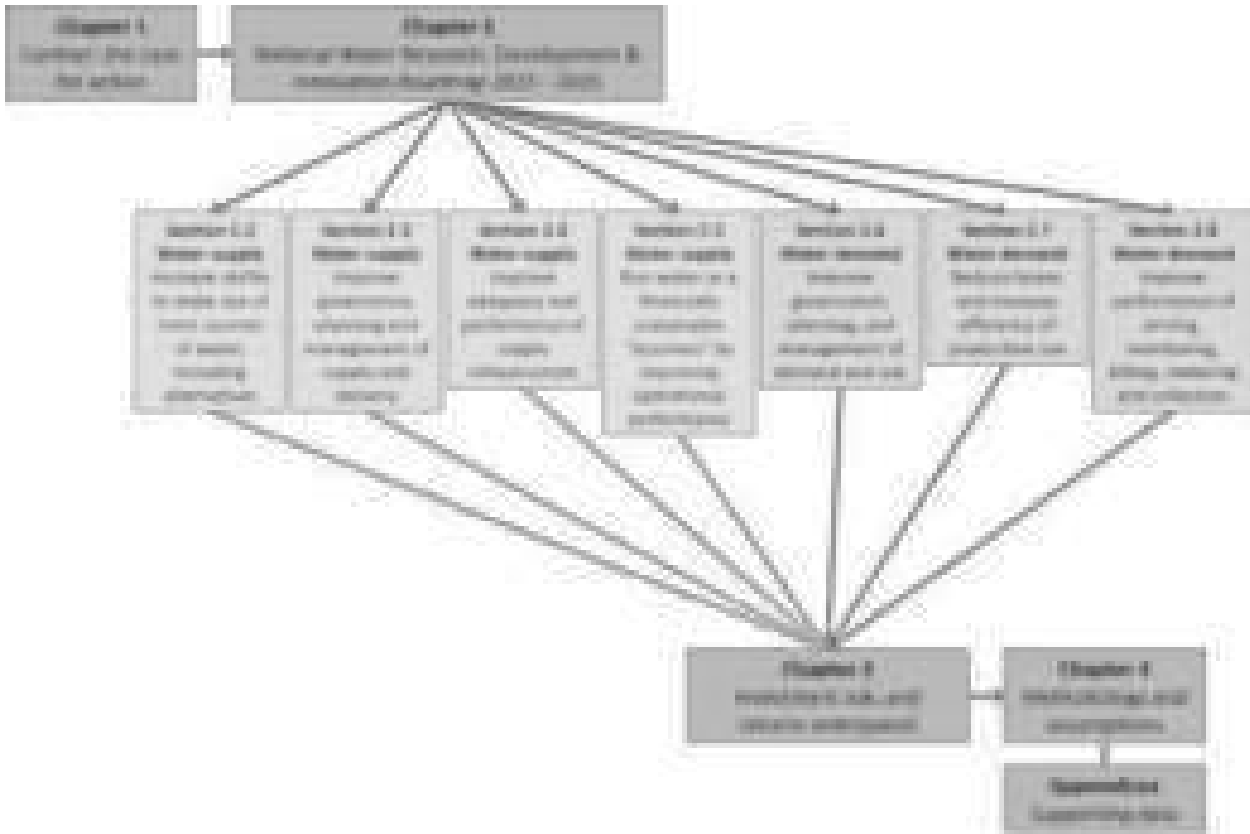


Figure 1: Organogram of this report

## CHAPTER 1: CONTEXT

---

### 1.1 CONTEXT

The context within which the RDI roadmap was created is one of increasing water scarcity. Numerous international bodies, including the Water Resources Group 2030 (WRG2030), and the World Economic Forum (WEF) have identified water as a priority concern.

For four years, WEF Global Risk Reports have identified water as one of the three most important challenges worldwide; in 2015, for the first time, it has moved to the top, as the biggest societal and economic risk for the next ten years (WEF, 2015)<sup>2</sup>. The report assesses risks that are global in nature and have the potential to cause significant negative impact across entire countries and industries.

Risks from water overuse and shortage, poor water infrastructure and management came out on top – not as future problems outlined by models and simulations, but as facts today which are rapidly worsening.

Water is key for life, central to societal development. Water risks affect industrialised and developing economies alike; repercussions of its overuse and increasing shortage are multiple and complex, widespread and severe.

**Water for people:** according to the World Health Organization (WHO) there are still more than 700 million people without access to so-called 'improved' water – here the trend is positive: the proportion of the world's population with access to improved drinking water sources increased from 76% to 89% globally between 1990 and 2012. But 'improved' is by no means 'safe'. An article by Gérard Payen, former chairman of Aquafed and Member of the United Nations Secretary General's Advisory Board on Water and Sanitation, states that close to 2 billion people use water that is unsafe and dangerous for their health, while 3.4 billion people use water of doubtful quality, at least from time to time. And these problems are getting worse, due to insufficient investment in water infrastructure, in low income, middle income, and high income economies.

**Water for food:** WEF (2015) reported seeing the first problems in regions where natural buffers have been exhausted in times of normal rainfall. The public and the media tend to see natural drought as the problem, but droughts come and go. The real problem is that we destroyed the 'natural' safety nets by overusing groundwater. So without a change in the way we use water, the global growth in population and prosperity are rapidly leading us into massive shortfalls in global cereal production.

In the past water was mostly abundant – at least up until the 1990s – so we have forgotten how important it is for **socioeconomic growth**. Some occasions in India, South Africa, and the USA when power generation in thermal plants had to be slowed down because of lack of cooling water may be interpreted as early signs for more widespread problems ahead.

There is a **transboundary**, and increasingly geopolitical dimension, e.g., in the Crocodile and Orange, to mention but two cross-border basins.

**Water for the environment:** this is about urgently needed wetlands, about biodiversity. But drying rivers also destroy human livelihoods, and sinking groundwater tables threaten human settlements.

Based on rising population, economic growth projections, scarcity of resources as well as current use and efficiency levels, South Africa will demand 17% more water than exists by 2030. The net deficit between supply and demand could grow to between 2.7 and 3.8 billion m<sup>3</sup>. In addition, it is crucial to recognise that South Africa's water supplies are already almost fully allocated. This means that new businesses and industries will find it increasingly difficult to access water licenses, particularly in more overdrawn catchments. Also, where licenses are allocated, increasing strain will be placed on the natural systems to produce a good quality and quantities of water.

This reality places renewed emphasis on the need for innovative solutions, technologies and processes as well as highly skilled individuals that will be able to rise to the challenge of navigating these complexities going into the future. It is this area of innovation and associated skills needs that the Water RDD Roadmap responds to.

---

<sup>2</sup> WEF (2015) *Global Risks 2015*. <http://reports.weforum.org/global-risks-2015/> (Accessed 12 February 2015)

## 1.2 ALIGNMENT WITH NATIONAL AND INTERNATIONAL STRATEGIC OBJECTIVES

The list below was developed in collaboration by all three of the WRC, DST, and DWS. The DWS paid particular attention to the alignment of the Roadmap with their strategies, especially with the National Water Resources Strategy 2. The Water RDI Roadmap will serve as the basis for the implementation of the NWRS2, especially Chapter 14 (Research and Innovation) and Chapter 15 (Water Sector Skills and Capacity).

The list provides, from left to right, the name of the national initiatives with which the RDD Programmes presented in Chapter 2 of the Roadmap align, the objectives which are shared by the named national initiatives and the RDI Roadmap, and finally the sections of the Roadmap which are aligned with the named national initiatives.

National initiative(s)	Strategic objectives of national initiatives and RDI Roadmap	Roadmap contribution to national initiatives
Outcome 2 (Job creation) Outcome 4 (Employment) Outcome 12 (Public service) New Growth Path	<ul style="list-style-type: none"> <li>Improve and increase the skills pool and build competencies in the DWS and within the sector</li> <li>To articulate the need for aligned qualifications development with DHET and EWSETA and build into RDD programmes</li> </ul>	<ul style="list-style-type: none"> <li>To maintain a minimum number of students supported in water research</li> <li>To enhance human capital development by supporting SMMEs in Water R&amp;D domain</li> <li>Knowledge dissemination and training will form part of the functions of the PSPs and TACs within the RDD programmes</li> </ul>
National Water Resources Strategy (NWRS2) Chapter 14, Chapter 9 (9.4.3), and Chapter 6 (6.4.3)	<ul style="list-style-type: none"> <li>Implement programmes that create job opportunities</li> </ul>	<ul style="list-style-type: none"> <li>To facilitate positive relationships with communities through active community participation in RDI</li> <li>To maintain the minimum number of students supported in water R&amp;D</li> </ul>
DST Grand Challenges: Adapting the Way We Live and Innovation for Sustainability NWRS2 Chapter 4: 4.1.4 – reconciliation strategy, 4.1.2 – urban development, 4.1.6 job creation	<ul style="list-style-type: none"> <li>Improve water resources and water services information</li> </ul>	<ul style="list-style-type: none"> <li>To increase water knowledge by initiating new R&amp;D</li> <li>To provide the country with supportive knowledge via completed projects</li> <li>To improve knowledge</li> <li>To promote the uptake and communication of research in the form of manuals, guidelines, and other supporting materials</li> <li>To engage the sector in knowledge-sharing events</li> </ul>
Provision of equitable and sustainable water services of acceptable quantity and quality	<ul style="list-style-type: none"> <li>Ensure effective performance of water management and services institutions</li> </ul>	<ul style="list-style-type: none"> <li>Provision of PSCs and TAC will support performance of WSAs and WSPs</li> </ul>
Constitutional right to Free Basic Water	<ul style="list-style-type: none"> <li>Ensure the availability of/access to water supply for environmental and socio-economic use</li> </ul>	<ul style="list-style-type: none"> <li>To increase water knowledge by initiating new R&amp;D that addresses the identified knowledge gaps</li> <li>To provide the country with supportive knowledge via completed RDI</li> <li>To improve knowledge dissemination</li> <li>To promote the uptake and communication of R&amp;D in the form of manuals, guidelines, and other supporting materials</li> <li>To engage the sector in D&amp;I via knowledge-sharing events through public dialogues and workshops</li> </ul>
NWRS2 Chapter 7: 7.4.3, Chapter 8: 8.6, and Chapter 9: 9.4.8	<ul style="list-style-type: none"> <li>Appropriate tariffs and effective economic regulation</li> </ul>	<ul style="list-style-type: none"> <li>The Price. Monitor. Bill. cluster provides for determination and review of pricing and tariffing best practices.</li> </ul>
NWRS Chapter 8: 8.5.2 NWRS2 Chapter 9: 9.4.9	<ul style="list-style-type: none"> <li>Regulatory coordination</li> <li>Coordinate regional and global water research cooperation</li> <li>Correct planning and management of resources and revenues</li> </ul>	<ul style="list-style-type: none"> <li>Through the Governance, Planning, and Demand clusters, enhance the relevance of South African water research locally and globally by coordinating strategic local and international partnerships, knowledge-sharing agreements or partnership agreements with knowledge-sharing institutions</li> </ul>

National initiative(s)	Strategic objectives of national initiatives and RDI Roadmap	Roadmap contribution to national initiatives
<p>Equitable and sustainable provisioning of raw water</p> <p>Outcome 2 (Job creation)</p> <p>Outcome 6 (Infrastructure)</p> <p>NWRS Chapter 7</p> <p>New Growth Path</p> <p>National Development Plan (NDP)</p>	<ul style="list-style-type: none"> <li>• Improve equity and efficiency in water allocation</li> <li>• Strengthen and implement strategies for water management</li> <li>• Improve water use efficiency</li> <li>• Achieve an efficient, competitive and responsive economic infrastructure network</li> </ul>	<ul style="list-style-type: none"> <li>• TRPs leading to RDI successes in the governance, planning and management of water allocation, and in productive use of water</li> <li>• TRP to support water availability by finding solutions to problems related to bulk water supply and assisting the development of appropriate regulations regarding water quantity, quality, and usage</li> </ul>
<p>Outcome 9 (Local government)</p> <p>DST Grand Challenge: Water Security for South Africa (Adapting the Way We Live)</p>	<ul style="list-style-type: none"> <li>• Support the water sector</li> </ul>	<ul style="list-style-type: none"> <li>• To improve the dissemination of water R&amp;D products</li> </ul>
<p>Protection of freshwater ecosystems ( 5.4.5 and 5.4.9)</p> <p>NWRS2 Chapter 5 (5.4.1)</p> <p>Outcome 10 (Environment)</p> <p>DST Grand Challenge: Conserving Biodiversity and Ecosystem Services (Reducing the Human Footprint)</p>	<ul style="list-style-type: none"> <li>• Improve the protection of water resources and ensure their sustainability</li> <li>• Achieve protection and enhancement of the country's environmental assets and natural resources</li> </ul>	<ul style="list-style-type: none"> <li>• The Water RDI roadmap supports this outcome through research aiming to improve basic services, with special emphasis on delivery of water and sanitation services</li> </ul>
<p>NWRS2 Chapter 15</p> <p>National Skills Development Strategy</p> <p>NWRS2 Chapter 7: 7.4.8 and 7.4.9</p>	<ul style="list-style-type: none"> <li>• Stakeholder mapping</li> <li>• Strengthen linkages between research organisations</li> <li>• Increase water services-relevant offerings at HEIs, including undergraduate pipeline</li> </ul>	<ul style="list-style-type: none"> <li>• Research focus area capability mapping</li> <li>• To increase water knowledge by initiating new research</li> <li>• To provide the country with supportive knowledge via completed R&amp;D, from fundamental research, through applied research, to demonstration via WADER, to implementation</li> <li>• To improve knowledge dissemination</li> </ul>
<p>National Desalination Strategy</p> <p>National Strategy for Water Re-use</p> <p>National Groundwater Strategy</p> <p>NWRS2 Chapter 4: 4.4.10, 4.4.11, 4.4.12, 4.4.13 and 4.4.14, Chapter 7: 7.4.1 and 7.4.2, and Chapter 9: 9.4.5)</p> <p>DST Grand Challenge: Doing More With Less (Reducing the Human Footprint)</p>	<ul style="list-style-type: none"> <li>• Increase the use of desalinated water sources, including wastewater, mine water, brackish water, and seawater</li> <li>• Increase the volume of wastewater being reused and / or recycled</li> <li>• Maximise use of rain water harvesting, groundwater and the artificial recharge of groundwater/ aquifers</li> </ul>	<ul style="list-style-type: none"> <li>• Through the Sources cluster, to diversify the mix of water resources in use</li> </ul>
<p>DST Grand Challenge: Earth observation and monitoring (Understanding a Changing Planet)</p>	<ul style="list-style-type: none"> <li>• Improving resource management</li> </ul>	<ul style="list-style-type: none"> <li>• Increased expertise in techniques such as GIS, remote sensing, to be utilised in the Supply Governance, Planning and Management cluster.</li> <li>• Such information underpins virtually all public policy decisions, from public health to water resource management, to protection of the ecosystem</li> </ul>

National initiative(s)	Strategic objectives of national initiatives and RDI Roadmap	Roadmap contribution to national initiatives
NWRS2 Chapter 9 and Chapter 8: 8.5.12	<ul style="list-style-type: none"> <li>Research into amendment of legislation (9.4.1)</li> </ul>	<ul style="list-style-type: none"> <li>Through the governance clusters, research into policy amendments to provide for evidence-based policy and regulation</li> <li>Increase capacity and capability related to water law and public administration</li> </ul>
<p>Outcome 7 (vibrant, equitable and sustainable rural communities)</p> <p>DST Grand Challenge: Food and Fibre Security for South Africa (Adapting the Way We Live)</p> <p>Department of Rural Development and Land Reform: Vibrant, Equitable and Sustainable Rural Communities and Food Security for all</p>	<ul style="list-style-type: none"> <li>Achieve vibrant, equitable and sustainable rural communities and food security for all</li> </ul>	<ul style="list-style-type: none"> <li>TRP addressing water utilisation in agriculture, as well as in informal settlements and peri-urban communities.</li> <li>The use of water by small-scale farmers (smallholders) and water allocation reform will be addressed in the clusters, Sources, Supply Governance, and Productive Use.</li> <li>The RDI roadmap will continue to support the wise use of water for agriculture, specifically to reduce water demand from irrigation.</li> </ul>
International and Regional Initiatives	Strategic objectives of International and Regional initiatives and the RDI Roadmap	Roadmap contribution to international and regional initiatives
Convention on the Law of the Non-navigational Uses of International Watercourses: equitable and reasonable use of shared water resources	<ul style="list-style-type: none"> <li>Use, development and protection of international watercourses shall be undertaken in an equitable and reasonable way.</li> <li>Water course states shall employ their best efforts to process, develop and collect data and information in a manner that facilitates equitable and reasonable use.</li> </ul>	<ul style="list-style-type: none"> <li>Two roadmap clusters focus on governance, planning and management that address the hydropolitical, transboundary, regional and international aspects of water innovation.</li> <li>The cluster focused on pricing, monitoring, billing and metering is essential to responding to the data and information sharing requirements of international legislation.</li> </ul>
Revised Protocol on Shared Watercourse in the Southern African Development Community: Research and appropriate technology development (Article 2E)	<ul style="list-style-type: none"> <li>Research and technology development, information exchange, capacity building, and the application of appropriate technologies to shared watercourses management.</li> </ul>	<ul style="list-style-type: none"> <li>The SADC protocol emphasises aligning national legislation and policy to the regional treaty. The Water RDI Roadmap responds to this by putting a clear RDI investment and HCD strategy in place for the next 10 years. This clear plan also facilitates regional partnership as needs are clearly articulated.</li> </ul>
SADC Regional Indicative Strategic Development Plan (RISDP): Environment and Sustainable development, Science and Technology	<ul style="list-style-type: none"> <li>Science and technology and Environment and Sustainable Development (to which water is linked) are highlighted as priority intervention areas for SADC.</li> </ul>	<ul style="list-style-type: none"> <li>This roadmap responds to the regional call for targeted and strategic investment into science and technology and water-related environmental challenges.</li> </ul>
Science, Technology and Innovation Strategy for Africa 2024: sustainable management of natural resources and environments to secure the interest of future generations	<ul style="list-style-type: none"> <li>Eradicate hunger and achieve food security.</li> <li>Protect our space – knowledge of the water cycle, river systems and basin management.</li> <li>Live together and build society – urban hydrology and urban waste management.</li> </ul>	<ul style="list-style-type: none"> <li>The Cluster on reducing losses and increasing efficiency of productive use has important synergies with the agricultural sector.</li> <li>The cluster focusing on water infrastructure (including ecological infrastructure) is essential to knowledge on river systems.</li> <li>The clusters on running water as a business, improving operational performance and infrastructure directly support urban hydrology and waste water management innovation.</li> </ul>

# CHAPTER 2: SOUTH AFRICA'S WATER RDI ROADMAP: 2015-2025

## 2.1 STRUCTURE OF THE ROADMAP

This chapter presents the end results of the roadmapping process – i.e. the roadmap itself. Explanations of how the information in this chapter was derived are provided in Chapter 4. Definitions of the specialised terms used may be found in the glossary and list of abbreviations on pages vi-vii.

The reader should be aware that in order to fully understand the methodology and assumptions that underpin the conclusions of the roadmapping process presented in Chapter 2, s/he will need to read, or at least refer to, Chapter 4.

In brief, a comprehensive workshoping and reiterative review and rebuild process was adopted to create a list of the needs of the water community. The water community as a whole was divided into four sectors: Agriculture, Industry, Public Sector, and Environmental Protection.

Each sector then identified Interventions in order to provide lists of recommended actions that would satisfy each need. The needs and interventions could be categorised into seven Clusters, around each of which a ten year programme of action and investment was created. The process is described in full in sections 4.1 to 4.3.

The seven Clusters are divided into supply and demand side needs and interventions, as follows:

### Water supply

1. Increase ability to make use of more **sources** of water, including alternatives
2. Improve **governance, planning and management of supply** and delivery
3. Improve adequacy and performance of supply **infrastructure**
4. Run water as a financially sustainable “**business**” by improving **operational performance**

### Water demand

5. Improve **governance, planning, and management of demand** and use
6. Reduce losses and increase efficiency of **productive use**
7. Improve performance of **pricing, monitoring, billing**, metering and collection

Sections 2.2 to 2.8 present the programmes of RDD Responses designed for each Cluster. Figure 2 illustrates the way in which sections 2.2 to 2.8 have been structured.

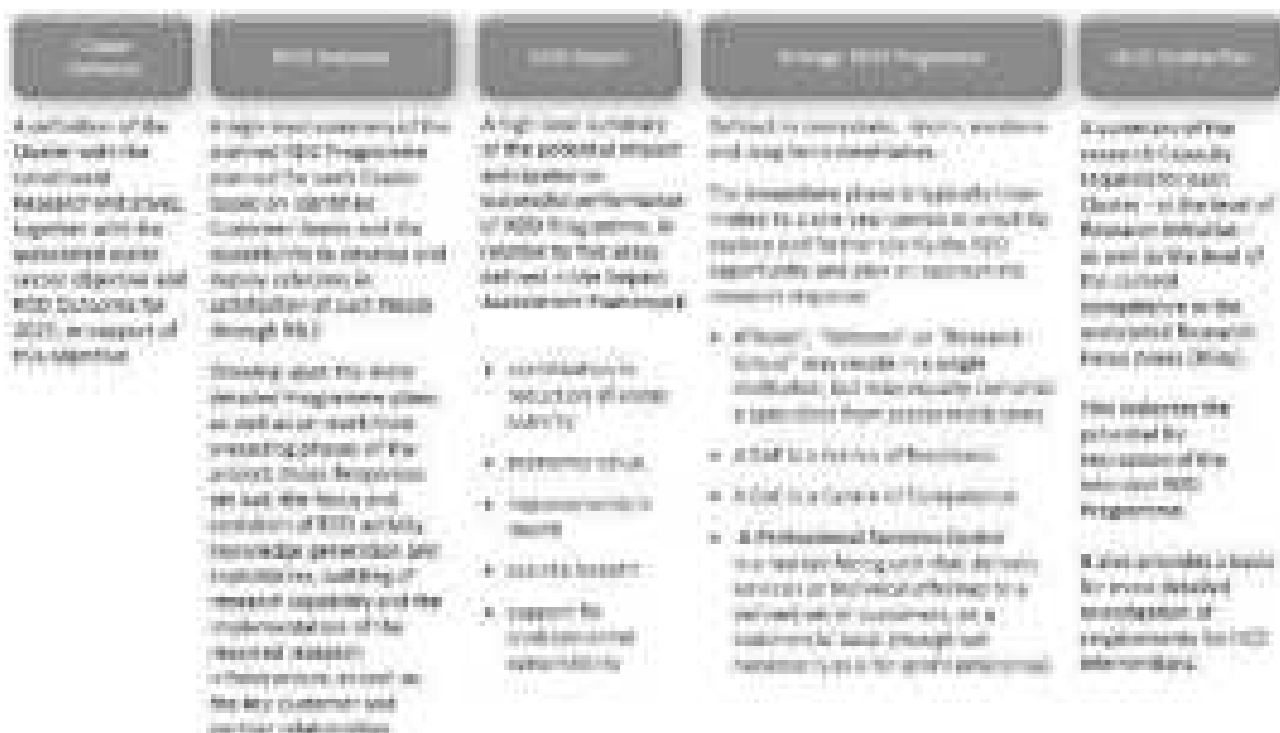


Figure 2: Structure and overview of the response for each Cluster

Each section begins by defining the Cluster, then provides the RDD Response, the anticipated impact of responding, an RDD programme which sets out actions over a ten year period, and finally an HCD plan for each research initiative within the RDD Programme.

The RDD Response plans each provide identification of national and international partners to be engaged, for each Cluster (for example, the Sources Cluster RDD Response is shown on page 7). This is important, as it informs decisions around co-funding, such as which donors may have overlapping priorities, and around internationalisation of the research outputs. Water is a major research and innovation theme that is central to Africa's development, and an area in which international co-operation is essential.

The impacts that would be made by implementing each ten year plan were assessed using the methodology set out in section 4.2.4. The appropriate instruments to implement each ten year plan were identified, and the costs estimated, based on sets of assumptions which are explained in detail in sections 4.2 and 4.3.

## 2.2 SUPPLY CLUSTER 1: INCREASE ABILITY TO MAKE USE OF MORE SOURCES OF WATER, INCLUDING ALTERNATIVES

### 2.2.1 Cluster definition, scope, and research initiatives

#### 2.2.1.1 Sector Objective

Increase ability to make use of more **sources** of water, including alternatives.

#### 2.2.1.2 Target RDD Outcome for 2025

**Technology development for utilisation of diverse water sources at catchment level, with source localisation and exploitation driven by fitness for use is a key point of excellence in South African practices.**

Focus on local resources and appropriate technologies, with strategic consideration of leverage potential and location opportunity from the adaption of inbound technology; explicit emphasis on deployment and uptake.

#### 2.2.1.3 Research Initiatives

The Sources Cluster contains three research initiatives, which are:

<b>Need</b>	Define requirement to identify and make use of alternative sources of water supply; create basis for evaluation of localised source potential; monitor ongoing reliability and changes in sources of supply
<b>Potential</b>	Evaluate potential value and feasibility of alternative approaches, including fitness for purpose and requirements on treatment; improve systems ability to make use of alternative supplies; technology management systems, capability
<b>Enablers</b>	Initiate and drive dialogue, research and programmes; involving producers, users and consumers to increase social acceptance of required water

## 2.2.2 RDD Response: Sources

<b>RDD Activity</b>	Identification of opportunities to improve mix of water sources in use. Development of technologies, capacity, information and management methods to increase the use of treated effluent, decrease levels of salinity through desalination, increase rainwater harvesting and the use of groundwater. Explore the country's potential to increase floodwater and stormwater harvesting and management.
Underlying Science	Multiple disciplines within natural sciences, engineering, humanities, and law
<b>Know-How</b>	
Intellectual Property	Potential for patentable treatment technologies for direct and indirect water reuse and recycling
Knowledge Diffusion	Agriculture: not many products making the market to address needs. Public sector, Industry, and Environment: invest in commercialisation vehicles, product development centres, technology development, seed funding, etc. to shift balance more towards research being translated into full adoption.
<b>Readiness to do Research™</b>	
Capacity	The research groups are distributed between several universities, science councils, and private organisations. Most groups are emerging or building. Investment focus should be on strengthening the existing research groups.
Strength <sup>1</sup>	Too many at mid-level (4-6). Funding may be insufficient to grow the strength of institutions. Alignment and refocus of research may be required to increase strength and bring resources together. TRP needed, leading to CoE.
<b>RDI Infrastructure</b>	
Install, Maintain	Mapping and modelling infrastructure, laboratory ability to do LCA analyses, computing, water quality testing, materials testing. Pilot / demonstration plant facilities.
<b>Customers and Partners</b>	
Government and Stakeholders	DWS, NPC, DST, DoH, DAFF, DHS, SALGA, Water Boards, Water Services Authorities, Water Services Providers
Private Sector	Private sector engineering companies
Research	
Agencies	NRF, WRC, TIA – agencies are largely responsible for enablement, such as funding, providing partnerships, or other support mechanisms
Science Councils and Universities	Broad range of partnerships at HEIs, ARC, Mintek, CSIR, CGS, with specific partners depending on RFA, discipline, and scale of technology. These organisations have roles and mandates relating to fundamental research, applied research, industrial development, and scale-up of innovative products and processes.
Other Partnerships	SWPN, NBI, NEPAD. These 'other' partners will be involved in diverse activities, for example, dissemination of new knowledge, assistance with finding and securing sites and/or partners for piloting / demonstration, co-funding, promotion of the RDI Outputs to their networks.

<sup>1</sup> Research Strength is gauged on a scale of 1 to 8. The ideal situation is one in which

- 20% of research groups in a certain focus area are below level 4 – this shows that there is growth, meaning new institutions starting to work in the focus area.
- 50% in levels 5-6, meaning that the majority of institutions are at a building level
- 30% at level 7 or 8, showing that there is enough research at a mature enough level to address market needs.

### 2.2.3 RDD Impact: Sources

<b>Water Scarcity</b>	Extremely high. Reduced withdrawal of raw water resources. Reduced consumption of raw and treated water. Improved water quality. Improved Quality, Productive use
<b>Economic</b>	
Wealth	Impact
Productivity	Moderate to high impact on increased product per drop (WUE: tonnes/ ton of water) including manufacturing and agro-industry, and reduced down-time (e.g. caused by severe maintenance schedules necessitated by poor quality or intermittent water supply).
Revenue	Impact due to beneficial effects increasing average revenues per unit product and per m <sup>3</sup> delivered, and increasing average revenue per producer (e.g. farmer, ecosystem, environment).
Cost Reduction	Impact resulting from decreased water footprint per unit produced, reduced material inputs (and cost), reduced energy inputs (and cost), reduced labour requirement (and cost), and reduced cost of healthcare. Reduced cost of treating process water and potable water due to decrease in contamination of raw resources.
Investment	Impact due to reduced capex requirements and reduced maintenance costs.
<b>Health</b>	
Sickness and Disease	No impact
Wellness and Mortality	No impact
<b>Society</b>	
Food and livestock	Effects will include: improved availability and quality of environmental goods and services, increased food security – livestock, crops, and reduced loss of animals.
Education	No impact
Relations and rights	Improved relations between all suppliers and consumers in a catchment (e.g. WUAs and farmers). Satisfaction of rights and demands of those without access to water.
Awareness and Behaviour	No impact
<b>Environment</b>	
Emissions, contaminants, pollution	Reduction in the following: carbon emissions, area of salinised land, groundwater contamination, contamination of surface water, downstream pollution.
Preservation and health	Reduced or reversed decline in biodiversity, reduced environmental debt, preservation and improved health of riverine and terrestrial habitats.



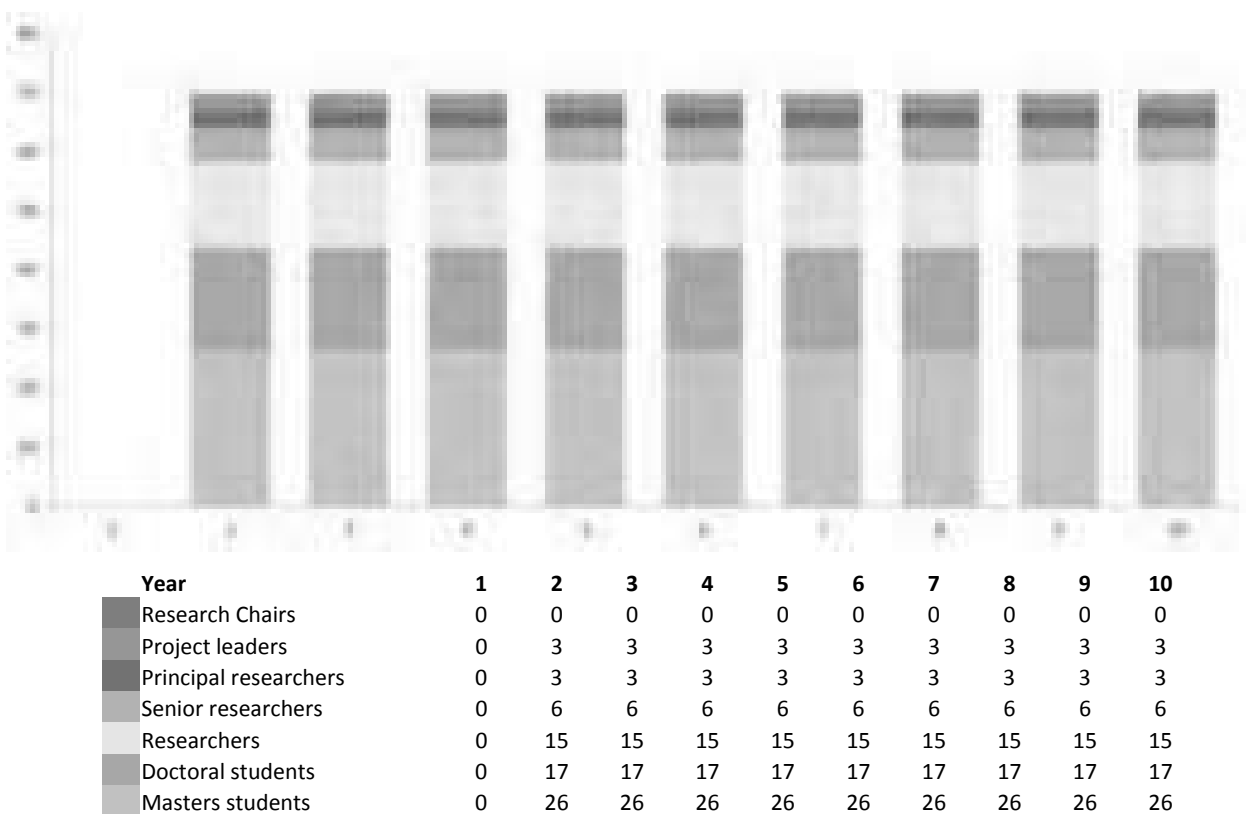
### 2.2.5 HCD Outline Plans per research initiative (Cluster: Sources)

The Research Capacity required to carry out RDD Programme, per year (i.e. number of people in each year, not a cumulative number) is presented graphically for each of the research initiatives.

The RDD Capacity by Research Initiative is also presented as a table indicating which research focus areas (RFAs) are relevant to the Research Initiative, and mapping the existing capacity in each RFA required to conduct research within the RDD programme set out in the preceding section.

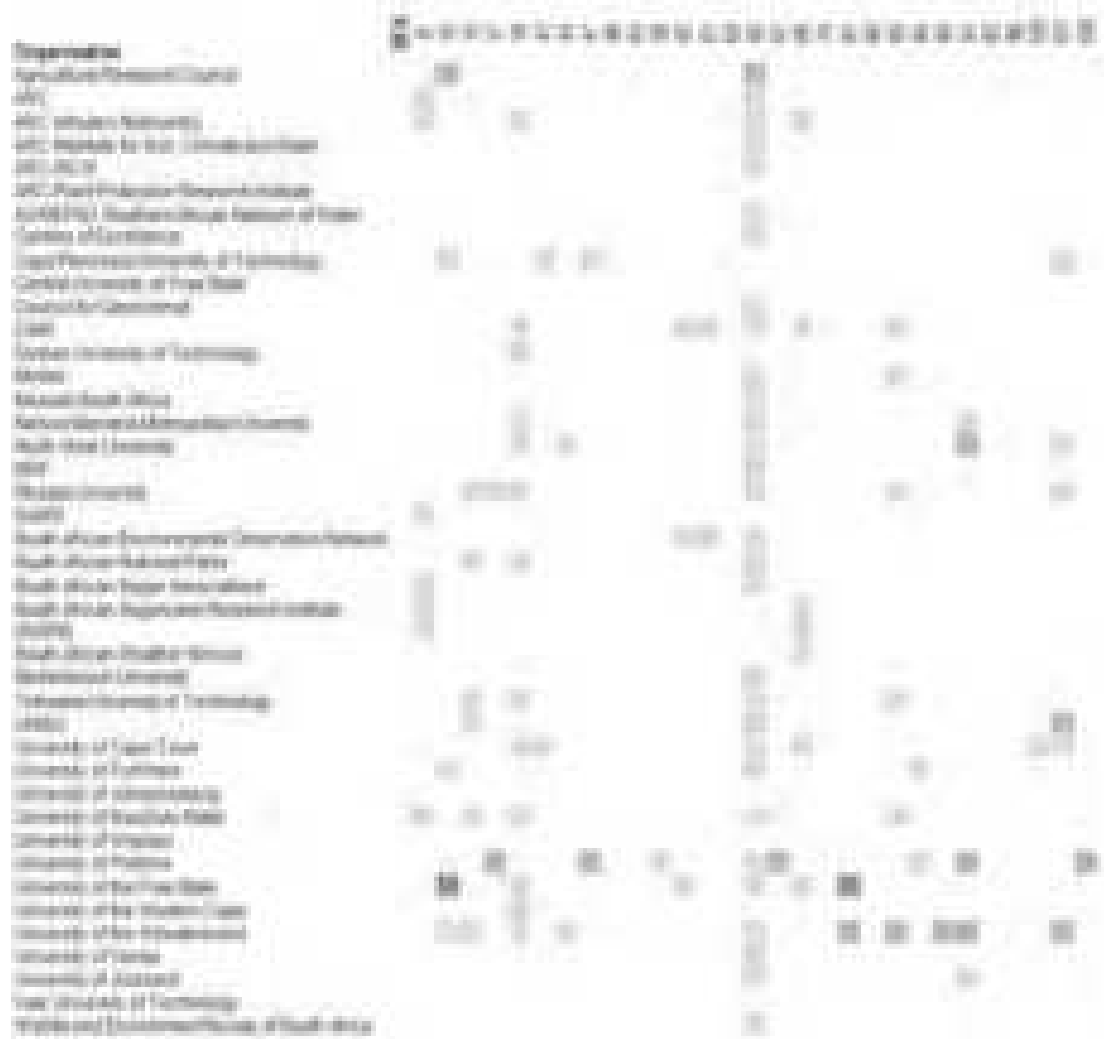
Capacity has been identified at four levels using a scoring system for each research group (Emerging 0, Building 4, Established 7, Mature 10 ) based on composite score on a scale of 0-10 based on number and seniority of people, budget, publications and products, and technical services.

#### 2.2.5.1 Needs Research Initiative (Sources)



**Figure 3: Research Capacity required each year to carry out RDD Programme, for the Research Initiative “Needs” within the Sources Cluster**

Table 1: Mapping of capacity in underlying science (RFA) required to conduct research into "Needs"

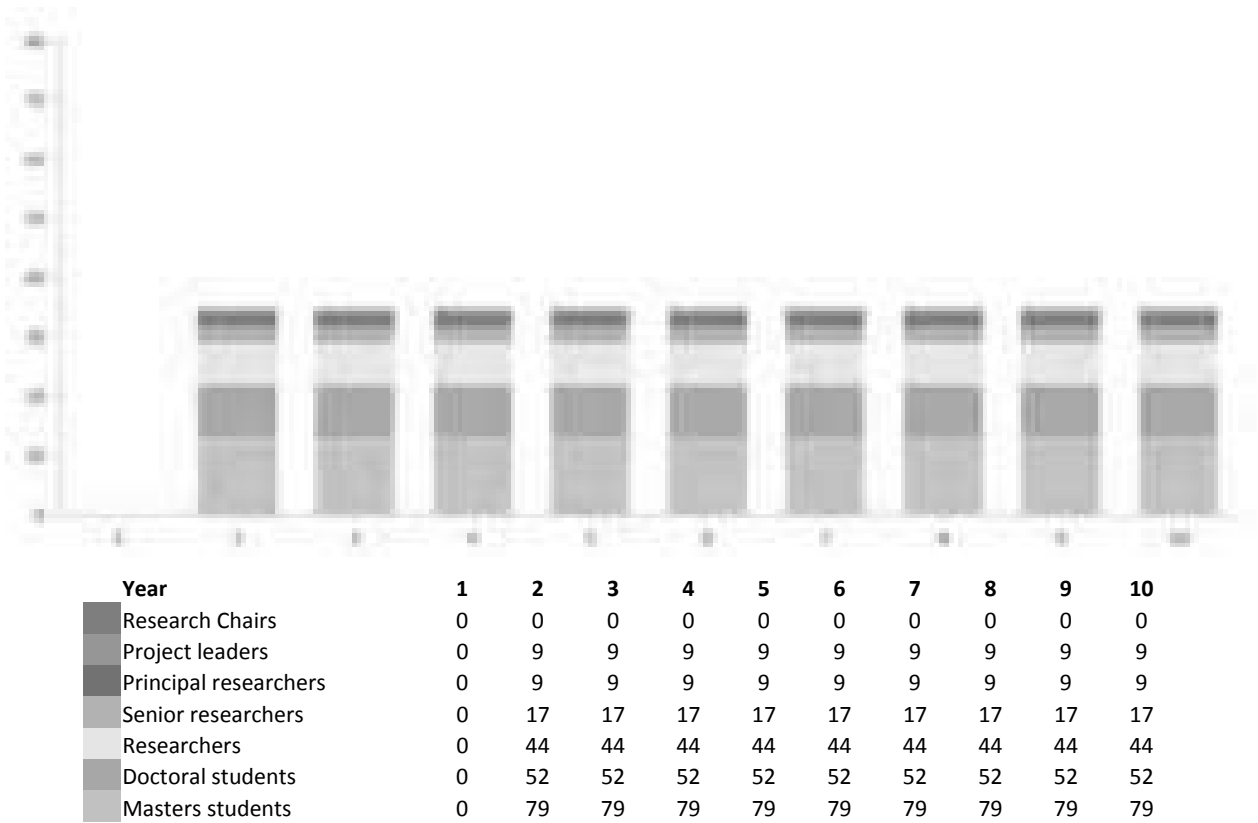


**Key:** Existing Building Unavailable Missing

**Source:** Mutualfruit Readiness to do Research™ 2014 survey, data analysis. n=209 RDD units

**Note:** RFA = Research Focus Area (please see RFA Taxonomy in Table 21, page 72). An RFA in red indicates no capacity identified at any academic units or research institutions.

2.2.5.2 Potential Research Initiative (Sources)



**Figure 4: Research Capacity required each year to carry out RDD Programme, for the Research Initiative “Potential” within the Sources Cluster**

Table 2: Mapping of capacity in underlying science (RFA) required to conduct research into "Potential"

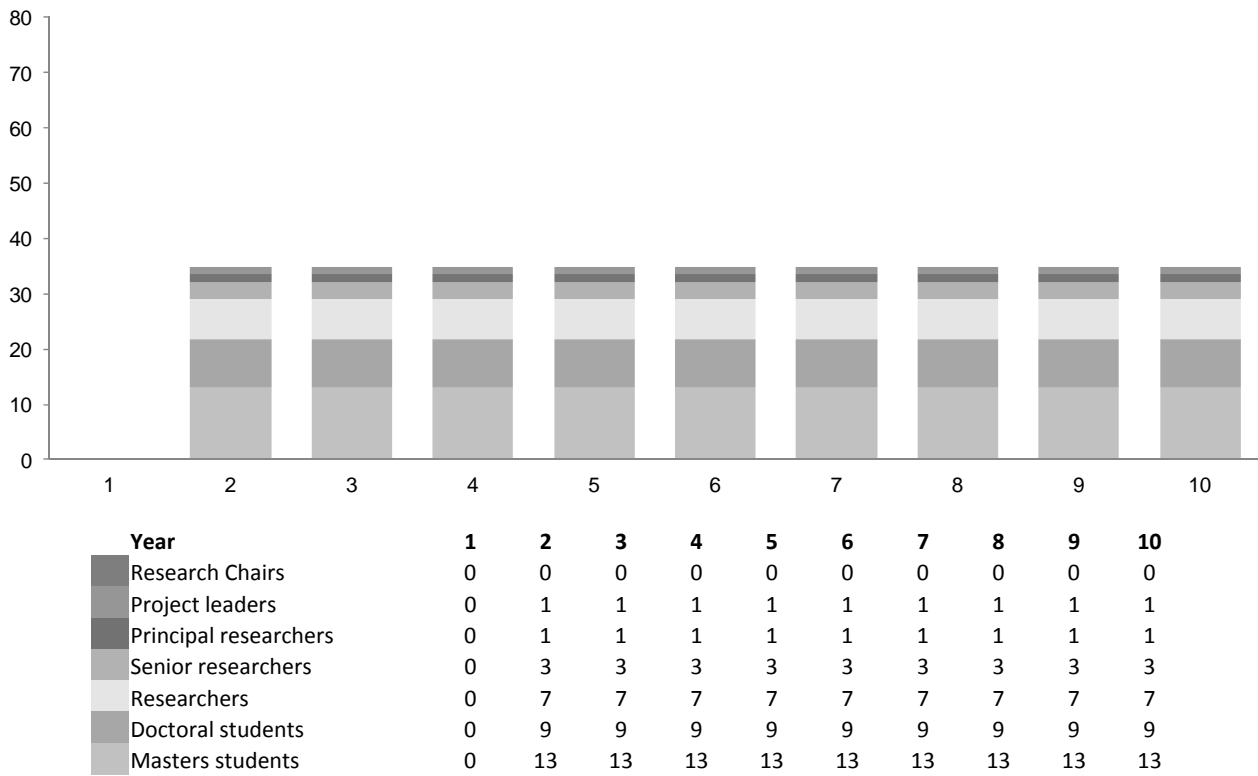


**Key:** Existing Building Established Missing

**Source:** Mutualfruit Readiness to do Research™ 2014 survey, data analysis. n=209 RDD units

**Note:** RFA = Research Focus Area (please see RFA Taxonomy in Table 21, page 72). An RFA in red indicates no capacity identified at any academic units or research institutions.

2.2.5.3 Enablers Research Initiative (Sources)



**Figure 5: Research Capacity required each year to carry out RDD Programme, for the Research Initiative “Enablers” within the Sources Cluster**

**Table 3: Mapping of capacity in underlying science (RFA) required to conduct research into “Enablers”**



**Key:** Existing Building Established Mature

**Source:** Mutualfruit Readiness to do Research™ 2014 survey, data analysis. n=209 RDD units

**Note:** RFA = Research Focus Area (please see RFA Taxonomy in Table 21, page 72). An RFA in red indicates no capacity identified at any academic units or research institutions.

## 2.3 SUPPLY CLUSTER 2: IMPROVE GOVERNANCE, PLANNING AND MANAGEMENT OF SUPPLY AND DELIVERY

### 2.3.1 Cluster definition, scope, and research initiatives

#### 2.3.1.1 Sector Objective

Improve **governance, planning and management of supply** and delivery.

#### 2.3.1.2 Target RDD Outcome for 2025

**The new DWS water allocations map (2016) is implemented by nine functional Catchment Management Agencies. The map includes groundwater, seawater, and wastewater.**

This enables optimised reallocation and distribution of supplies and an improved ability to manage water flows. Focus on improved quality and resilience of planning for the future – ability to respond to changes, including climate change.

#### 2.3.1.3 Research Initiatives

This cluster contains two research initiatives, which are Governance, and Planning and Management:

<b>Governance</b>	Design, implement, drive uptake and support in an integrated manner: <ul style="list-style-type: none"> <li>▶ effective governance models and mechanisms</li> <li>▶ context-specific and transparent planning processes</li> <li>▶ more efficient management of allocation and distribution</li> </ul> all as the means to enable effective functioning of Catchment Management Agencies
<b>Planning and management</b>	



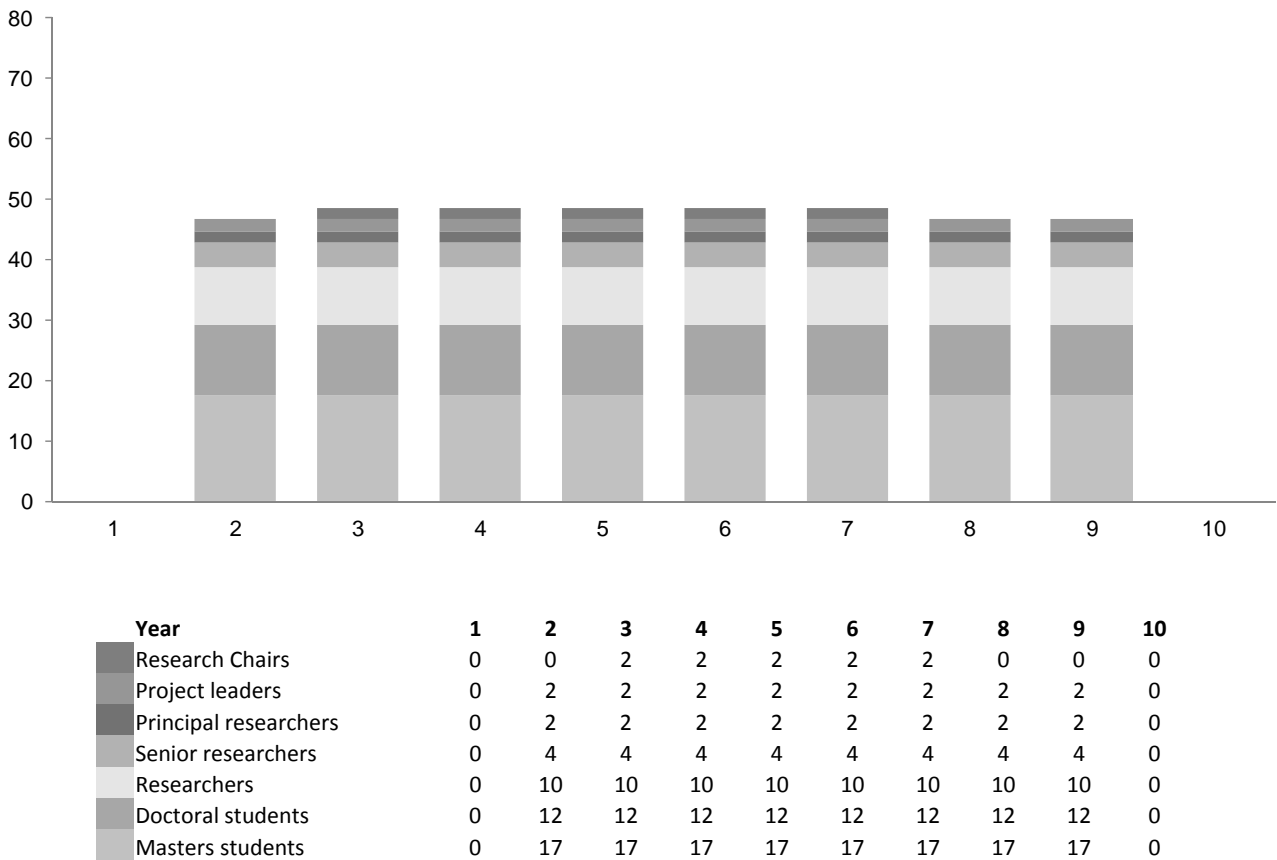


2.3.4 Strategic RDD Programme: Governance, planning and management of supply

Strategic RDD Programme: Governance, planning and management of supply	Strategic RDD Programme: Governance, planning and management of supply	Strategic RDD Programme: Governance, planning and management of supply	Strategic RDD Programme: Governance, planning and management of supply
<p><b>Enables</b></p> <ul style="list-style-type: none"> <li>Develop a R&amp;D – innovation pipeline strategy aligned with research and innovation strategy</li> <li>Develop business plan for Research Plans</li> </ul>	<p><b>Research Programme</b></p> <p>Programme plan for research plans and governance structure</p>	<p><b>Enables</b></p> <p>Develop a R&amp;D – innovation pipeline strategy aligned with research and innovation strategy</p>	<p><b>Enables</b></p> <p>Develop a R&amp;D – innovation pipeline strategy aligned with research and innovation strategy</p>
<ul style="list-style-type: none"> <li>Develop a R&amp;D – innovation pipeline strategy aligned with research and innovation strategy</li> <li>Develop business plan for Research Plans</li> </ul>	<p><b>Research Programme</b></p> <p>Programme plan for research plans and governance structure</p>	<p><b>Enables</b></p> <p>Develop a R&amp;D – innovation pipeline strategy aligned with research and innovation strategy</p>	<p><b>Enables</b></p> <p>Develop a R&amp;D – innovation pipeline strategy aligned with research and innovation strategy</p>
<ul style="list-style-type: none"> <li>Develop a R&amp;D – innovation pipeline strategy aligned with research and innovation strategy</li> <li>Develop business plan for Research Plans</li> </ul>	<p><b>Research Programme</b></p> <p>Programme plan for research plans and governance structure</p>	<p><b>Enables</b></p> <p>Develop a R&amp;D – innovation pipeline strategy aligned with research and innovation strategy</p>	<p><b>Enables</b></p> <p>Develop a R&amp;D – innovation pipeline strategy aligned with research and innovation strategy</p>

**2.3.5 HCD Outline Plans: Governance, planning and management of supply**

*2.3.5.1 Required research capacity: Governance, planning and management of supply*



**Figure 6: Research Capacity required each year to carry out RDD Programme, for the two Research Initiatives “Governance” and “Planning and Management” within the Governance, Planning and Management of Supply Cluster**

2.3.5.2 Current research capacity per research initiative within Cluster: Governance, planning and management of supply

**Table 4: Mapping of capacity in underlying science (RFA) required to conduct research into "Governance" (Supply)**



**Key:** Existing Building Established Mature

**Source:** Mutualfruit Readiness to do Research<sup>TM</sup> 2014 survey, data analysis. n=209 RDD units

**Note:** RFA = Research Focus Area (please see RFA Taxonomy in Table 21, page 72). An RFA in red indicates no capacity identified at any academic units or research institutions.

**Table 5: Mapping of capacity in underlying science (RFA) required to conduct research into “Planning and Management (Supply)”**



**Key:** Growing Building Established Mutualfruit Readiness to do Research

**Source:** Mutualfruit Readiness to do Research™ 2014 survey, data analysis, n=209 RDD units

**Note:** RFA = Research Focus Area (please see RFA Taxonomy in Table 21, page 72). An RFA in red indicates no capacity identified at any academic units or research institutions.

## 2.4 SUPPLY CLUSTER 3: IMPROVE ADEQUACY AND PERFORMANCE OF SUPPLY INFRASTRUCTURE

### 2.4.1 Cluster definition, scope, and research initiatives

#### 2.4.1.1 Sector Objective

Improve adequacy and performance of supply **infrastructure**.

#### 2.4.1.2 Target RDD Outcome for 2025

**Increased volume and adaptability of storage capacity for raw water and treated effluent is available.**

This has increased the levels of protection and reliability of ecological infrastructure, and the ecological reserve is sufficient.

#### 2.4.1.3 Research Initiatives

This cluster contains two research initiatives, which are:

<p><b>Ecological Infrastructure</b></p>	<p>Increase the ability and practice of making and implementing informed choices (based on improvements in the performance of ecological infrastructure), including through rehabilitation and mitigation measures.</p> <p>The decision basis is sound socio-economic evaluation of the benefits and impacts of introduction or changes to environmental goods and services.</p>
<p><b>Built Infrastructure</b></p>	<p>Evaluate performance of built infrastructure in respect of suitability, availability, capacity, flexibility.</p> <p>Support development and implementation of plans to optimise investment in supply infrastructure, including with tools for investment decision-making and integrated approaches to asset management.</p>



2.4.3 RDD Impact: Infrastructure

<b>Water Security</b>	
<b>Food Security</b>	
<b>Energy Security</b>	
<b>Health</b>	
<b>Skills</b>	
<b>Environment</b>	
<b>Transport</b>	
<b>Information</b>	
<b>Science and Innovation</b>	
<b>Industry and Mobility</b>	
<b>Security</b>	
<b>Food and Energy</b>	
<b>Education</b>	
<b>Skills and Rights</b>	
<b>Environment and Resources</b>	
<b>Information</b>	
<b>Industry, Innovation and Skills</b>	
<b>Transportation and Health</b>	

2.4.4 Strategic RDD Programme: Infrastructure

2010-2014	2015-2019	2020-2024	2025-2030	2031-2035
<p><b>Science</b></p> <ul style="list-style-type: none"> <li>Develop the scientific research system, plan aligned with priority and investment strategy</li> <li>Develop and the capabilities of Research Councils</li> <li>Define and maintain the science and technology policies including science and technology infrastructure</li> </ul>	<p><b>Two Research Programmes</b></p> <p>Development of a fully fledged research and development programme</p> <ul style="list-style-type: none"> <li>Develop ability to make informed choices on national and regional science and technology policy</li> <li>Develop policy framework for science and technology (STI) research</li> </ul>	<p><b>Two Centres of Excellence</b></p> <ul style="list-style-type: none"> <li>Build up science and technology research and development capacity</li> </ul>	<p><b>Two Professional Service Centres</b></p>	
<p><b>Biological Infrastructure</b></p> <ul style="list-style-type: none"> <li>Develop capability to create and maintain world world-class research centres</li> <li>Develop research and development centres, including building up research and development capacity</li> <li>Develop research and development centres, including building up research and development capacity</li> </ul>	<p><b>Biological Infrastructure</b></p> <ul style="list-style-type: none"> <li>Develop capability to create and maintain world world-class research centres</li> <li>Develop research and development centres, including building up research and development capacity</li> <li>Develop research and development centres, including building up research and development capacity</li> </ul>	<p><b>Biological Infrastructure</b></p> <ul style="list-style-type: none"> <li>Develop capability to create and maintain world world-class research centres</li> <li>Develop research and development centres, including building up research and development capacity</li> <li>Develop research and development centres, including building up research and development capacity</li> </ul>	<p><b>Biological Infrastructure</b></p> <ul style="list-style-type: none"> <li>Develop capability to create and maintain world world-class research centres</li> <li>Develop research and development centres, including building up research and development capacity</li> <li>Develop research and development centres, including building up research and development capacity</li> </ul>	<p><b>Two Professional Service Centres</b></p>
<p><b>Biological Infrastructure</b></p> <ul style="list-style-type: none"> <li>Develop capability to create and maintain world world-class research centres</li> <li>Develop research and development centres, including building up research and development capacity</li> <li>Develop research and development centres, including building up research and development capacity</li> </ul>	<p><b>Biological Infrastructure</b></p> <ul style="list-style-type: none"> <li>Develop capability to create and maintain world world-class research centres</li> <li>Develop research and development centres, including building up research and development capacity</li> <li>Develop research and development centres, including building up research and development capacity</li> </ul>	<p><b>Biological Infrastructure</b></p> <ul style="list-style-type: none"> <li>Develop capability to create and maintain world world-class research centres</li> <li>Develop research and development centres, including building up research and development capacity</li> <li>Develop research and development centres, including building up research and development capacity</li> </ul>	<p><b>Biological Infrastructure</b></p> <ul style="list-style-type: none"> <li>Develop capability to create and maintain world world-class research centres</li> <li>Develop research and development centres, including building up research and development capacity</li> <li>Develop research and development centres, including building up research and development capacity</li> </ul>	<p><b>Two Professional Service Centres</b></p>
<p><b>Biological Infrastructure</b></p> <ul style="list-style-type: none"> <li>Develop capability to create and maintain world world-class research centres</li> <li>Develop research and development centres, including building up research and development capacity</li> <li>Develop research and development centres, including building up research and development capacity</li> </ul>	<p><b>Biological Infrastructure</b></p> <ul style="list-style-type: none"> <li>Develop capability to create and maintain world world-class research centres</li> <li>Develop research and development centres, including building up research and development capacity</li> <li>Develop research and development centres, including building up research and development capacity</li> </ul>	<p><b>Biological Infrastructure</b></p> <ul style="list-style-type: none"> <li>Develop capability to create and maintain world world-class research centres</li> <li>Develop research and development centres, including building up research and development capacity</li> <li>Develop research and development centres, including building up research and development capacity</li> </ul>	<p><b>Biological Infrastructure</b></p> <ul style="list-style-type: none"> <li>Develop capability to create and maintain world world-class research centres</li> <li>Develop research and development centres, including building up research and development capacity</li> <li>Develop research and development centres, including building up research and development capacity</li> </ul>	<p><b>Two Professional Service Centres</b></p>

2.4.5 HCD Outline Plans per research initiative: Infrastructure

2.4.5.1 Ecological Infrastructure (Infrastructure)

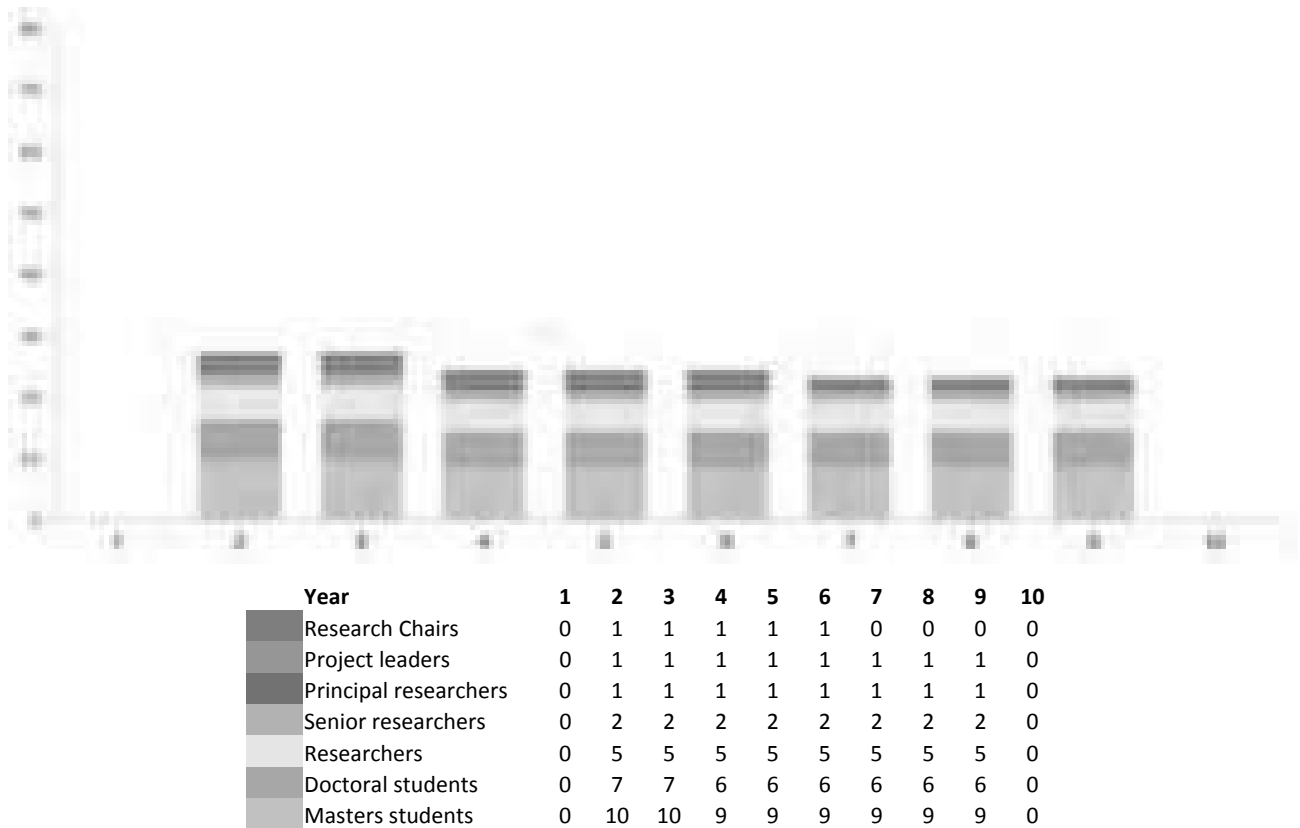


Figure 7: Research Capacity required each year to carry out RDD Programme, for the Research Initiative “Ecological Infrastructure” within the Infrastructure Cluster

**Table 6: Mapping of capacity in underlying science (RFA) required to conduct research into “Ecological Infrastructure”**



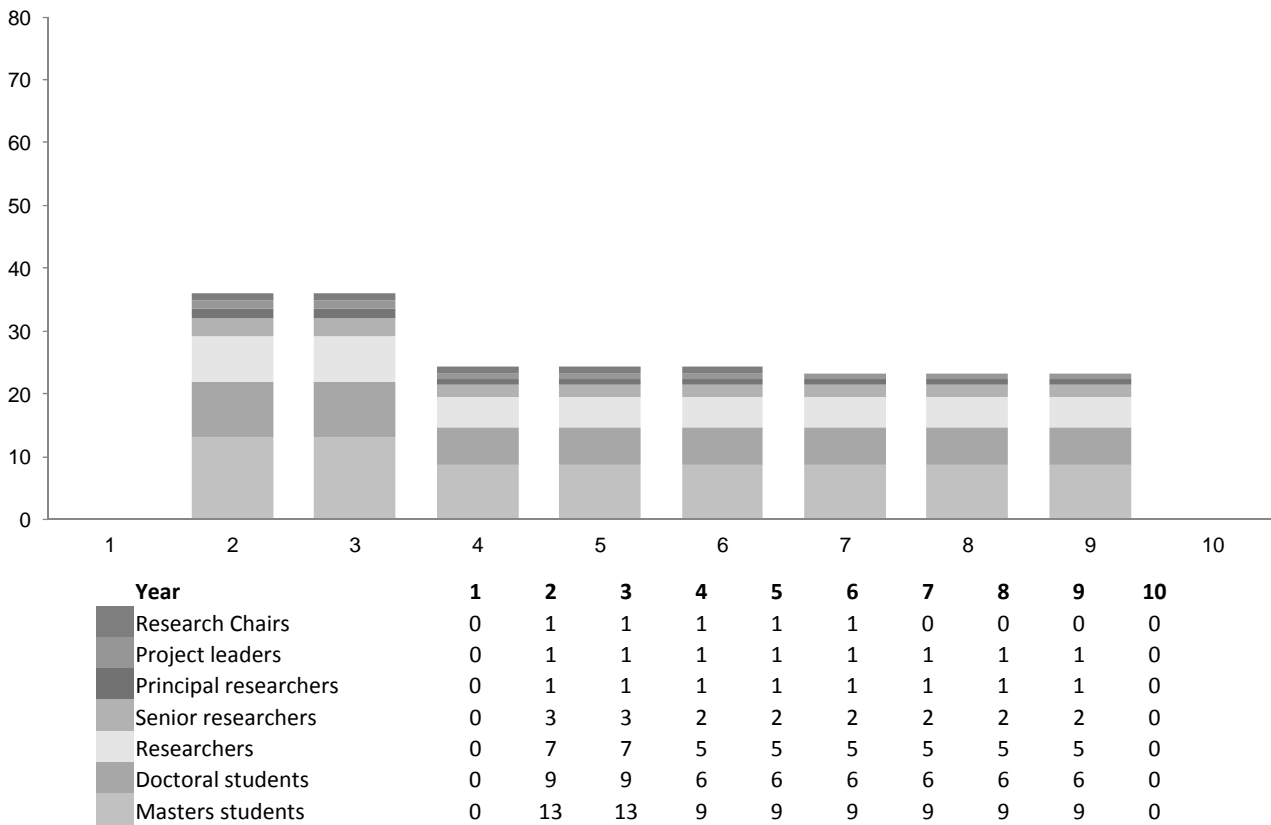
**Key:**

- Existing
- Building
- Discontinued
- None

**Source:** Mutualfruit Readiness to do Research™ 2014 survey, data analysis. n=209 RDD units

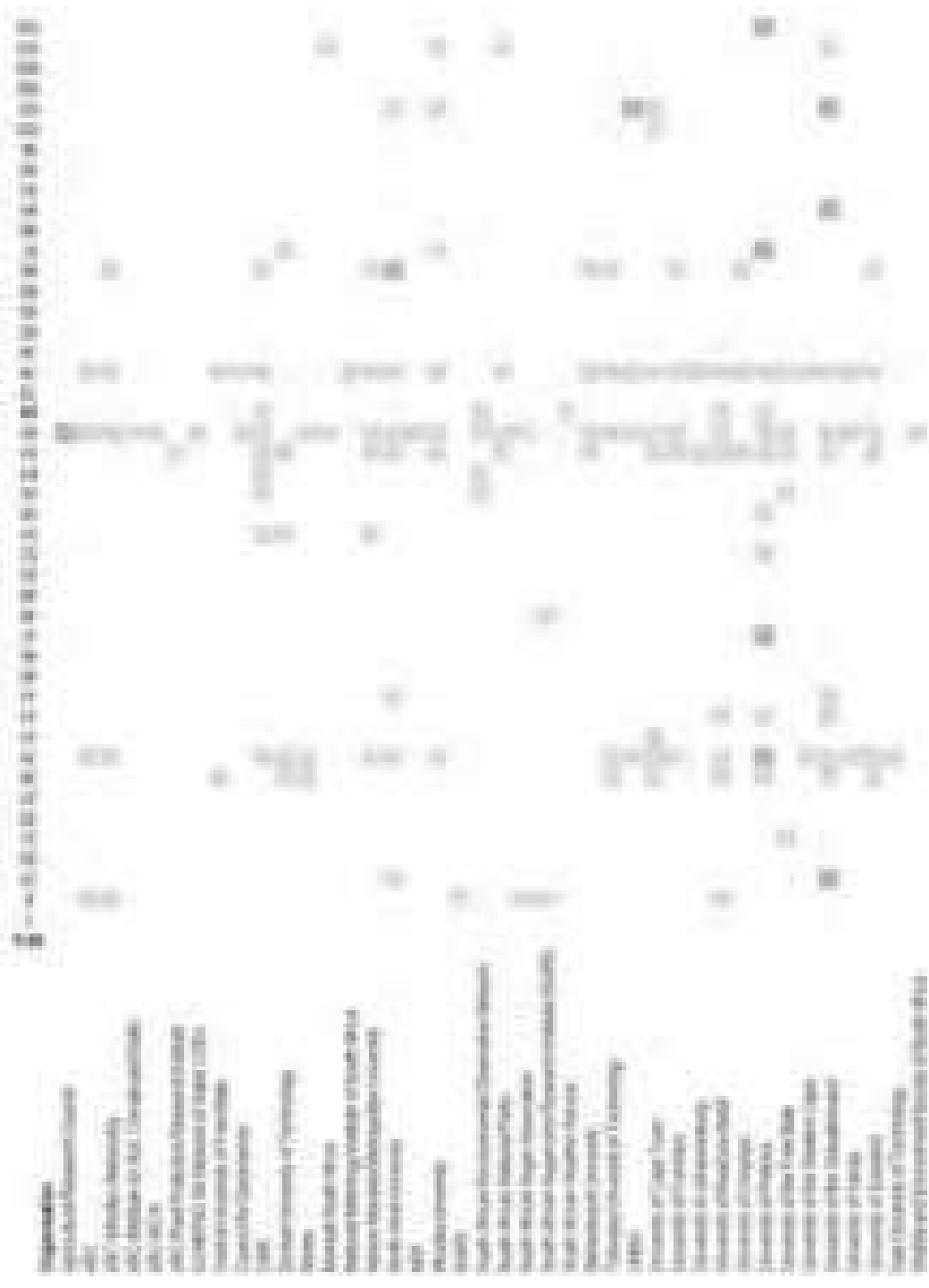
**Note:** RFA = Research Focus Area (please see RFA Taxonomy in Table 21, page 72). An RFA in red indicates no capacity identified at any academic units or research institutions.

2.4.5.2 Built Infrastructure (Infrastructure)



**Figure 8: Research Capacity required each year to carry out RDD Programme, for the Research Initiative “Built Infrastructure” and “Planning and Management” within the Infrastructure Cluster**

Table 7: Mapping of capacity in underlying science (RFA) required to conduct research into "Built Infrastructure"



## 2.5 SUPPLY CLUSTER 4: RUN WATER AS A FINANCIALLY SUSTAINABLE “BUSINESS” BY IMPROVING OPERATIONAL PERFORMANCE

### 2.5.1 Cluster definition, scope, and research initiatives

#### 2.5.1.1 Sector Objective

Improve **operational performance** and run Water as a sustainable “business”,

#### 2.5.1.2 Target RDD Outcome for 2025

**The financial sustainability of the water services system is secured.**

Pricing is equitable and the attribution of water use is accurate. Non-revenue water is below 15% and revenues are collected punctually. Operational efficiency has been gained and >90% of water and wastewater treatment works have Blue Drop / Green Drop status.

#### 2.5.1.3 Research Initiatives

This cluster contains three research initiatives combined into one:

<b>Policy, Technology and Capacity</b>	<p>Improve the ability to monitor and evaluate the public sector system and its performance, including through technology insertion, service responsiveness and reporting of capacity</p> <p>Increase the financial sustainability of the public water supply system through support for evidence-based policy reviews relating to the requirement to pay</p>
--	---

**2.5.2 RDD Response: Operational performance**

<b>RDD Activity</b>	
RDD Focus and Progression	Explore new tools for management and information dissemination. Demonstrate and deploy technologies and build capacity.
Underlying Science	Multiple disciplines within economics, management, political science, and social science.
<b>Know-How</b>	
Intellectual Property	No / little potential for commercial IP envisaged.
Knowledge Diffusion	Not many products making the market to address needs. Investment required into technology development and deployment, commercialisation vehicles, product development centres, seed funding, etc. to shift balance more towards research being translated into full adoption.
<b>Readiness to do Research™</b>	
Capacity	Smaller number of groups are distributed between universities, public entities, and private organisations. Most groups are emerging or building, with only a few established and none mature. Investment focus should be on strengthening the existing research groups.
Strength	Too high a proportion of research groups at mid-level. Funding insufficient to grow the strength of institutions. Alignment and refocus of research may be required to increase strength and bring resources together. TRP needed.
<b>RDI Infrastructure</b>	
Install, Expand	Investment required into technology development and deployment, information dissemination and utilisation.
<b>Customers and Partners</b>	
Government and Stakeholders	DWS, NPC, DST, DHS, SALGA, Water Boards, Water Services Authorities, Water Services Providers
Private Sector	Private sector engineering companies
Research	
Agencies	NRF, WRC, TIA
Science Councils and Universities	Broad range of partnerships at HEIs, science councils, with specific partners depending on RFA ,discipline, and scale of technology
Other Partnerships	SWPN, NBI

**Agencies** are largely responsible for enablement, such as funding, providing partnerships, or other support mechanisms. **Science Councils and Universities** have roles and mandates relating to fundamental research, applied research, industrial development, and scale-up of innovative products and processes. **'Other' partners** will be involved in diverse activities, for example, dissemination of new knowledge, assistance with finding and securing sites and/or partners for piloting / demonstration, co-funding, promotion of the RDI Outputs to their networks

### 2.5.3 RDD Impact: Operational performance

<b>Water Scarcity</b>	Extremely high. Reduced withdrawal of raw water resources. Reduced consumption of raw and treated water. Improved water quality. Improved Quality, Productive use
<b>Economic</b>	
Wealth	Impact
Productivity	Moderate to high impact on increased product per drop (Water Use Efficiency (WUE): tonnes/ ton of water) including manufacturing and agro-industry, and reduced down-time (e.g. caused by severe maintenance schedules necessitated by poor quality or intermittent water supply).
Revenue	Impact due to beneficial effects increasing average revenues per unit product and per m <sup>3</sup> delivered, and increasing average revenue per producer (e.g. farmer, ecosystem, environment).
Cost Reduction	Impact resulting from decreased water footprint per unit produced, reduced material inputs (and cost), reduced energy inputs (and cost), reduced labour requirement (and cost), and reduced cost of healthcare. Reduced cost of treating process water and potable water due to decrease in contamination of raw resources.
Investment	Impact due to reduced capex requirements and reduced maintenance costs.
<b>Health</b>	
Sickness and Disease	Impact will be made through the reduction of the incidence of waterborne sickness and disease
Wellness and Mortality	Some impact will result from reduced absenteeism and early retirement – through increased wellness – and a reduced mortality rate.
<b>Society</b>	
Food and livestock	Effects will include: increased food security – livestock, crops, reduced loss of animals – and reduced environmental debt
Education	Increased school attendance (driven by access and quality) and improved educational outcomes
Relations and rights	Satisfaction of rights and demands of those without access to water. Improved availability and quality of environmental goods and services.
Awareness and Behaviour	Raised awareness of the value of water, driving increased willingness to pay (augmented by improved confidence in the public sector)
<b>Environment</b>	
Emissions, contaminants, pollution	Reduction in the following: carbon emissions, soil erosion, groundwater contamination, contamination of surface water, downstream pollution.
Preservation and health	Improved availability and quality of environmental goods and services.



2.5.5 HCD Outline Plans: Operational performance

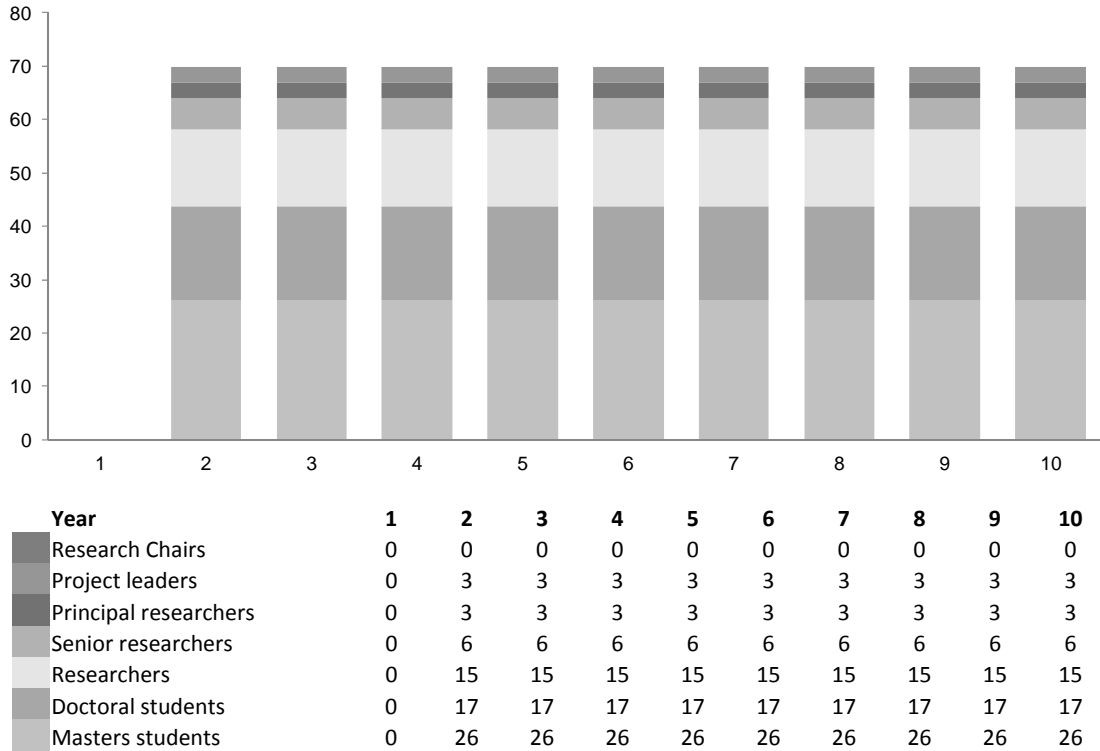


Figure 9: Research Capacity required each year to carry out RDD Programme, for the Operational Performance Cluster

Table 8: Mapping of capacity in underlying science (RFA) required to conduct research into “Operational Performance”



Key:  ongoing  existing  intended  new

Source: Mutualfruit Readiness to do Research™ 2014 survey, data analysis. n=209 RDD units

Note: RFA = Research Focus Area (please see RFA Taxonomy in Table 21, page 72). An RFA in red indicates no capacity identified at any academic units or research institutions.

## 2.6 DEMAND CLUSTER 5: IMPROVE GOVERNANCE, PLANNING, AND MANAGEMENT OF DEMAND AND USE

### 2.6.1 Cluster definition, scope, and research initiatives

#### 2.6.1.1 Sector Objective

Improve **governance planning** and its implementation in the **management of demand** and use.

#### 2.6.1.2 Target RDD Outcome for 2025

**There is equitable and transparent access to water supplies that are managed at catchment level by DWS co-operatively with DoH, DAFF, DHS, and DEA.**

Transparency over rights, quotas, allocations, and transfers has been achieved and co-operative governance with respect to planning and management has been improved.

#### 2.6.1.3 Research Initiatives

This cluster contains two research initiatives, which are:

<p><b>Demand Governance</b></p>	<p>Design and evaluate implementation of improved and more co-operative governance with respect to planning and management of demand, including regulatory frameworks, decision-making and achieving optimum balance between economic growth and development and the need for water and food security</p>
<p><b>Demand Planning and Management</b></p>	<p>Improve quality and effectiveness of water supply decision-making, planning, implementation and regulation processes in respect of water use authorization, rights, social allocation and transfers</p> <p>Increase water use efficiency through support for implementation and uptake of WUDM measures proposed in MWRM, including provision of strategic and management information and effective functioning of Catchment Management Agencies</p>

2.6.2 RDD Response: Governance, Planning, and Management of Demand

<b>RDD Activities</b>	
<b>RDD Focus and Programme</b>	includes research by public, private, and management and for educational, dissemination, demonstration and applying (technology and skills) applying
<b>Enabling Environments</b>	includes structures within government, national, provincial, and local spheres
<b>Key Issues</b>	
<b>Industrial Property</b>	the public ownership of commercial intellectual
<b>Knowledge Protection</b>	the many products making the market to public goods. Government research has technology management and intellectual communication activities, product management systems, and funding, as to which business may want to research being conducted and R&D activities
<b>Researchable Research</b>	
<b>Priority</b>	Research done for (diffused) between commercial, public systems, and private organisations. Management and funding for building, with only a few established and non-researching, investment focus should be strengthening the existing research groups and addressing collaboration between public, private, academic, and industry partners
<b>Strength</b>	the high concentration of research in certain and local. Funding conditions to give the strength of universities, government and industry research that is required to sustain through and being innovative together. R&D results
<b>RDD Infrastructure</b>	
<b>Public Finance</b>	includes financial institutions - other stakeholders
<b>University and Partners</b>	
<b>Government and Stakeholders</b>	public, private, R&D, state, industry, state, service providers, other business partners
<b>Private Sector</b>	Private sector supporting commercial
<b>Research</b>	
<b>Agencies</b>	DSIR, NRF, IPR
<b>Science Councils and Institutes</b>	Science Councils and Institutes, with specific research funding in R&D, education, and skills development
<b>Other Participants</b>	industry, etc.

Agencies are largely responsible for enablement, such as funding, providing partnerships, or other support mechanisms. Science Councils and Universities have roles and mandates relating to fundamental research, applied research, industrial development, and scale-up of innovative products and processes. Other partners will be involved in diverse activities, for example, dissemination of new knowledge, assistance with finding and securing sites and/or partners for piloting / demonstration, co-funding, promotion of the RDI Outputs to their networks

### 2.6.3 RDD Impact: Governance, Planning, and Management of Demand

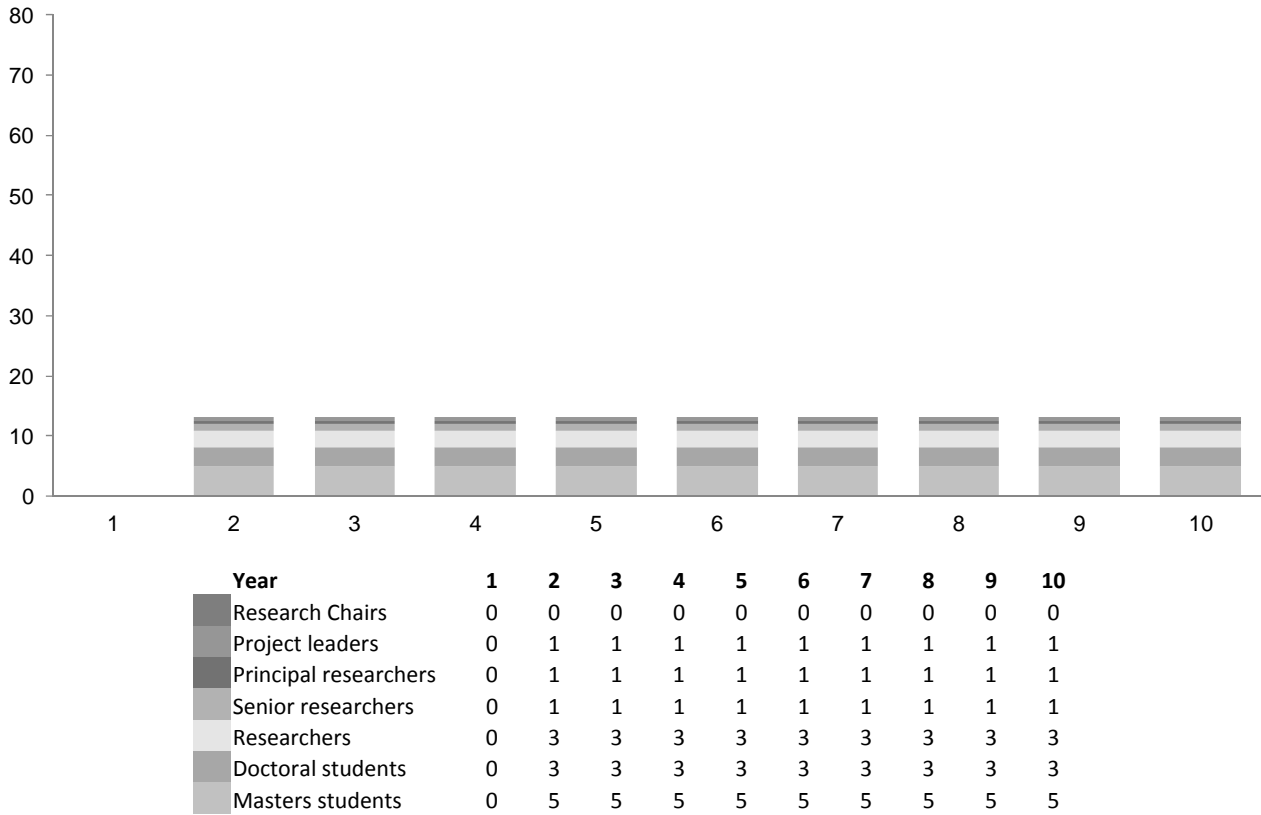
<b>Water Scarcity</b>	Withdrawal, Consumption, Quality, Productive use	Moderate to high impact. Reduced withdrawal of raw water resources. Improved water quality. Improved productivity of use.
<b>Economic</b>		
Wealth	Impact	
Productivity	Moderate to high impact on increased product per drop (WUE: tonnes/ ton of water) including manufacturing and agro-industry, and reduced down-time (e.g. caused by severe maintenance schedules necessitated by poor quality or intermittent water supply).	
Revenue	No impact	
Cost Reduction	Impact resulting from decreased water footprint per unit produced, reduced material inputs (and cost), reduced energy inputs (and cost), reduced labour requirement (and cost), and reduced cost of healthcare. Reduced cost of treating process water and potable water due to decrease in contamination of raw resources.	
Investment	Impact due to reduced capex requirements and reduced maintenance costs.	
<b>Health</b>		
Sickness and Disease	Impact will be made through the reduction of the incidence of waterborne sickness and disease	
Wellness and Mortality	Some impact will result from reduced absenteeism and early retirement - through increased wellness - and a reduced mortality rate.	
<b>Society</b>		
Food and livestock	Effects will include: increased food security – livestock, crops, reduced loss of animals – and reduced environmental debt	
Education	Increased school attendance (driven by access and quality) and improved educational outcomes	
Relations and rights	Improved relations between all suppliers and consumers in a catchment (e.g. WUAs and farmers). Satisfaction of rights and demands of those without access to water. Improved availability and quality of environmental goods and services.	
Awareness and Behaviour	Raised awareness of the value of water, driving increased willingness to pay	
<b>Environment</b>		
Emissions, contaminants, pollution	Reduction in the following: carbon emissions, soil erosion, area of salinised land, groundwater contamination, contamination of surface water, downstream pollution.	
Preservation and health	Reduced or reversed decline in biodiversity, preservation of riverine habitats, reduced soil erosion, and improved health of terrestrial environment. Improved availability and quality of environmental goods and services.	

2.6.4 Strategic RDD Programme: Governance, Planning, and Management of Demand

2015	Short Term (2015 – 2016)	Medium Term (2016-2020)	Long Term (2020 – 2030+)
<p>Enable Division 90's research, research, development, and innovation activities and capabilities through:</p> <ul style="list-style-type: none"> <li>• Enable Division 90's research, development, and innovation activities and capabilities through:</li> </ul>	<p>Research Programme (using funding opportunities)</p> <p>Research Open for Researchers (using cooperative governance)</p> <ul style="list-style-type: none"> <li>• Build and maintain the Strategic Research</li> <li>• Build, align and implement research support activities (with, with, with, with, with)</li> <li>• Develop and maintain research, development, and innovation activities and capabilities through:</li> </ul>	<p>Centre of Excellence in Transformational research, research, development, and innovation activities and capabilities through:</p> <ul style="list-style-type: none"> <li>• Enhance the Strategic Research</li> <li>• Enhance the Strategic Research</li> </ul> <p>Global Management of Research, Planning and Management of Demand</p> <ul style="list-style-type: none"> <li>• Enhance the Strategic Research</li> <li>• Enhance the Strategic Research</li> </ul>	<p>Professional Services Centre focused on the professional, technical and support services, research, development, and innovation activities and capabilities through:</p> <ul style="list-style-type: none"> <li>• Enhance the Strategic Research</li> <li>• Enhance the Strategic Research</li> </ul>
<p>Enable Division 90's research, development, and innovation activities and capabilities through:</p> <ul style="list-style-type: none"> <li>• Enable Division 90's research, development, and innovation activities and capabilities through:</li> </ul>	<p>Research Programme (using funding opportunities)</p> <p>Research Open for Researchers (using cooperative governance)</p> <ul style="list-style-type: none"> <li>• Build and maintain the Strategic Research</li> <li>• Build, align and implement research support activities (with, with, with, with, with)</li> <li>• Develop and maintain research, development, and innovation activities and capabilities through:</li> </ul>	<p>Centre of Excellence in Transformational research, research, development, and innovation activities and capabilities through:</p> <ul style="list-style-type: none"> <li>• Enhance the Strategic Research</li> <li>• Enhance the Strategic Research</li> </ul> <p>Global Management of Research, Planning and Management of Demand</p> <ul style="list-style-type: none"> <li>• Enhance the Strategic Research</li> <li>• Enhance the Strategic Research</li> </ul>	<p>Professional Services Centre focused on the professional, technical and support services, research, development, and innovation activities and capabilities through:</p> <ul style="list-style-type: none"> <li>• Enhance the Strategic Research</li> <li>• Enhance the Strategic Research</li> </ul>
<p>Enable Division 90's research, development, and innovation activities and capabilities through:</p> <ul style="list-style-type: none"> <li>• Enable Division 90's research, development, and innovation activities and capabilities through:</li> </ul>	<p>Research Programme (using funding opportunities)</p> <p>Research Open for Researchers (using cooperative governance)</p> <ul style="list-style-type: none"> <li>• Build and maintain the Strategic Research</li> <li>• Build, align and implement research support activities (with, with, with, with, with)</li> <li>• Develop and maintain research, development, and innovation activities and capabilities through:</li> </ul>	<p>Centre of Excellence in Transformational research, research, development, and innovation activities and capabilities through:</p> <ul style="list-style-type: none"> <li>• Enhance the Strategic Research</li> <li>• Enhance the Strategic Research</li> </ul> <p>Global Management of Research, Planning and Management of Demand</p> <ul style="list-style-type: none"> <li>• Enhance the Strategic Research</li> <li>• Enhance the Strategic Research</li> </ul>	<p>Professional Services Centre focused on the professional, technical and support services, research, development, and innovation activities and capabilities through:</p> <ul style="list-style-type: none"> <li>• Enhance the Strategic Research</li> <li>• Enhance the Strategic Research</li> </ul>
<p>Enable Division 90's research, development, and innovation activities and capabilities through:</p> <ul style="list-style-type: none"> <li>• Enable Division 90's research, development, and innovation activities and capabilities through:</li> </ul>	<p>Research Programme (using funding opportunities)</p> <p>Research Open for Researchers (using cooperative governance)</p> <ul style="list-style-type: none"> <li>• Build and maintain the Strategic Research</li> <li>• Build, align and implement research support activities (with, with, with, with, with)</li> <li>• Develop and maintain research, development, and innovation activities and capabilities through:</li> </ul>	<p>Centre of Excellence in Transformational research, research, development, and innovation activities and capabilities through:</p> <ul style="list-style-type: none"> <li>• Enhance the Strategic Research</li> <li>• Enhance the Strategic Research</li> </ul> <p>Global Management of Research, Planning and Management of Demand</p> <ul style="list-style-type: none"> <li>• Enhance the Strategic Research</li> <li>• Enhance the Strategic Research</li> </ul>	<p>Professional Services Centre focused on the professional, technical and support services, research, development, and innovation activities and capabilities through:</p> <ul style="list-style-type: none"> <li>• Enhance the Strategic Research</li> <li>• Enhance the Strategic Research</li> </ul>

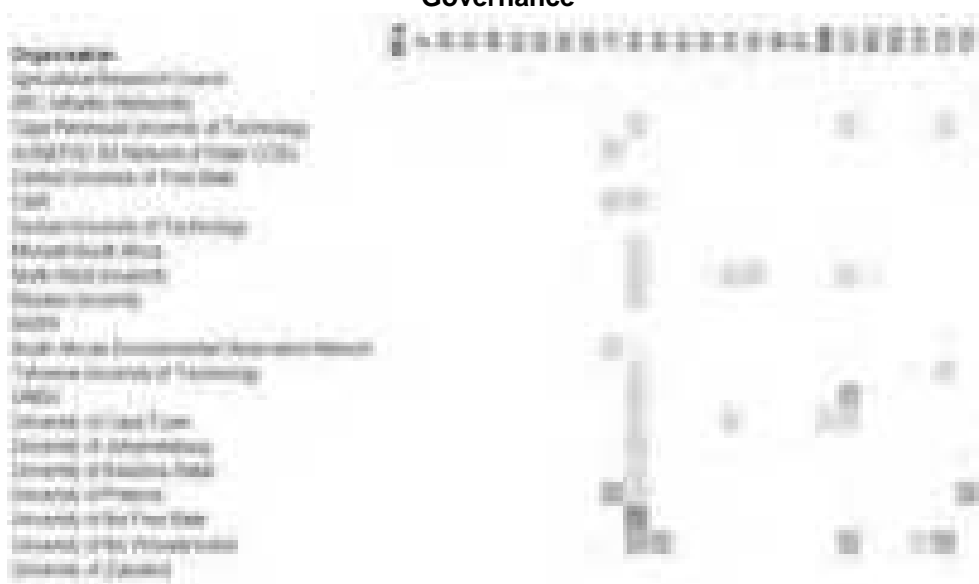
**2.6.5 HCD Outline Plans per research initiative: Governance, Planning, and Management of Demand**

**2.6.5.1 Governance (Demand)**



**Figure 10: Research Capacity required each year to carry out RDD Programme, for “Governance” in the Cluster, Governance, Planning, and Management of Demand**

**Table 9: Mapping of capacity in underlying science (RFA) required to conduct research into “Governance”**



**Key:** Existing Building Limited None

**Source:** Mutualfruit Readiness to do Research™ 2014 survey, data analysis. n=209 RDD units

**Note:** RFA = Research Focus Area (please see RFA Taxonomy in Table 21, page 72). An RFA in red indicates no capacity identified at any academic units or research institutions.

2.6.5.2 Planning and Management (Demand)

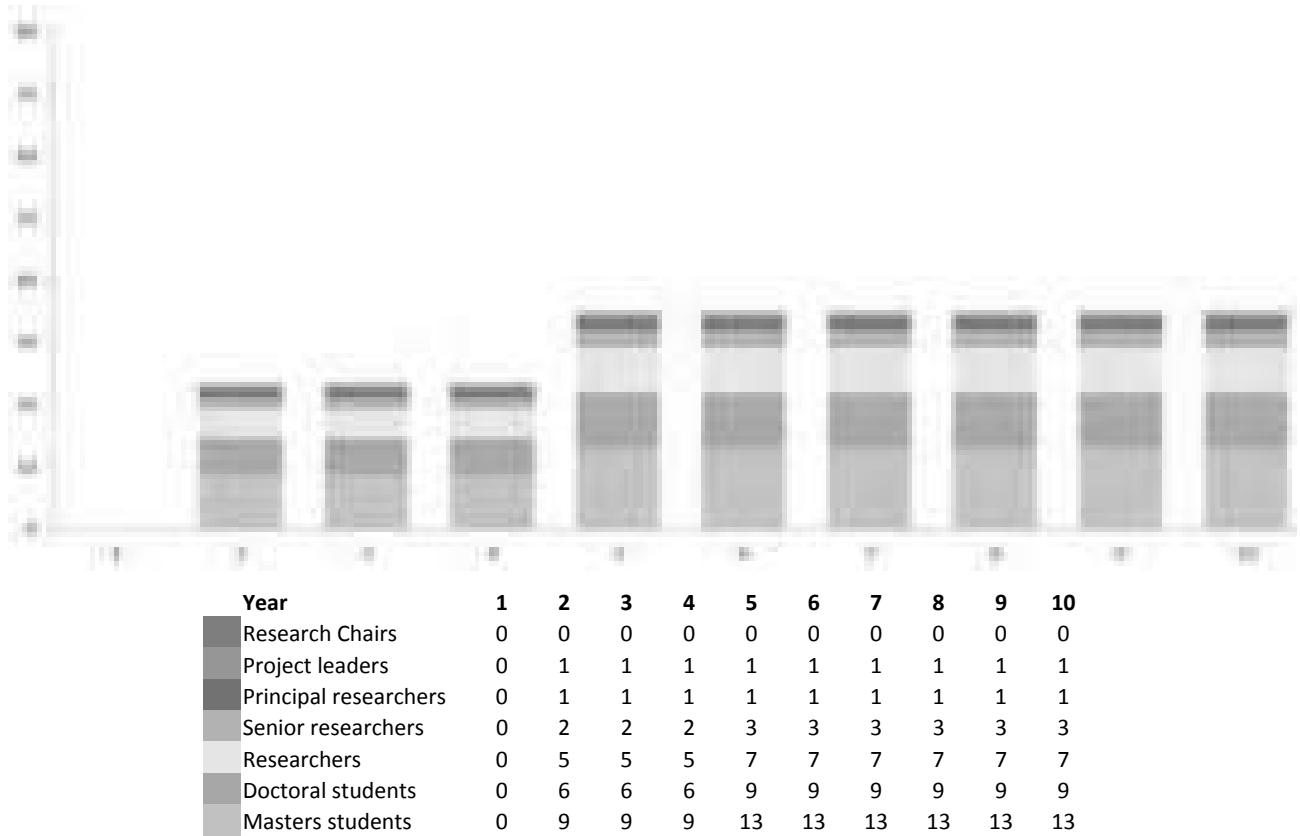


Figure 11: Research Capacity required each year to carry out RDD Programme, for “Planning and Management” in the Cluster, Governance, Planning, and Management of Demand

Table 10: Mapping of capacity in underlying science (RFA) required to conduct research into “Planning”

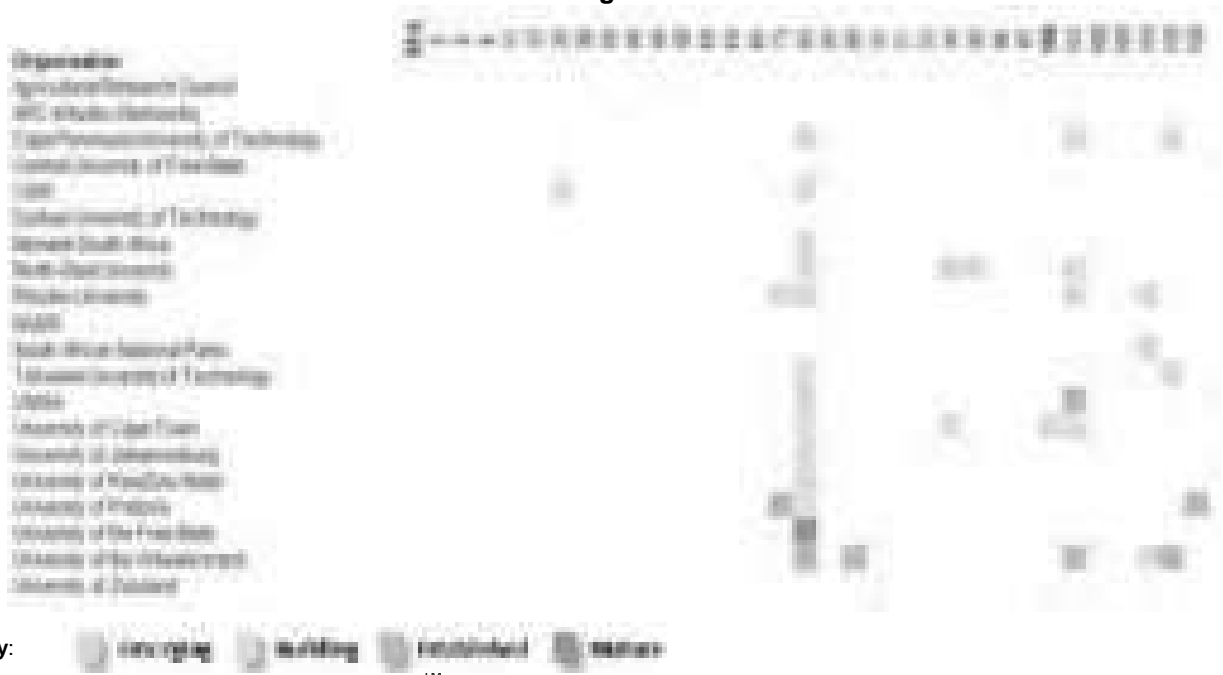


Key: Example Building Established Missing

Source: Mutualfruit Readiness to do Research™ 2014 survey, data analysis. n=209 RDD units

Note: RFA = Research Focus Area (please see RFA Taxonomy in Table 21, page 72). An RFA in red indicates no capacity identified at any academic units or research institutions.

**Table 11: Mapping of capacity in underlying science (RFA) required to conduct research into "Management"**



**Source:** Mutualfruit Readiness to do Research™ 2014 survey, data analysis. n=209 RDD units

**Note:** RFA = Research Focus Area (please see RFA Taxonomy in Table 21, page 72). An RFA in red indicates no capacity identified at any academic units or research institutions.

## 2.7 DEMAND CLUSTER 6: REDUCE LOSSES AND INCREASE EFFICIENCY OF PRODUCTIVE USE

### 2.7.1 Cluster definition, scope, and research initiatives

#### 2.7.1.1 Sector Objective

Reduce unintended losses and increase efficiency of **productive use**.

#### 2.7.1.2 Target RDD Outcome for 2025

**Non-productive uses of water have been eliminated or minimised.**

This is evinced by reductions in: water transport losses, leakages, volume of water use, output to unrecoverable sources, volume and toxicity of pollution, and discharge of poor quality water. There have been concomitant increases in: conjunctive use of water, the area under irrigation, efficiency of water use, and levels of water reuse.

#### 2.7.1.3 Research Initiatives

This cluster contains two research initiatives, which are:

Technical Loss	Identify, enable and support (municipalities to) targeted improvements in prioritised water loss situations through prevention, mitigation and reduction measures, including technology solutions, operational practices and institutional efficiencies.
Deliberate Demand	Support deliberate decision-making intended to optimise balance between the right to water and productive use of the water.  Develop and test technologies focused on efficiency of use, fitness for use, transfer of water and waste minimisation (with transfer to PARDP for demonstration and deployment where appropriate).



### 2.7.3 RDD Impact: Productive use

<b>Water Scarcity</b>	
Withdrawal, Consumption, Quality, Productive use	Moderate to high impact. Reduced withdrawal of raw water resources. Reduced consumption of raw and treated water. Improved productivity of use.
<b>Economic</b>	
Wealth	No impact
Productivity	Moderate to high impact on increased product per drop (WUE: tonnes/ ton of water) including manufacturing and agro-industry, and reduced down-time (e.g. caused by severe maintenance schedules necessitated by poor quality or intermittent water supply).
Revenue	Impact due to beneficial effects increasing average revenues per unit product and per m <sup>3</sup> delivered, and increasing average revenue per producer (e.g. farmer, ecosystem, environment).
Cost Reduction	Impact resulting from decreased water footprint per unit produced, reduced material inputs (and cost), reduced energy inputs (and cost), reduced labour requirement (and cost), and reduced cost of healthcare. Reduced cost of treating process water and potable water due to decrease in contamination of raw resources.
Investment	Impact due to reduced capex requirements and reduced maintenance costs.
<b>Health</b>	
Sickness and Disease	No impact
Wellness and Mortality	No impact
<b>Society</b>	
Food and livestock	Effects will include: reduced environmental debt and improved availability and quality of environmental goods and services.
Education	No impact
Relations and rights	Improved relations between all suppliers and consumers in a catchment (e.g. WUAs and farmers). Satisfaction of rights and demands of those without access to water. Improved availability and quality of environmental goods and services.
Awareness and Behaviour	No impact
<b>Environment</b>	
Emissions, contaminants, pollution	Reduction in the following: carbon emissions, groundwater contamination, contamination of surface water, downstream pollution.
Preservation and health	Preservation of riverine habitats, and improved health of terrestrial environment.

2.7.4 Strategic RDD Programme: Productive use

Short Term (2016 - 2018)	Medium Term (2018 - 2024)	Long Term (2024 - 2030)
<p><b>Objective</b></p> <ul style="list-style-type: none"> <li>Reduce energy intensity levels and improve energy efficiency</li> </ul> <p><b>RDD Focus</b></p> <ul style="list-style-type: none"> <li>Identify and quantify energy savings opportunities</li> </ul>	<p><b>Technical Area: Professional Services</b></p> <p><b>Objective</b></p> <ul style="list-style-type: none"> <li>Target commercial and industrial sectors</li> <li>Increase energy efficiency in industrial sector</li> </ul> <p><b>RDD Focus</b></p> <ul style="list-style-type: none"> <li>Develop and deploy industrial energy efficiency solutions</li> </ul>	<p><b>Technical Area: Professional Services</b></p> <p><b>Objective</b></p> <ul style="list-style-type: none"> <li>Target commercial and industrial sectors</li> <li>Increase energy efficiency in industrial sector</li> </ul> <p><b>RDD Focus</b></p> <ul style="list-style-type: none"> <li>Develop and deploy industrial energy efficiency solutions</li> </ul>
<p><b>Objective</b></p> <ul style="list-style-type: none"> <li>Reduce energy intensity levels and improve energy efficiency</li> </ul> <p><b>RDD Focus</b></p> <ul style="list-style-type: none"> <li>Identify and quantify energy savings opportunities</li> </ul>	<p><b>Technical Area: Professional Services</b></p> <p><b>Objective</b></p> <ul style="list-style-type: none"> <li>Target commercial and industrial sectors</li> <li>Increase energy efficiency in industrial sector</li> </ul> <p><b>RDD Focus</b></p> <ul style="list-style-type: none"> <li>Develop and deploy industrial energy efficiency solutions</li> </ul>	<p><b>Technical Area: Professional Services</b></p> <p><b>Objective</b></p> <ul style="list-style-type: none"> <li>Target commercial and industrial sectors</li> <li>Increase energy efficiency in industrial sector</li> </ul> <p><b>RDD Focus</b></p> <ul style="list-style-type: none"> <li>Develop and deploy industrial energy efficiency solutions</li> </ul>
<p><b>Objective</b></p> <ul style="list-style-type: none"> <li>Reduce energy intensity levels and improve energy efficiency</li> </ul> <p><b>RDD Focus</b></p> <ul style="list-style-type: none"> <li>Identify and quantify energy savings opportunities</li> </ul>	<p><b>Technical Area: Professional Services</b></p> <p><b>Objective</b></p> <ul style="list-style-type: none"> <li>Target commercial and industrial sectors</li> <li>Increase energy efficiency in industrial sector</li> </ul> <p><b>RDD Focus</b></p> <ul style="list-style-type: none"> <li>Develop and deploy industrial energy efficiency solutions</li> </ul>	<p><b>Technical Area: Professional Services</b></p> <p><b>Objective</b></p> <ul style="list-style-type: none"> <li>Target commercial and industrial sectors</li> <li>Increase energy efficiency in industrial sector</li> </ul> <p><b>RDD Focus</b></p> <ul style="list-style-type: none"> <li>Develop and deploy industrial energy efficiency solutions</li> </ul>

2.7.5 HCD Outline Plans per research initiative: Productive use

2.7.5.1 Technical Loss

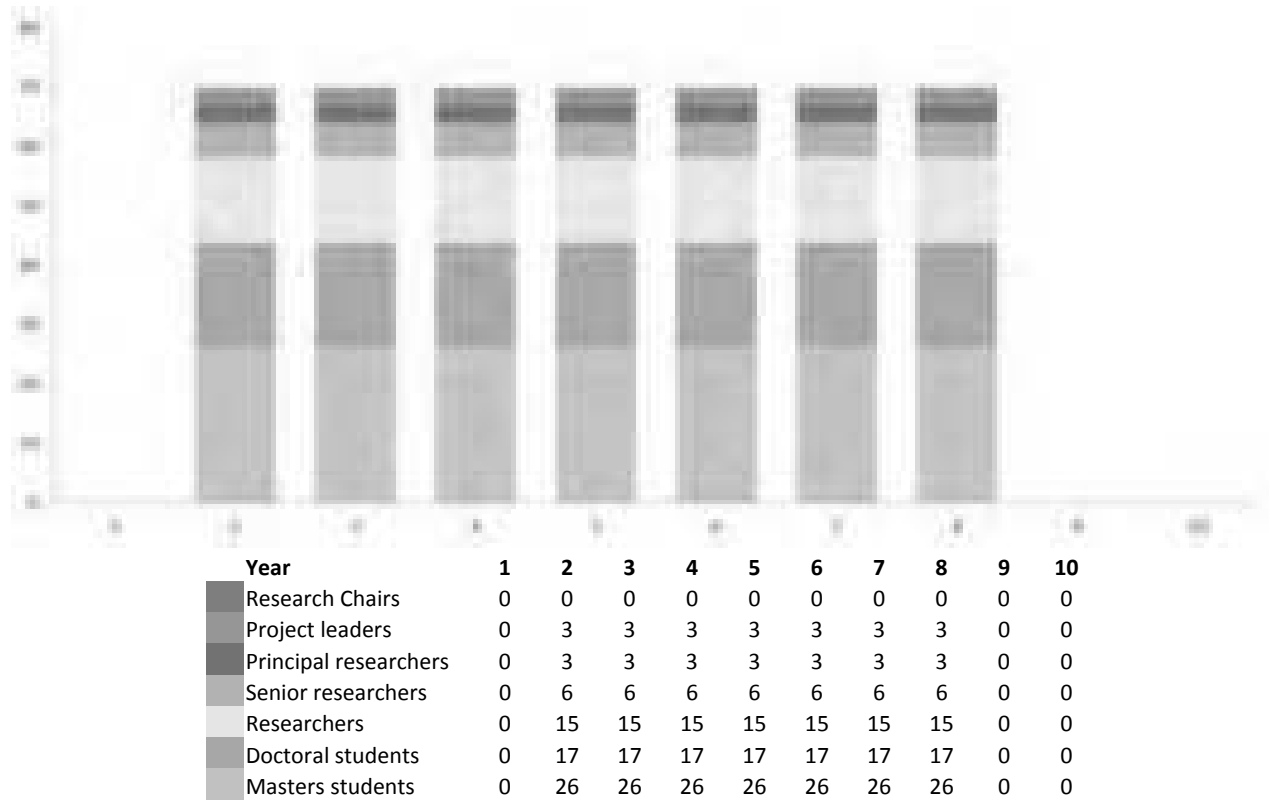
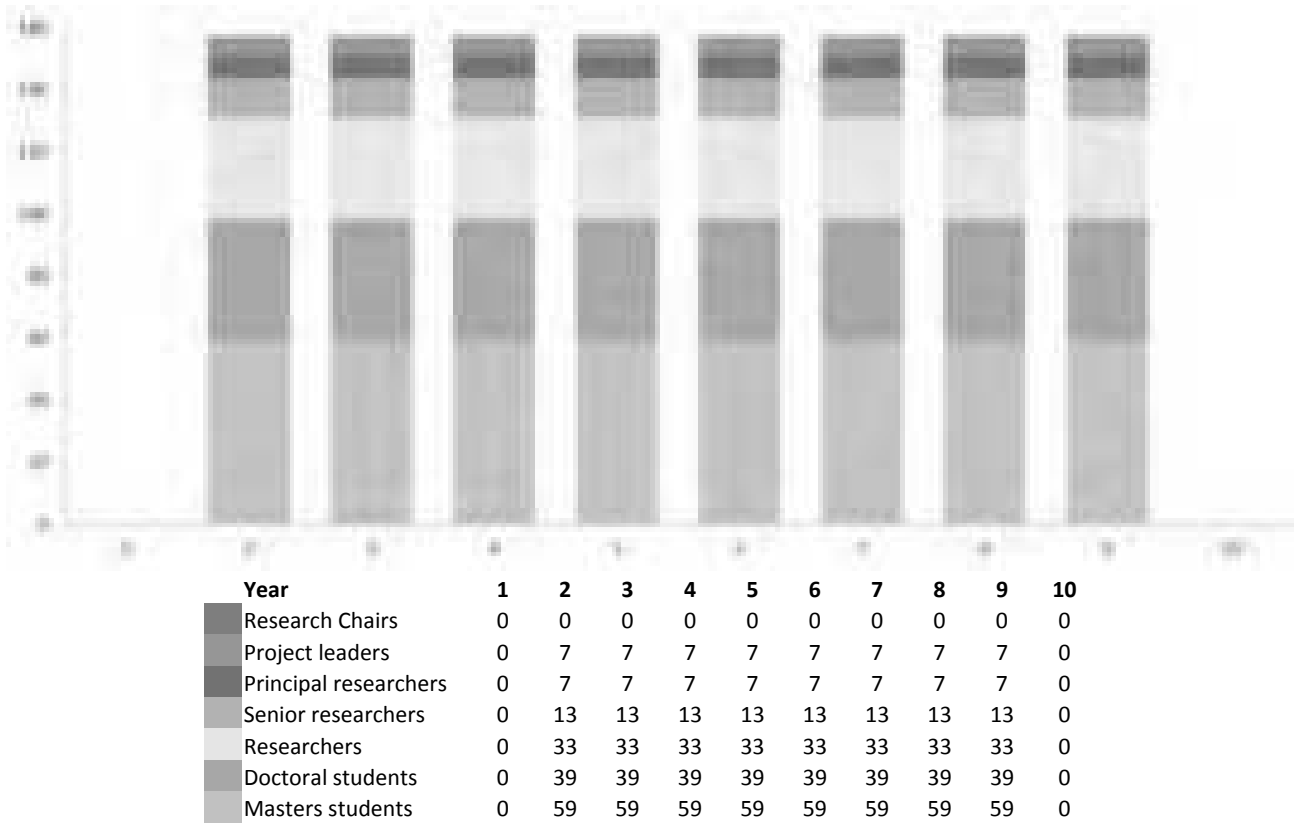


Figure 12: Research Capacity required each year to carry out RDD Programme, for “Technical Loss” in the Cluster, Productive Use

**Table 12: Mapping of capacity in underlying science (RFA) required to conduct research into “Technical Loss”**

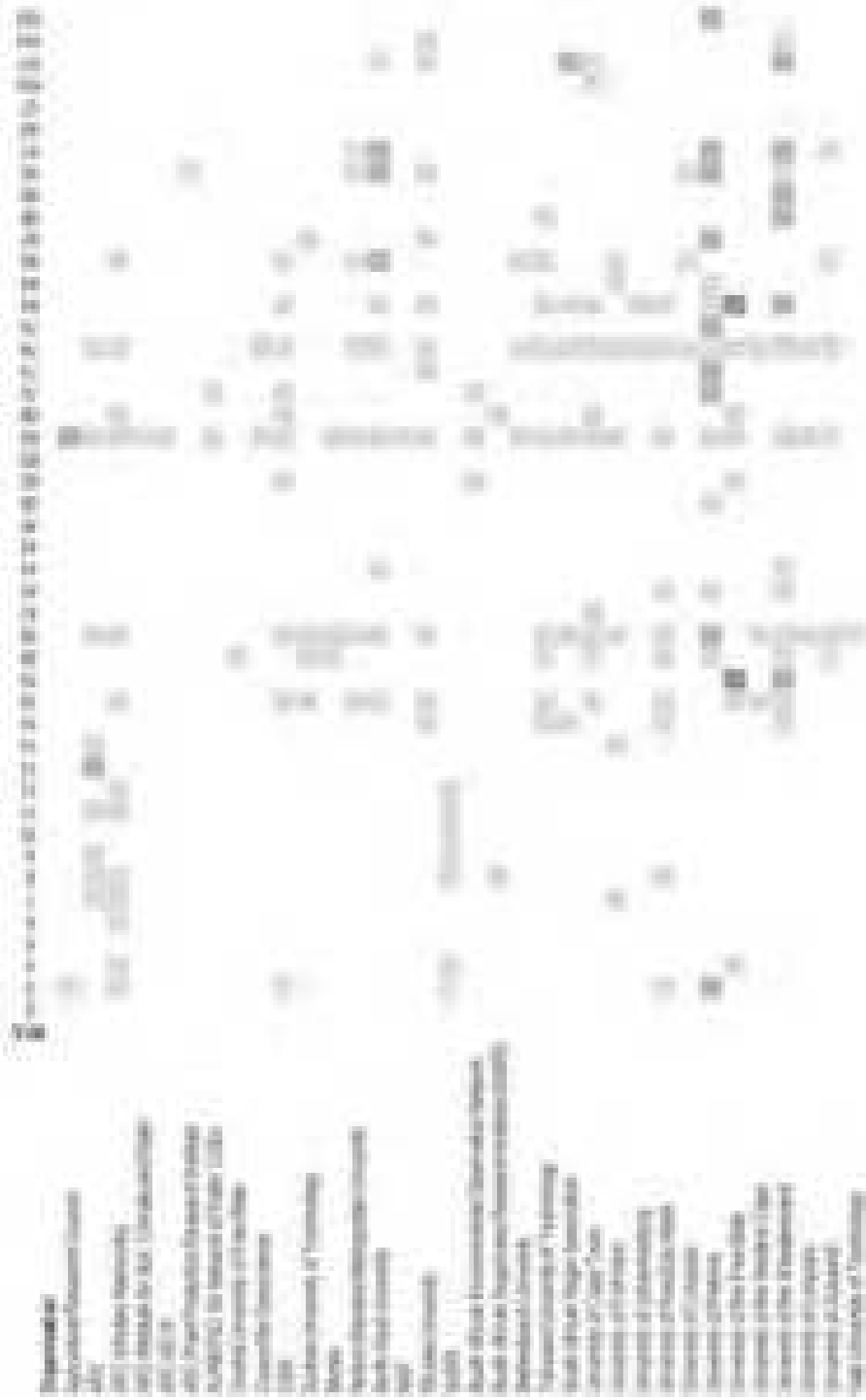


2.7.5.2 Deliberate Demand



**Figure 13: Research Capacity required each year to carry out RDD Programme, for “Technical Loss” in the Cluster, Productive Use**

**Table 13: Mapping of capacity in underlying science (RFA) required to conduct research into “Technical Loss”**



**Key:** Existing Building Discontinued Missing

**Source:** Mutualfruit Readiness to do Research™ 2014 survey, data analysis. n=209 RDD units

**Note:** RFA = Research Focus Area (please see RFA Taxonomy in Table 21, page 72). An RFA in red indicates no capacity identified at any academic units or research institutions.

## 2.8 DEMAND CLUSTER 7: IMPROVE PERFORMANCE OF PRICING, MONITORING, BILLING, METERING AND COLLECTION

### 2.8.1 Cluster definition, scope, and research initiatives

#### 2.8.1.1 Sector Objective

Improve performance of **Pricing, Monitoring, Billing**, Metering and Collection.

#### 2.8.1.2 Target RDD Outcome for 2025

##### **Improved accuracy has been attained in water use monitoring, billing and management**

Pricing is equitable, the attribution of water use is accurate. Non-revenue water is below 15% and revenues are collected punctually.

#### 2.8.1.3 Research Initiatives

This cluster contains two research initiatives, which are:

<b>Cost:</b>	Improve results of pricing by creating and optimising pricing and billing systems that are representative of true cost of water and sanitation services
<b>Volume:</b>	Improve the performance (coverage and accuracy) of flow monitoring, metering, distribution, billing and collection processes and systems

## 2.8.2 RDD Response: Pricing, Monitoring, Billing

<b>RDD Activity</b>	
RDD Focus and Progression	Explore new tools for management and metering. Test, demonstrate and deploy technologies and build human capacity.
Underlying Science	Multiple disciplines within WCDM, loss minimisation, M&E and automation / control.
<b>Know-How</b>	
Intellectual Property	No / little potential for commercial IP envisaged
Knowledge Diffusion	Extremely small pool of expertise. Too many groups at levels 0 to 3, thus investment into technology import and deployment is needed.
<b>Readiness to do Research™</b>	
Capacity	Small number of research groups that are distributed between universities, and a mixture of public and private organisations. Most groups are emerging or building. Only six RFAs represented.
Strength	Investment needed into knowledge generation, and HCD. Research groups require strengthening and multiplying. TRP needed to focus funding.
<b>RDI Infrastructure</b>	
Install, Expand	Investment required into capacity building, technology demonstration and deployment, and metering methods.
<b>Customers and Partners</b>	
Government and Stakeholders	DWS, SALGA, Water Boards, Water Services Authorities, Water Services Providers
Private Sector	Private sector engineering companies.
Research	
Agencies	WRC, possibly TIA
Science Councils and Universities	Partnerships at HEIs, private and public companies, and science councils, with specific partners depending on RFA, discipline, and scale of technology
Other Partnerships	Ofwat

**Agencies** are largely responsible for enablement, such as funding, providing partnerships, or other support mechanisms. **Science Councils and Universities** have roles and mandates relating to fundamental research, applied research, industrial development, and scale-up of innovative products and processes. **Other partners** will be involved in diverse activities, for example, dissemination of new knowledge, assistance with finding and securing sites and/or partners for piloting / demonstration, co-funding, promotion of the RDI Outputs to their networks

### 2.8.3 RDD Impact: Pricing, Monitoring, Billing

<b>Water Scarcity</b>	Moderate to high impact. Reduced withdrawal of raw water resources. Reduced consumption of raw and treated water. Improved productivity of Quality, Productive use
<b>Economic</b>	
Wealth	Impact
Productivity	Moderate to high impact on increased product per drop (WUE: tonnes/ ton of water) including manufacturing and agroindustry, and reduced down-time (e.g. caused by severe maintenance schedules necessitated by poor quality or intermittent water supply).
Revenue	Impact due to beneficial effects increasing average revenues per unit product and per m <sup>3</sup> delivered, and increasing average revenue per producer (e.g. farmer, ecosystem, environment).
Cost Reduction	Impact resulting from decreased water footprint per unit produced, reduced material inputs (and cost), reduced energy inputs (and cost), reduced labour requirement (and cost), and reduced cost of healthcare. Reduced cost of treating process water and potable water due to decrease in contamination of raw resources.
Investment	Impact due to reduced capex requirements and reduced maintenance costs.
<b>Health</b>	
Sickness and Disease	No impact
Wellness and Mortality	No impact
<b>Society</b>	
Food and livestock	Effects will include: reduced environmental debt and improved availability and quality of environmental goods and services.
Education	No impact
Relations and rights	Improved relations between all suppliers and consumers in a catchment (e.g. WUJAs and farmers). Satisfaction of rights and demands of those without access to water.
Awareness and Behaviour	Raised awareness of the value of water, driving increased willingness to pay.
<b>Environment</b>	
Emissions, contaminants, pollution	Reduction in the following: carbon emissions, contamination of surface water, downstream pollution.
Preservation and health	No impact

2.8.4 Strategic RDD Programme: Pricing, Monitoring, Billing

Period: 2010-2015	Period: 2016-2020	Period: 2021-2025	Period: 2026-2030	Period: 2031-2035
<p><b>Strategic Objectives:</b></p> <ul style="list-style-type: none"> <li>• Enhance the quality of research and development activities, research outcomes, and innovation.</li> </ul>	<p><b>Strategic Objectives:</b></p> <ul style="list-style-type: none"> <li>• Enhance the quality of research and development activities, research outcomes, and innovation.</li> </ul>	<p><b>Strategic Objectives:</b></p> <ul style="list-style-type: none"> <li>• Enhance the quality of research and development activities, research outcomes, and innovation.</li> </ul>	<p><b>Strategic Objectives:</b></p> <ul style="list-style-type: none"> <li>• Enhance the quality of research and development activities, research outcomes, and innovation.</li> </ul>	<p><b>Strategic Objectives:</b></p> <ul style="list-style-type: none"> <li>• Enhance the quality of research and development activities, research outcomes, and innovation.</li> </ul>
<p><b>Key Results:</b></p> <ul style="list-style-type: none"> <li>• Increase in the number of research and development activities, research outcomes, and innovation.</li> </ul>	<p><b>Key Results:</b></p> <ul style="list-style-type: none"> <li>• Increase in the number of research and development activities, research outcomes, and innovation.</li> </ul>	<p><b>Key Results:</b></p> <ul style="list-style-type: none"> <li>• Increase in the number of research and development activities, research outcomes, and innovation.</li> </ul>	<p><b>Key Results:</b></p> <ul style="list-style-type: none"> <li>• Increase in the number of research and development activities, research outcomes, and innovation.</li> </ul>	<p><b>Key Results:</b></p> <ul style="list-style-type: none"> <li>• Increase in the number of research and development activities, research outcomes, and innovation.</li> </ul>
<p><b>Key Results:</b></p> <ul style="list-style-type: none"> <li>• Increase in the number of research and development activities, research outcomes, and innovation.</li> </ul>	<p><b>Key Results:</b></p> <ul style="list-style-type: none"> <li>• Increase in the number of research and development activities, research outcomes, and innovation.</li> </ul>	<p><b>Key Results:</b></p> <ul style="list-style-type: none"> <li>• Increase in the number of research and development activities, research outcomes, and innovation.</li> </ul>	<p><b>Key Results:</b></p> <ul style="list-style-type: none"> <li>• Increase in the number of research and development activities, research outcomes, and innovation.</li> </ul>	<p><b>Key Results:</b></p> <ul style="list-style-type: none"> <li>• Increase in the number of research and development activities, research outcomes, and innovation.</li> </ul>
<p><b>Key Results:</b></p> <ul style="list-style-type: none"> <li>• Increase in the number of research and development activities, research outcomes, and innovation.</li> </ul>	<p><b>Key Results:</b></p> <ul style="list-style-type: none"> <li>• Increase in the number of research and development activities, research outcomes, and innovation.</li> </ul>	<p><b>Key Results:</b></p> <ul style="list-style-type: none"> <li>• Increase in the number of research and development activities, research outcomes, and innovation.</li> </ul>	<p><b>Key Results:</b></p> <ul style="list-style-type: none"> <li>• Increase in the number of research and development activities, research outcomes, and innovation.</li> </ul>	<p><b>Key Results:</b></p> <ul style="list-style-type: none"> <li>• Increase in the number of research and development activities, research outcomes, and innovation.</li> </ul>

\* Time frames overlap, due to difference in duration of RPs for Cost and Volume.

2.8.5 HCD Outline Plans per research initiative: Pricing, Monitoring, Billing

2.8.5.1 Cost

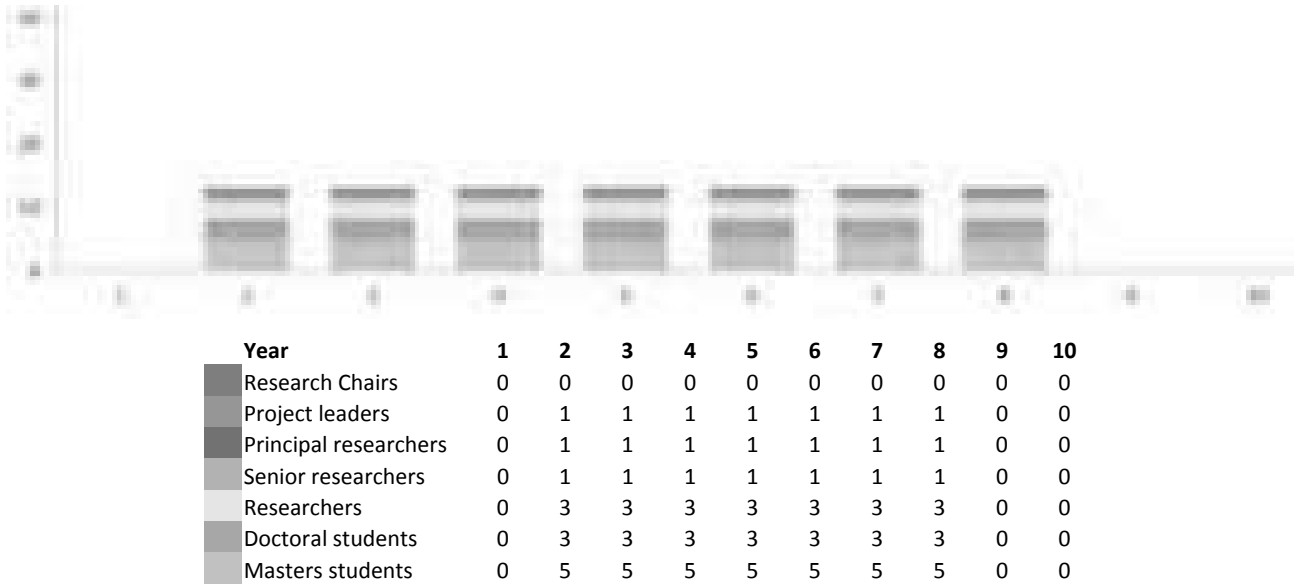


Figure 14: Research Capacity required each year to carry out RDD Programme, for “Cost” in the Cluster, Price, Monitor, Bill

Table 14: Mapping of capacity in underlying science (RFA) required to conduct research into “Cost”



Key: Existing Building Doubtful Missing

Source: Mutualfruit Readiness to do Research™ 2014 survey, data analysis. n=209 RDD units

Note: RFA = Research Focus Area (please see RFA Taxonomy in Table 21, page 72). An RFA in red indicates no capacity identified at any academic units or research institutions.

2.8.5.2 Volume

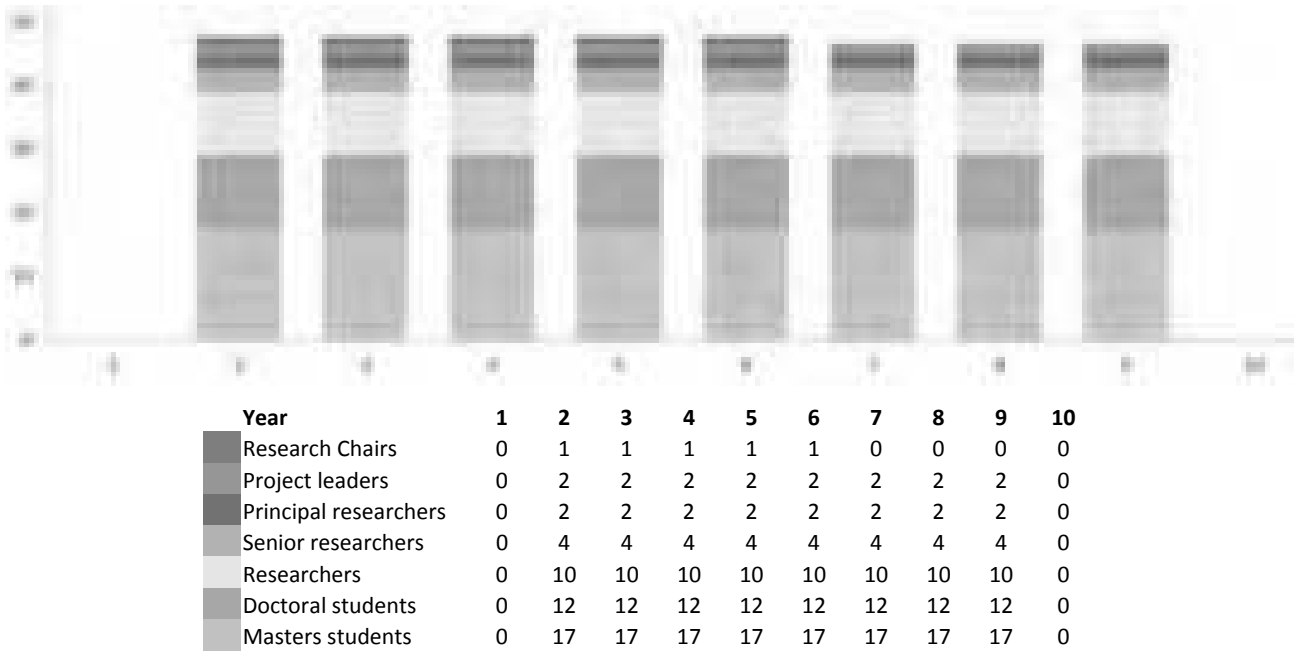
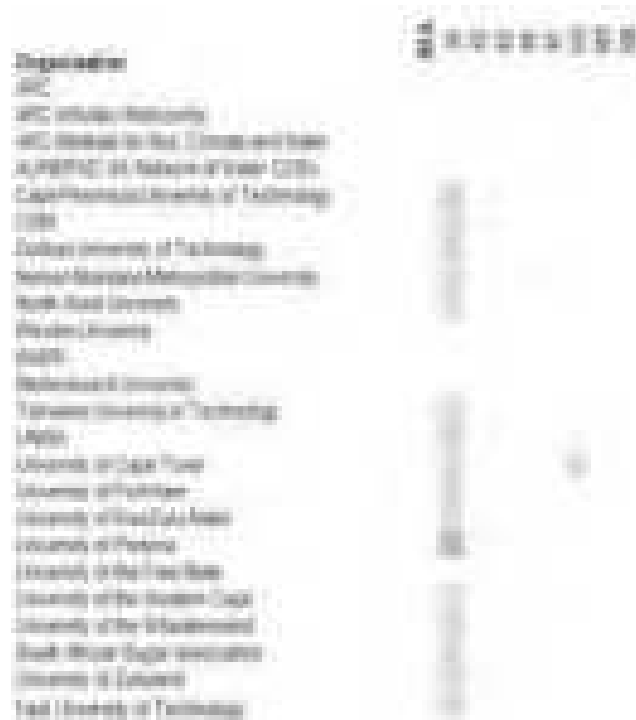


Figure 15: Research Capacity required each year to carry out RDD Programme, for “Volume” in the Cluster, Price, Monitor, Bill

Table 15: Mapping of capacity in underlying science (RFA) required to conduct research into “Volume”



Key: ■ Existing ■ Building ■ Doubtful ■ Missing

Source: Mutualfruit Readiness to do Research™ 2014 survey, data analysis. n=209 RDD units

Note: RFA = Research Focus Area (please see RFA Taxonomy in Table 21, page 72). An RFA in red indicates no capacity identified at any academic units or research institutions.

## CHAPTER 3: RETURNS AND INVESTMENTS

Section 3.1 presents the anticipated returns, in the form of impact and outputs, that results from the successful implementation of the Research, Development, and innovation / deployment programmes that have been designed for the seven Clusters listed in sections 2.2 to 2.8 above.

Section 3.2 presents the associated investment requirements that enable the ten-year programmes. These were quantified for each Cluster based on the respective RDD programmes. A structured, parameter-driven investment modelling approach was used, based on a set of established investment instruments.

### 3.1 ANTICIPATED RETURNS ON INVESTMENT

There are broadly three areas that the return on the roadmap investment can be considered.

- 1) Medium to long term savings that are unlocked by making the projected 10 year RDI investment;
- 2) Socio-economic impacts that investment in and implementation of the roadmap create;
- 3) Direct and measurable outputs that will be created from the roadmap investment.

At present there is not a clear idea of the over system level savings that can be achieved by making the projected 10 year RDI investment. This area of work will be explored as part of the implementation programme of the water roadmap. It is however, possible to derive some early estimates from specific sub-sectors and case studies within the water sector.

The investment model is systemic and focused on delivering socio-economic impact. These socio-economic impacts were illustrated in Chapter 2 in terms of the anticipated impact of each cluster. The anticipated impacts of implementing the roadmap are beneficial effects on water scarcity, economics, public health, society, and the natural and built environment.

There are also many direct and measurable RDI related outputs that will emerge from the roadmap investment. Figure 16 illustrates an overview of the RDI investment focus and returns. To realise the socio-economic impacts, investments are required to support technology development, knowledge generation, and human capital development.



Figure 16: Overview of the investment focus and returns

The return on the investment includes a set of RDI Outputs, as shown in Table 16. These values assume that a) total investment indicated is made and b) RDD Productivity assumptions (please see Table 17) are achieved in practice.

Assumptions in respect of investment in Human Capital Development and Knowledge Generation are derived from prior domain experience in South Africa. Anticipated conversion rates in technology development are consistent with international benchmarks in the translation of science to end-use technology. The investment per patent application refers to the level of investment in R&D activity that typically results in one patent application, and not to the cost of patent application fees and management.

The return on investment in terms of research capacity is considerable. Figure 17 indicates that significant strengthening of research capacity can be expected if the seven Cluster RDD programmes are implemented.

**Table 16: Anticipated RDD Outputs, by Objective and Indicator**

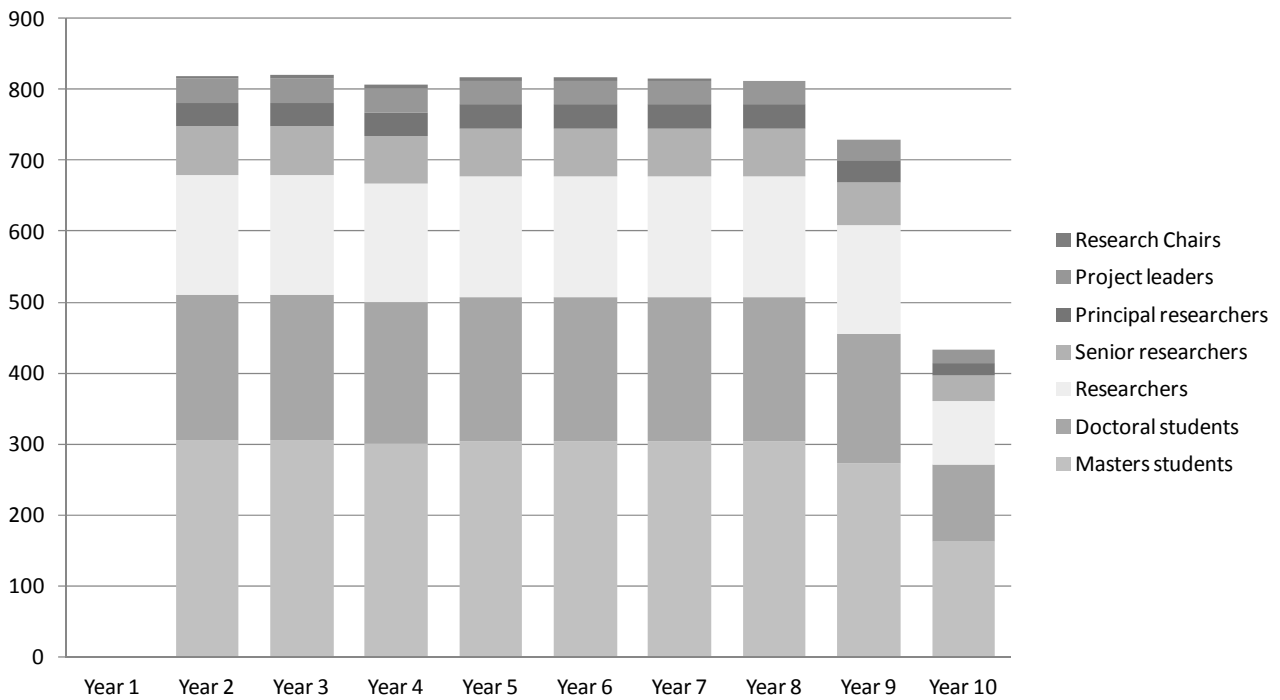
Objectives	Key Performance Indicator	RDD Outputs*	Explanatory notes
Technology Development	Breakthrough products and services to market	2	Breakthrough technologies
	Technology packages	11	New technols. developed / deployed
	Prototypes	32	Brand new technols. developed
Knowledge Generation	Registered full patents	78	New, full patents
	Provisional patents / applications	224	Provisional patent applications
	Publications	1937	Peer-reviewed
<i>In addition to current national HCD numbers in water SET, which are (ASSAf, 2010<sup>1</sup>):</i>			
Human Capital Development	Post-doctoral researchers	215	425
	Doctorates	537	1274
	Masters	805	7516

Note that Table 16 and 17 need to be read together in order to understand output assumptions.

**Table 17: RDD Productivity Assumptions**

Objectives	Assumption	Value	Explanatory notes
Technology Development	Investment per tech development prototype	R10 million	Average, from national experience
	Prototype iterations per technology package	3	Average no. prototype generations
	Success rate for transfer	60%	From research to development
	Success rate for commercialisation	30%	From development to implementation / commercialised product or service
Knowledge Generation	Investment to point of patent appl.	R21 million	Value of R&D activity resulting in patent
	Success rate of registered patents	35%	No. successfully licensed / commercialised
Human Capital Development	Success rate of M and D level candidates	80%	20% drop-out rate (ASSAf, 2010 <sup>1</sup> )
	No. of years to graduation	2.5 Masters 4 Doctoral	Average time to achieve degree (ASSAf, 2010 <sup>1</sup> )
	Multiplier to pay for overheads such as office space and equipment	1%	Cost estimate for research group office and communications equipment

<sup>1</sup> ASSAf (2010). *The PhD Study*. Academy of Science of South Africa



**Figure 17: Number of additional people entering water-related SET research via the ten year RDI programme, categorised by research seniority**

The root contribution of the Roadmap to sector success comes through allowing better coordination, improved decision-making, and greater enablement, principally through the systematic translation of research into operational practice

Products and services delivered to market is but the end point of a total pipeline of technology development that includes attempts and failures. This is expressed by the conversion ratios in Table 17.

The principal purpose of technology in the water RDI Roadmap is deployment to solve national needs. The return on the total investment over 10 years is expressed clearly on page 11 (South Africa's water and wastewater industry outperforms) – i.e. if we are successful in the execution of our RDD Objectives (listed in full on page 77), we will have enabled the water sector to have achieved its objectives (right-most column)

If the purpose of investment in technology were for the purpose of export, this would have driven a different strategy. Our target market would have been different and our approach to developing a market strategy would have assessed needs and South Africa's ability to satisfy them better, faster (and possibly cheaper) than the competition.

We assessed the Impact and summarised this in Table 18. However, due to the lack of underlying data and associated models – as identified in discussions with a leading resource economist – this project could not provide a more specific and quantified estimation of the overall value, as was the case for the ICT and Waste Roadmaps.

However, it should be noted that some of the impacts may be semi-quantifiable. For example, “the country loses R7 billion a year to water losses<sup>1</sup>”. One of the performance measures of the RDI Roadmap is the reduction of water losses from a national average of approx. 35% to 15%; this would indirectly create a saving of approx. R3.5 billion per annum to the nation. Quantifying the benefits of the Water RDI Roadmap is an ongoing initiative.

<sup>1</sup> President Zuma, State of the Nation Address 2015

**Table 18: Significant Impact anticipated on five dimensions – Summary**

<b>Water Scarcity</b>	
Withdrawal,	
Consumption, Quality, Productive use	Reduced withdrawal of raw water resources. Reduced consumption of raw and treated water. Improved water quality. Improved productivity of use.
<b>Economic</b>	
Wealth	Impact not yet fully quantified
Productivity	Increased product per drop (WUE: tonnes/ ton of water) including manufacturing and agro-industry, and reduced down-time (e.g. caused by severe maintenance schedules necessitated by poor quality or intermittent water supply).
Revenue	Impact due to beneficial effects increasing average revenues per unit product and per m <sup>3</sup> delivered, and increasing average revenue per producer (e.g. farmer, ecosystem, environment).
Cost Reduction	Impact resulting from decreased water footprint per unit produced, reduced material inputs (and cost), reduced energy inputs (and cost), reduced labour requirement (and cost), and reduced cost of healthcare. Reduced cost of treating process water and potable water due to decrease in contamination of raw resources.
Investment	Impact due to reduced capex requirements and reduced maintenance costs.
<b>Health</b>	
Sickness and Disease	Impact will be made through the reduction of waterborne sickness and disease
Wellness and Mortality	Impact will be result from reduced absenteeism and early retirement – through increased wellness – and a reduced mortality rate
<b>Society</b>	
Food and livestock	Effects will include: increased food security – livestock, crops, and reduced loss of animals.
Education	Increased school attendance (driven by water access and quality) and improved educational outcomes will exert moderate influence on education
Relations and rights	Improved relations between all suppliers and consumers in a catchment (e.g. WUAs and farmers). Satisfaction of rights and demands of those without access to water.
Awareness and Behaviour	Raised awareness of the value of water, driving increased willingness to pay
<b>Environment</b>	
Emissions, contaminants, pollution	Reduction in the following: carbon emissions, area of salinised land, groundwater contamination, contamination of surface water, downstream pollution.
Preservation and health	Reduced or reversed decline in biodiversity, preservation of riverine habitats, reduced soil erosion and improved health of terrestrial environment, improved availability and quality of environmental goods and services, reduced environmental debt

### 3.2 INVESTMENT REQUIREMENTS

The overall investment ambition required to achieve all aspects of the roadmap over a 10 year period is R 8.419 billion. The investment required can be itemised according to source of funding, to Cluster of needs / interventions, and to investment instrument.

The sources of funding contemplated are the Water Levy (via the WRC), the DST and its organisations (such as the NRF and TIA), other government departments (for example focused programmes of the DWS, DEA, and DAFF), and industrial funding (including the private sector and SOEs such as Eskom).

A table itemising the investment requirements breakdown is shown on page 79. This section presents summaries of the same figures, showing investment per Cluster year-on-year (Figure 18) and in total (Figure 19), investment instrument year on year (Figure 20) and in total (Figure 21). Finally Figure 22 and 23 illustrate how catalytic public funding investment unlocks co-funding and industry leverage.

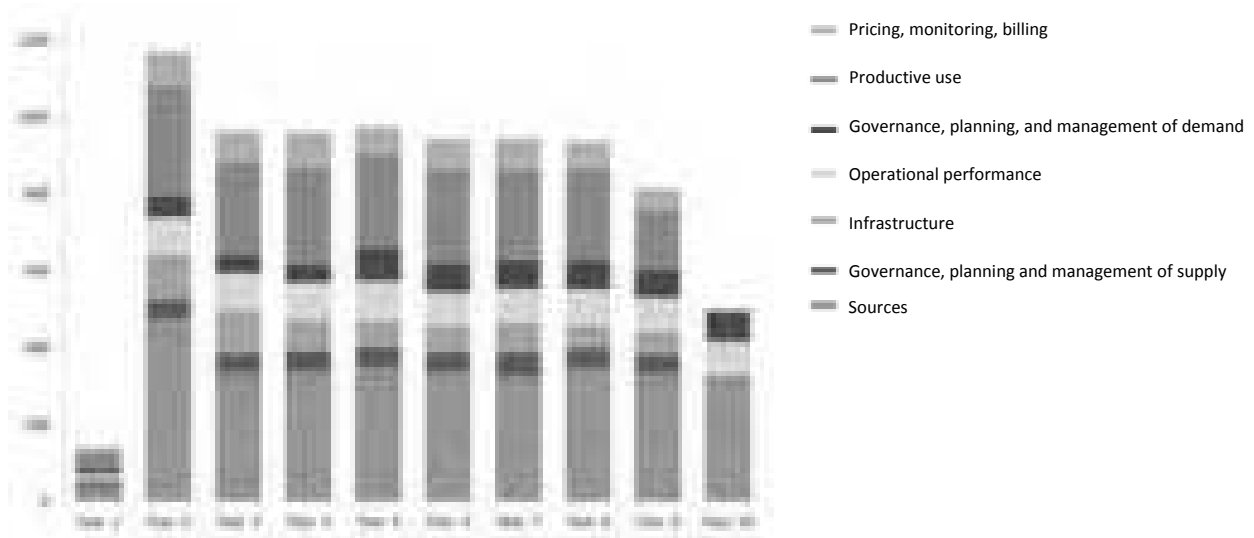


Figure 18: Investment requirement per year, by cluster, in ZARm

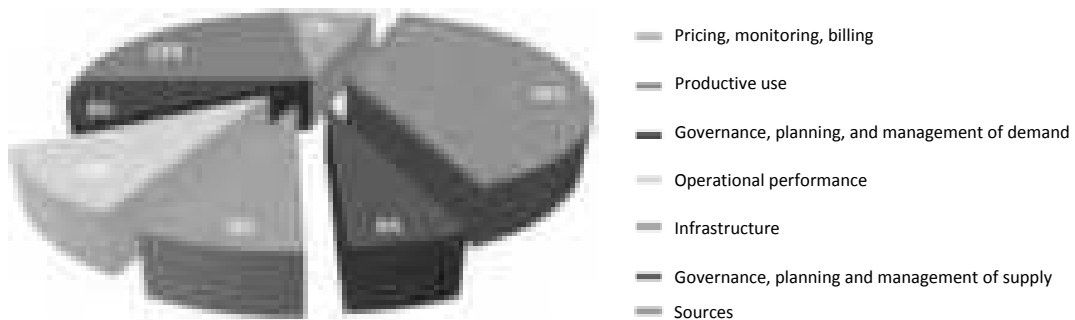


Figure 19: Total investment requirement, proportion of investment per Cluster

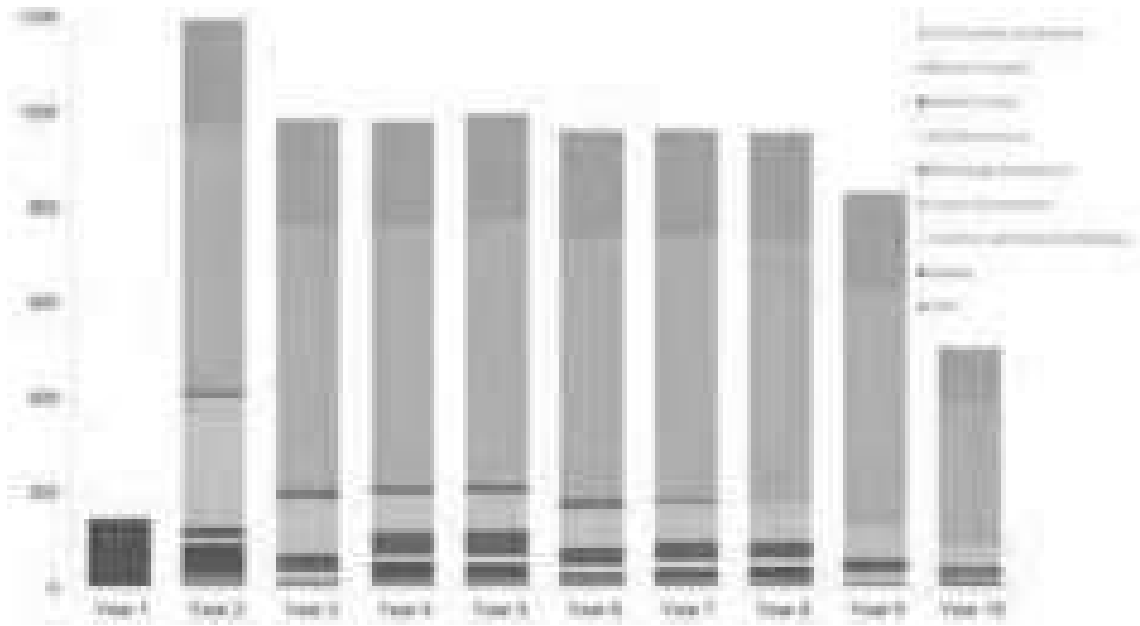


Figure 20: Investment requirement per year, by investment instrument, in ZARm

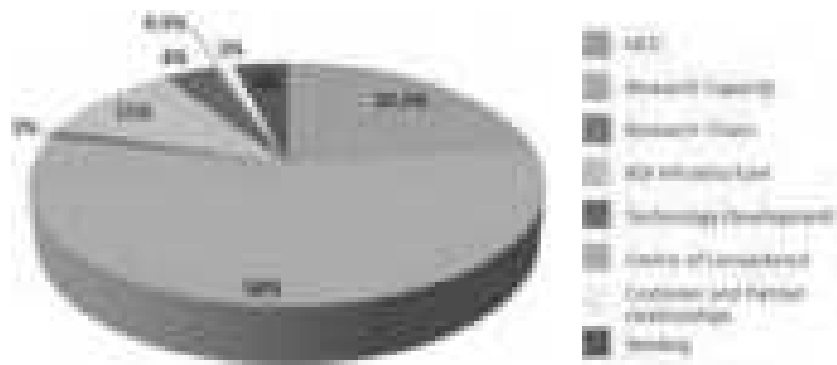


Figure 21: Total investment requirement, proportion of investment per instrument

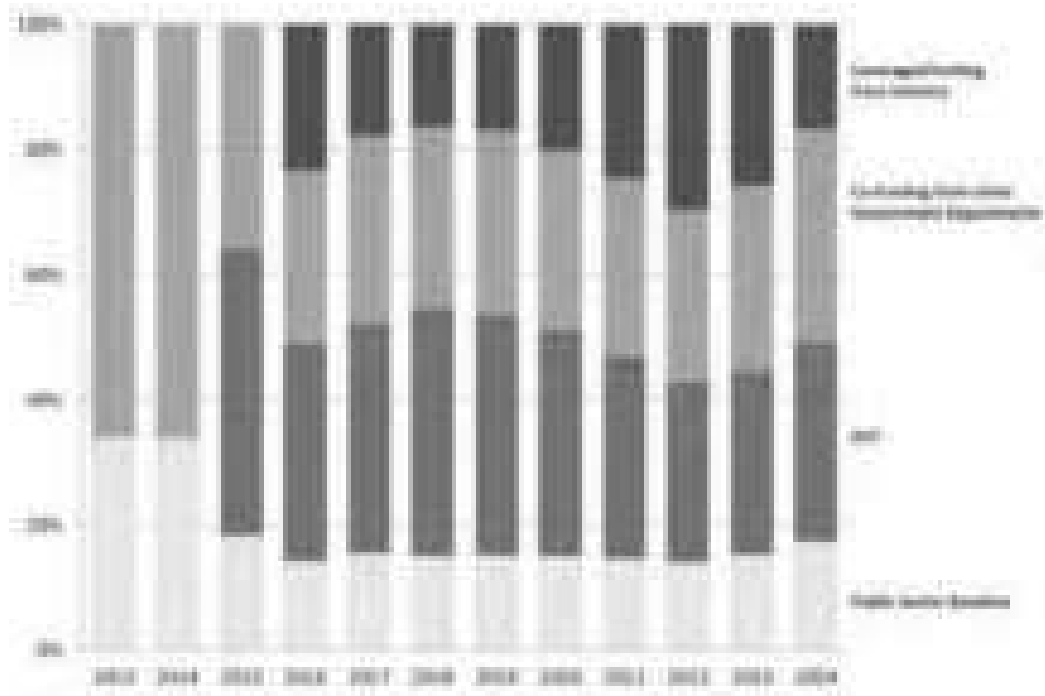


Figure 22: Funding by source as % of investment requirement, by year

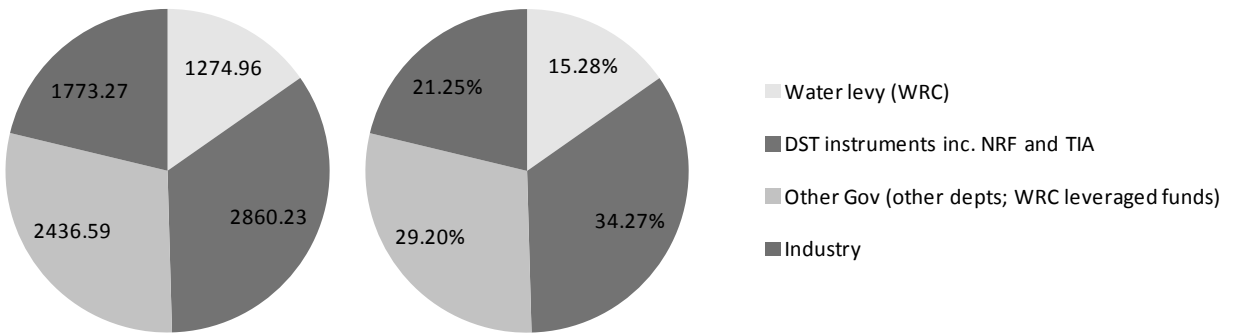


Figure 23: Funding by source in total, over ten years in R million (left) and as proportion of total investment requirement (right)

## CHAPTER 4: APPROACH AND PARTICIPATION

---

Having provided the context and case for action in Chapter 1, and the roadmap itself in Chapter 2, and investments with returns on investments in Chapter 3, this chapter presents the two-stage, customer-driven approach to development of the Roadmap (Figure 24).

Step 1 was an exploration of what customers want provided the basis for a focused approach to developing South Africa's Research, Development, and Deployment (RDD) Response. Step 2 was framing the RDD response, and developing out the roadmap itself. The two steps were broken down into eleven phases of work, which are summarised in chronological order in Figure 24 and will be described in the following sections.

### 4.1 WHAT DO CUSTOMERS WANT?

#### 4.1.1 Identify customer needs

The 'customers' in this context were members of the water community of professionals, which were divided into four sectors:

- Agriculture
- Industry
- The public sector
- Environmental protection

A comprehensive series of 32 work sessions and workshops took place between June 2013 and January 2015.

To identify customers' needs, the four sectors were initially engaged separately. The premise of the roadmap was explained in summary, and then they were given a blank slate upon which to write simple statements of needs specific to their sector. The four sectors' lists of needs were captured into a first long list of 154 statements (Table A1, Appendix A). The statements of each sector were not shared with the other three sectors until the second round of work sessions, as each sector was required to provide their own, sector-specific list of needs rather than to choose needs from a menu of previous inputs.

#### 4.1.2 Review needs, and articulate interventions

The second series of sector work sessions used the list of 154 needs as a departure point. The participants were provided with the list, and asked to review it for clarity and mutual understanding. They were then asked to describe what interventions they deemed would enable each need to be met.

The participants were asked to provide the **nature** of the intervention required to satisfy the need, without prescribing a solution. The interventions were drawn up by breakaway groups within each sector work session, and then exchanged in plenary. A satisfying level of convergence emerged during these sessions. The interventions are listed in full in Table A1 (Appendix A).



### 4.1.3 Confirm clusters of needs and interventions

Several of the needs stated were either the same, but phrased differently, or were so similar that they could be combined into a single rewritten definition of a need. The individual statements of need and their associated interventions (Table A1) were therefore collated by the project team into a shorter list of 41 (Table A2, Appendix A), which simply removed duplicate needs and recorded which needs had been expressed by which sector. The frequency with which each need was expressed was later used as an input into the assessment of impact (boxes 9 and 10 in Figure 24 above).

The list of needs shown in Table A2 was used as the basis for a second round of sector-specific work sessions in which the same participants were asked back to review the list, both for clarity and insurance of common understanding, and to ensure that the nuanced meaning they had intended to convey had not been lost during the collation process. The participants were then asked to group the individual needs into clusters of needs which could be readily related to one another. These clusters form the basis of the programme of work of the roadmap.

The resulting clusters of needs that emerged were:

#### Water supply

1. Increase ability to make use of more **sources** of water, including alternatives
2. Improve **governance, planning and management of supply** and delivery
3. Improve adequacy and performance of supply **infrastructure**
4. Run water as a financially sustainable “**business**” by improving **operational performance**

#### Water demand

5. Improve **governance, planning, and management of demand** and use
6. Reduce losses and increase efficiency of **productive use**
7. Improve performance of **pricing, monitoring, billing**, metering and collection

The clustering exercise enabled the project team to collate the interventions according to the newly defined clusters. Table 19 shows which needs were identified by which sectors, and what the summarised interventions were.

**Table 19: Clustered needs identified by the four sectors, and their summarised interventions**

Table 17		Agriculture	Industry	Public Sector	Environment
<b>Increase ability to make use of more <u>sources</u> of water, including alternatives</b>					
1	Increase the ability to identify and make use of alternative supplies	Identify suitable sites; improve yields – e.g. from enhanced rainfall, fog harvesting for strategic uses		Identify suitable sites; improve yields – e.g. from enhanced rainfall, fog harvesting for strategic uses	
2	Increase use of treated effluent	Implement efficient treatment management system. Address public perception issue. Catalyse linkages between those that discharge between producers and users – e.g. mines and farms	Improve regulatory frameworks; improve the quality of decision-making information.	Improve regulatory frameworks; improve the quality of decision-making information. Implement efficient treatment management system. Address public perception issue.	Investigate treated effluent to artificial recharge of ground water as potential conjunctive source. Increase ability to optimise mix for context
3	Decrease levels of salinity	Increase soil integrity – Regularise soil sampling at site level, introduce more efficient irrigation system suited to individual farms and particular regions; create detailed soil maps; models: co-operatives and delivery of extension services			

<b>Table 17</b>		<b>Agriculture</b>	<b>Industry</b>	<b>Public Sector</b>	<b>Environment</b>
4	Increase levels of desalination	Increase performance of purification technologies and processes	Increase levels of reclamation. Improve performance of purification technologies and processes – reduce energy requirement and materials costs	Increase levels of reclamation. Improve performance of purification technologies and processes – reduce energy requirement and materials costs	Improve performance of desalination technologies and processes – reduce energy requirement and materials costs
5	Increase rainwater harvesting	Increase and sustain levels of water harvesting and efficiency of conservation methods. Conduct scientific-economic evaluation of alternative approaches (Jonathon Denison)	Incentivise adoption. Separate rain water and polluted water	N/A	Improve good land use practices
6	Increase use of wastewater	1 and 5 linked: fitness for use	Integrate better with agriculture and energy production	Improve regulatory frameworks; improve the quality of decision-making information. Implement efficient treatment management system. Address public perception issue.	Improve performance and cost of purification.
7	Increase levels of groundwater use	Make better use of local water resources	Identify groundwater sources, yields and uses. Make better use of local water resources	Identify groundwater sources, yields and uses. Make better use of local water resources	Identify, map, declare and adopt Priority Water Areas. Design and introduce regulation and management mechanisms
8	Increase stormwater harvesting and management	Investigate potential of infield rainwater harvesting. Identify legislation gap on stormwater management and use – recharge, aquifers	Incentivise broader adoption and uptake	Improve regulatory frameworks; improve the quality of decision-making information. Objective? Decrease runoff into foul sewers and increase use of rainwater in urban setting.	Improve regulatory frameworks; improve the quality of decision-making information. Objective? Decrease runoff and increase percolation. Develop and implement national design philosophy for storm water management – provide ToR (SUDS) (larger metros) Neil Armitage UCT.
9	Increase capture of floodwaters	infrastructure		N/A	Improve land use practices and flood control measures
<b>Improve governance, planning and management of supply and delivery</b>					
10	Enable optimised reallocation and distribution	Enable optimised reallocation and distribution	Enable transfers between end uses: client-client, community	Enable easier transfers between end uses: client-client, community	
13	Improve effectiveness of Institutional landscape in respect of governance, planning and supply management (actors, management, institutions)	Improve effectiveness of Institutional landscape in respect of governance, planning and supply management (actors, management, institutions)	Training and capacity development. Staff turn-over (capacity) sustainable knowledge-transfer. Revised understanding of the policy positions irt Water Act. Enforcement and compliance – institutions missing, not capacitated to perform/ mandate	Training and capacity development. Staff turn-over (capacity) sustainable knowledge-transfer. Revised understanding of the policy positions irt Water Act. Enforcement and compliance – institutions missing, not capacitated to perform/ mandate	Refine accountability along the value chain

<b>Table 17</b>		<b>Agriculture</b>	<b>Industry</b>	<b>Public Sector</b>	<b>Environment</b>
14	Improve the ability to manage water flows. Align allocation and mix to requirements	Improve the ability to manage water flows. Align allocation and mix to requirements	Explore macro-economic models	Explore macro-economic models	Integrated planning — water reconciliation plans, revised allocations system, incentivise WCDM and wastewater reuse. Linked to no. 10.
15	Improve quality and resilience of planning for the future — ability to respond to volatility	Improve quality and resilience of planning for the future — ability to respond to volatility			Integrated planning – water reconciliation plans? Are they based on lowest cost or strategic consideration Social systems and demand — Development of rural areas
16	Optimise the ability to manage water resources from source to source in an integrated way	Optimise the ability to manage water resources from source to source in an integrated way			Refine accountability along the value chain. Implement current legislation — WRN NWA NWRS
<b>Improve adequacy and performance of supply infrastructure</b>					
11	Increase adaptability of storage capacity	Enhance artificial recharge – aquifers, rainwater tanks, existing capacity — small dams	Increase suitability, availability, capacity, flexibility — add tanks, man-made dams, underground or alternative storage (e.g. in mining void)		Improve control of alien invasive plants and wetland rehabilitation. Recognise volatility — Uprate competence and introduce adaptive practices to increase flexibility to plan and respond to the water effects of climate change
12	Increase protection and reliability of ecological infrastructure				Improve land use practices and conserve natural ecological infrastructure
23	Improve performance, optimise investment in infrastructure			Improve visibility and management of asset base. Develop and implement plans to optimise investment in supply infrastructure – to increase flexibility and responsiveness. Role of Technology?	
<b>Run water as a financially sustainable “business” by improving operational performance</b>					
18	Improve the financial sustainability of the water system			Ring fence — "Run water as a business in municipality"	
19	Improve the equity of pricing			Revise policy around requirement to pay. Increase the range of tariffs	
20	Increase the accuracy of attribution of water use			Increase customer confidence in Billing system — able to pay but don't trust it	
21	Increase proportion of water that is paid for			Reduce undesirable or unproductive political involvement in enforcement	

<b>Table 17</b>		<b>Agriculture</b>	<b>Industry</b>	<b>Public Sector</b>	<b>Environment</b>
22	Improve performance of revenue collection			Improve metering, billing systems, attitudes, prepaid meters. Improve the monitoring throughout the system — inflow. At system level, improve the ability to monitor flow, use and quality (water balance)	
24	Improve operational efficiencies			Ring fence — "Run water as a business in municipality"	
<b>Improve governance, planning, and management of demand and use</b>					
36	Increase transparency over rights, quotas, allocation and transfers	Explore SA potential for trading and transfer of water entitlement	Improve Regulation and Decision making processes for water use authorisation	Improve Regulation and Decision making processes for water use authorisation. Standardise policy application across regions.	Publish and maintain the Ecological Reserve
37	Improve co-operative governance with respect to planning and management. Cross-sectoral.	Reduce impediments to implementation — issues of mandates, responsibility and accountability around decision-making. Institutional, organisational, actors. Programmes (e.g. for emerging farmers), capacity	Increase institutional efficiencies, including via technology support	Resolve conflicts of mandate / jurisdiction between local, provincial and national government.	Increase institutional efficiencies and create functional Catchment Management agencies
38	Improve quality and effectiveness of context-specific planning and implementation	Enable water ordering, improve management of distribution	Systematically increase water independence: map footprint, develop reduction strategy	Provide alignment with NWRS2 in terms of policy instruments and regulations governing licence applications granted or denied.	
<b>Reduce losses and increase efficiency of productive use</b>					
25	Reduce water transport losses	Refurbish irrigation networks, incentivise improved management of losses	Minimise water tank overflows and bulk supply losses; protect transmission systems against corrosion	Maintenance? Prioritise funds, improve allocation of funds for operations.	Reduce consumption by alien invasive species
26	Reduce leakages	Improve ability to detect leakages; uprate repair performance	Implement preventive maintenance plans; Introduce monitoring and early warning systems	Encourage and support customers in detection of leakages and performance of repairs	
27	Optimise conjunctive use of water	Balance use of all sources in an integrated manner	Balance use of all sources in an integrated manner. Minimise demand on supplier (e.g. municipality)	Increase the degree of alignment of the quality of water with use	
28	Reduce volume of water use	Use water-saving crops and varieties	Minimise water use, application and losses in primary processes: avoid use of water (e.g. optimised or new no-water processes), recover and recycle condensate, reduce steam leakage, manage water pressure	Stimulate growth more economically (use of water). Highlight the importance of water and its scarcity to encourage consumers to reduce demand. Improve dry solution systems and encourage acceptance	

<b>Table 17</b>		<b>Agriculture</b>	<b>Industry</b>	<b>Public Sector</b>	<b>Environment</b>
29	Increase the area under irrigation	Use savings in current water use. Change NDP word "irrigation" to "agricultural water use" (in line with the rest of the world)			
30	Improve efficiency of water use	Encourage uptake of land and water use practices Introduce irrigation systems and improve performance: Optimise irrigation: Plan, meter, schedule; Monitor soil moisture; Reduce evapo-transpiration; Optimise fertiliser use. Increase effectiveness of knowledge transfer. Increase levels of rehabilitation	Reduce water in ancillary processes, reduce demand for domestic water		
31	Increase levels of water reuse	Reduce volume of wastewater, recover and recycle	Reduce volume of wastewater, increase levels of recovery and recycling;		
32	Minimise output to unrecoverable sources	Reduce wastewater released to sewers	Reduce volume of wastewater released to sewers. Recycle water streams for water and wastewater treatment		
33	Minimise volume and toxicity of pollution	Reduce rainwater runoff	Minimise production of waste (e.g. cleaner production methods)	Increase number of WWTW with Green Drop certification to >95%. Link to no. 35	Maximise natural water resource function (aquatic response)
34	Optimise balance between the right to water and productive use of this water	Reduce downstream pollution (point-sources and diffuse sources)			Investigate and develop economic modelling on the use and value of environmental goods and services. Inform greater clarity at a macro level in order to inform decision-making and policy evidencing
35	Minimise discharge of poor quality water		Minimise production of effluent (e.g. cleaner production methods)	Increase number of WWTW with Green Drop certification to >95%	
<b>Improve performance of pricing, monitoring, billing, metering, and collection</b>					
39	Improve equity of pricing, encourage desirable practice	Introduce tariffs and incentives ("real cost" of water); enforce quotas	Introduce tariffs and incentives ("real cost" of water). Increase cost of discharge to sewer	Improve pricing structures based on full cost pricing to reflect the "real cost" of water, including equitable charging.	
40	Improve accuracy: use monitoring, billing and management	Increase coverage, accuracy of flow monitoring, attribution; introduce management systems	Increase coverage and accuracy of monitoring, metering, attribution and billing. Target reductions	Improve coverage and accuracy and hence confidence in metering — similar to electricity metering	Increase coverage and accuracy of monitoring
41	Reduce levels of unmetered use	Detect and remove unmetered supplies; ensure meters are operating	Detect and remove unmetered supplies; ensure meters are operating; improve management of collection	Define, implement and support policy on billing control	

#### 4.1.4 Define Sector Performance Measures

The satisfaction of the customers' needs has value, which can be expressed in relation to measures of performance (speed, reliance, cost). In order to be motivated to adopt a new or improved solution in the pursuit of the satisfaction of their needs, customers have an expectation (a minimum requirement for an improvement in performance) that a solution must deliver. These expectations should be specifically quantifiable in terms of a target (e.g. cost less than R100 per m<sup>3</sup>), a percentage (e.g. faster by 20%). These expectations were elicited from the sectors through a series of sessions in which the expectations were sought and then reviewed. An example is shown in Table 18, and the full list of performance measures is shown in Table A4, Appendix A.

To the extent that RDD can make a contribution to developing and delivering a solution a) these expectations were used to later set the objectives for the RDD activity, and the value that the customer attached to adopting the solution underpins the case for investing in RDD.

A joint scoring workshop was held to assess the attractiveness of the seven agreed clusters of RDD opportunities which had been listed as responses to the needs and their interventions. The participants, from all four sectors of the water community, evaluated the opportunities and interventions in a structured and consistent manner using the dimensions of Customer Need, Market Opportunity, and the potential Value and Impact that attaches to successful realisation. Four follow-up sessions were held to cross-check the validity and level of ambition of the performance measures on which the sectors settled.

**Table 20: Example Performance Measures created by the water community**

Need	Performance Measures	Minimum change required
10 Enable optimised reallocation and distribution	DWA water allocations remapped	A new map completed by 2016
36 Increase transparency over rights, quotas, allocation and transfers	Consumers within catchments know everyone's water allocation	Nine functional Catchment Management Agencies

The Sector Objectives and Performance Measures (determined as described in Section 4.1.3 and 4.1.4) can be summarised as (Table 21):

**Table 21: Sector Objectives and Performance Measures**

<b>Increase ability to make use of more sources of water, including alternatives</b>	<b>Improve governance, planning and management of supply and delivery</b>	<b>Improve adequacy and performance of supply infrastructure</b>	<b>Run water as a financially sustainable "business" by improving operational performance</b>	<b>Improve governance, planning, and management of demand and use</b>	<b>Reduce losses and increase efficiency of productive use</b>	<b>Improve performance of pricing, monitoring, billing, metering and collection</b>
<ul style="list-style-type: none"> <li>▶ 75% of treated wastewater reused</li> <li>▶ Coastal communities obtain 5% of the water supply from seawater; inland 5-10% of water is abstracted from groundwater and recharge, and 20% water supply from treated wastewater.</li> <li>▶ All metropolitan areas have rainwater and stormwater drainage and storage</li> </ul>	<ul style="list-style-type: none"> <li>▶ A new DWS allocations map completed by 2016</li> <li>▶ Nine functional Catchment Management Agencies</li> <li>▶ The new reconciliation strategy and allocations map include groundwater, seawater, and wastewater</li> </ul>	<ul style="list-style-type: none"> <li>▶ Storage facilities similar to Rand Water's Fountains Treatment Works exist in all metropolitan areas.</li> <li>▶ New rainfall maps have led to a new limit for the ecological reserve, which is protected by regulation</li> <li>▶ Adequate ICT infrastructure exists for automation and M&amp;E</li> </ul>	<ul style="list-style-type: none"> <li>▶ Non-revenue water is below 15%</li> <li>▶ All domestic and industrial users are on metered supplies</li> <li>▶ All leaks are detected in under 12 hours and repaired in under 48</li> </ul>	<ul style="list-style-type: none"> <li>▶ Nine functional Catchment Management Agencies</li> <li>▶ Storage facilities similar to Johannesburg Water's Northern Treatment Works exist in all metropolitan areas</li> <li>▶ &gt;95% functional municipalities (capable of carrying out their functions and responsibilities)</li> </ul>	<ul style="list-style-type: none"> <li>▶ Non-revenue water is below 15%</li> <li>▶ All leaks are detected in under 12 hours and repaired in under 48</li> <li>▶ PICWAT and SAPWAT, or equivalents, are in use on all commercial farms and 30% of family farms</li> <li>▶ 75% of treated domestic and industrial wastewater reused</li> <li>▶ 90% of wastewater treatment works attain Green Drop status</li> <li>▶ &gt;75% of sludge from sanitation put to beneficial use</li> </ul>	<ul style="list-style-type: none"> <li>▶ Free basic water remains free; reasonable use is reasonably priced; wasted water is prohibitively expensive</li> <li>▶ All domestic and industrial users are on metered supplies</li> <li>▶ Non-revenue water is below 15%</li> <li>▶ All industries are benchmarked with fair and honest targets set</li> </ul>

Sector Objective

Sector Performance Measure

These Sector Objectives and Performance Measures were then used to help frame the RDI Success Factors, RDD Potential and RDD Opportunity.

The Success Factors (required in enabling achievement of the RDD Objectives) were defined as:

RDI Success Factors	Target Objectives by 2025
<p>1. Foster and drive comprehensive deployment of context-appropriate performance improvements:</p> <ul style="list-style-type: none"> <li>• the water-use design, design, models and tested data and critical technology, model improvements and costs</li> </ul>	<ul style="list-style-type: none"> <li>• Treatment and RDD opportunities: Technology Development Centre</li> <li>• Technical parameters of cost and critical technology from period</li> <li>• Improving management of South African resources in the water and wastewater performance</li> </ul>
<p>2. Strengthen RDI capability and capacity</p>	<ul style="list-style-type: none"> <li>• Being prepared to present critical RDI opportunities to water use, companies, business, industry and law, including, analysis and design, deployment of engineering, information technology, design, modelling and simulation of complex networks and systems, development of the social context and settings, political, economic and governance, organisational, technical, environmental and public health.</li> </ul>
<p>3. Increased impact of SA innovation and technology</p> <ul style="list-style-type: none"> <li>• water form of commercial identity, technology, intellectual property, innovation and administration to register the RDI systems</li> </ul>	<ul style="list-style-type: none"> <li>• Education and research in the past, contribution and support of initiatives to commercialisation, related activities (such as RDI, innovation, technology and service)</li> </ul>

## 4.2 SOUTH AFRICA'S RDD RESPONSE

### 4.2.1 Articulate and assess RDD Potential

Step 2 of the road mapping process was to shape South Africa's RDD response, by asking and answering two questions: How could the customers' need be met? What do we need to do?

The clustered needs and interventions were then given back to the work groups in a further set of work sessions, and to the WRC's research managers in a separate session. The participants were asked to provide their assessments of whether undertaking each intervention presented an opportunity in terms of research, development, and deployment (RDD).

When RDD opportunities were identified, the participants were then asked to decide at what stage in the innovation chain the opportunity presented itself, from Explore to Deploy:

- **Explore** – exploration is the earliest stage in the innovation chain and represents quantification of a possibility.
- **Test** – testing is fundamental or early applied research, and includes proof of concept and feasibility studies.
- **Demonstrate** – demonstration is late stage research, in which a proven concept (such as a prototype) is piloted, trialled, or otherwise demonstrated in a context approximating the situation or conditions under which the technology is intended to be utilised.
- **Deploy** – deployment is roll-out, or more widespread introduction and implementation of a new technology, technique, or piece of know-how so that it becomes mainstream / accepted, rather than being perceived as novel.

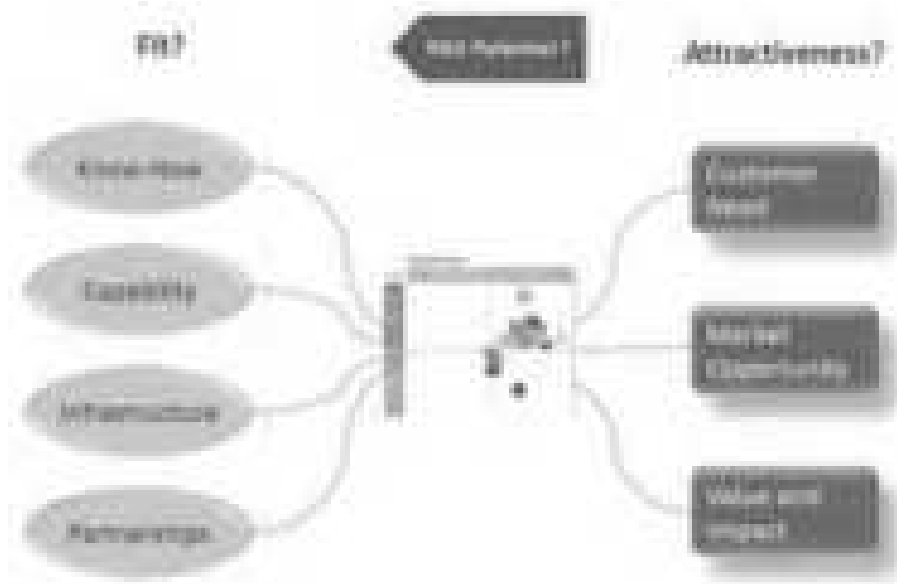
In addition, the participants were required to decide what the nature of the RDD potential was:

- **Management** – the potential to satisfy a particular need through better management of existing technology and/or know-how.
- **Information** – the potential to satisfy a particular need through providing higher quality and/or more commonly available information about existing technology and/or know-how.
- **Technology** – the potential to satisfy a particular need through the creation of a new technological item or process.
- **Capacity** – the potential to satisfy a particular need through increasing the number of people in the water community who possess the skills required to implement and operate appropriate technology and/or know-how.

The results of this round of sessions (provided in Table A3, in Appendix A) were synthesised to quantify the RDD potential in terms of both stage (**Explore, Test, Demonstrate, Deploy**) and nature (Management, Information, Technology, Capacity). Figure 25 (page 70) shows that the method of applying each opportunity to each need, within each cluster allowed the team to identify where in the innovation chain the opportunities presented themselves and what the nature of the opportunity was.

Figure 25 requires some scrutiny in order to make the most of the information presented. At this point it is useful to recap the process so far using an example, as shown on page 76.

The RDD Potential was identified per cluster of needs using a structured drill down into each individual need and intervention. The evaluation framework (Figure 26) enabled us to understand the fit – the likelihood with which South Africa can respond to customer needs through successful delivery of identified RDD potential.



**Figure 26: Evaluation Framework for RDD Potential**

The attractiveness and fit of the interventions per cluster and per sector were determined and are shown in Appendix B.

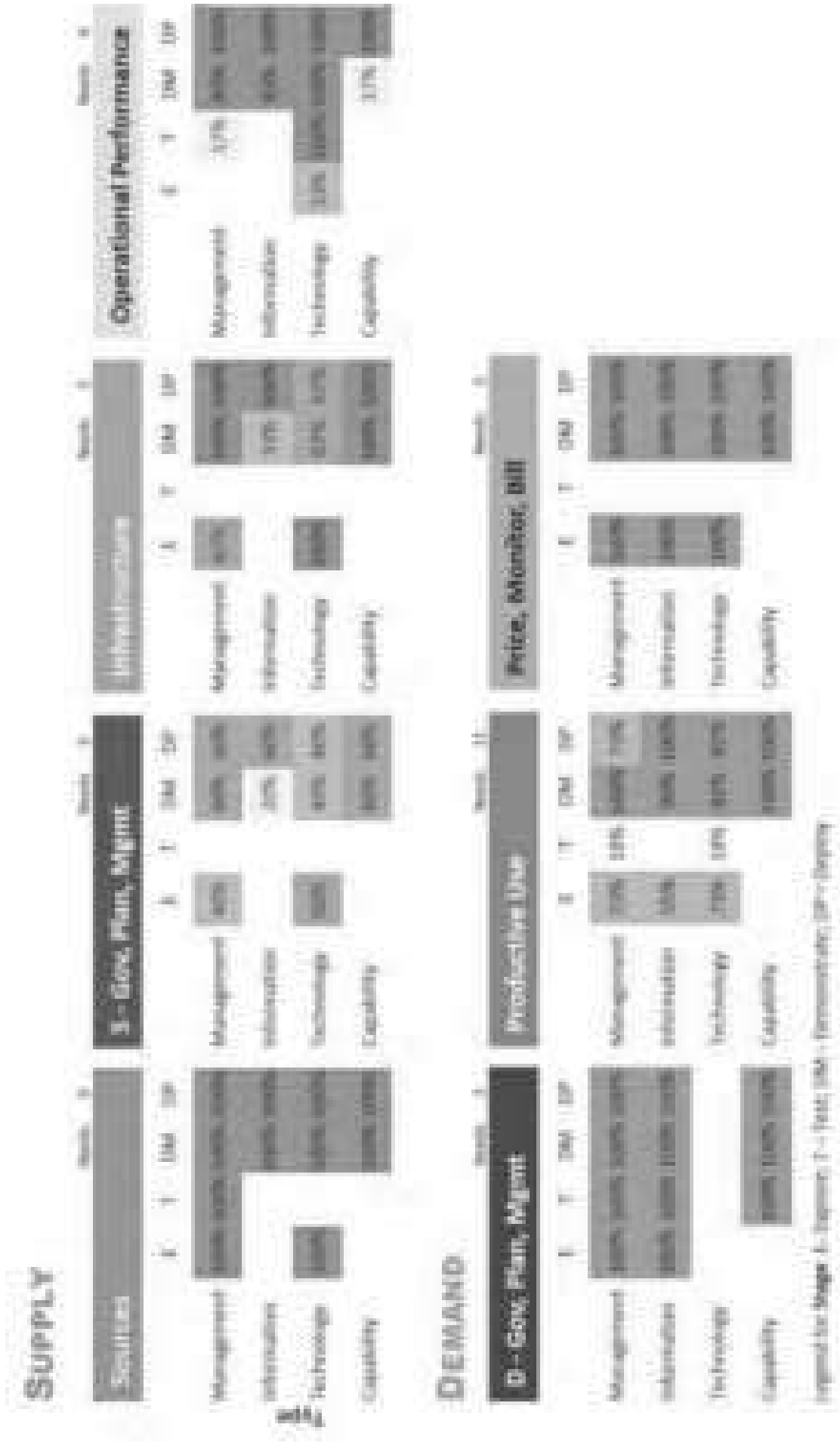


Figure 25: RDD Potential by Nature and Stage in the innovation chain, expressed in % of needs per cluster, all sectors Stage (Explore, Test, Demonstrate, Deploy) and Nature (Management, Information, Technology, Capacity) are explained at the top of page 11.

Example: What do customers want?

Let us use the water supply cluster of Source (Increase ability to make use of more sources of water, including alternatives) as our example.

Table A1 (page 81) shows us the raw inputs – the long list of needs and matching interventions as provided in the initial sector work sessions, such as in this excerpt:

	Needs Agriculture	Interventions Agriculture
S	Increase diversity and optimisation of mix	
1	Increase use of treated effluent	Implement efficient treatment management system. Address public perception issue. Catalyse linkages between those that discharge between producers and users – e.g. mines and farms
... 11		

Table A2 (page 87) then shows the creation of a cluster of nine needs which could be categorised as being related to sources of water, and it tells us which sectors identified which need:

		Agriculture	Industry	Public Sector	Environment
<b>SUPPLY: Increase ability to make use of more sources of water, including alternatives</b>					
1	Increase the ability to identify and make use of alternative supplies to			•	
9	Increase capture of floodwaters	•			•

Finally, Table A3 (page 88) provides us with the identified opportunities for a research, development, or deployment response, for example:

		Management	Information	Technology	Capacity
S	<b>Increase ability to make use of more sources of water, including alternatives</b>				
1	Increase the ability to identify and make use of alternative supplies	E T DM DP	DM DP	E T DM DP	DM DP
to					
9	Increase capture of floodwaters				

Legend for **stage**: E = Exploration; T = Testing; DM = DeMonstration; DP = DePloyment

These tables together allow us to see that wherever there are opportunities to undertake research, demonstration, or deployment to implement any of the interventions that were identified as being able to satisfy the need, those opportunities always include a demonstration of Technology. Therefore the summary of RDD opportunities shown in Figure 25 (page 70) lists the Demonstration stage as representing an opportunity 100% of the time, for all four natures of opportunity:



#### 4.2.2 Research capability mapping

Concurrently, the project team ran two questionnaires in order to map the existing capacity and capability of South African researchers. Individual and institutional questionnaires were designed and respondents asked to identify their relevant areas of expertise. The areas of expertise were defined both by the underlying academic discipline (e.g. microbiology) and the research focus area (RFA), or area of interest (e.g. potable water quality). The full list of RFAs is shown in Appendix C. The 106 unique RFAs (Table 22) were mapped onto the clusters by the WRC research managers (Appendix C). Questionnaire respondents who felt that their particular discipline or RFA was not already represented were able to select 'Other' and add their self-defined discipline or RFA.

**Table 22: Taxonomy of Research Focus Areas (RFAs)**

RFA no.	RFA name
1	Agroforestry
2	Business efficiency
3	Crop production <i>Genetics and Plant Breeding</i>
4	Efficient agriculture
5	Food security and business efficiency
6	Horticulture
7	Improved food production
8	Irrigation and Drainage
9	Soil chemistry
10	Soil fertility
11	Soil management
12	Soil microbiology and biochemistry
13	Soil morphology and genesis
14	Soil physics
15	Animal, human, public, and environmental health <i>Endocrinology</i>
16	Ecosystem functioning
17	Wastewater treatment <i>Microbiology and Chemistry</i>
18	Animal, human, public, and environmental health Fate and behaviour of pollutants
19	Human health
20	Process automation and control – potable and waste water treatment
21	Wastewater treatment <i>Bioinformatics</i>
22	Environmental water quality
23	Environmental health and ecosystem functioning <i>Remote sensing</i>
24	Food security and business efficiency
25	Econometrics
26	Macroeconomics
27	Microeconomics
28	Applied economics
29	Computational economics
30	Economic modelling
31	Decision sciences
32	Entrepreneurship and Management
33	Technoeconomics
34	Insurance <i>Mathematics and Economics</i>
35	Forecasting and Game Theory
36	Behavioural finance
37	Business and Economic Statistics
38	Civil engineering aspects of water cycle
39	Wastewater and Potable water treatment <i>Domestic</i>
40	Treatment and distribution
41	Stormwater management
42	Water /wastewater and industrial Process optimisation
43	Wastewater and potable treatment <i>Industrial</i>
44	Mine water desalination

RFA no.	RFA name
45	Mine water membrane treatment
46	Mine water passive treatment
47	Industrial wastewater treatment (urban) water management / engineering
48	Crop production <i>Applied Engineering in agriculture</i>
49	Flood defence
50	Hydrology and hydrogeology
51	Hydrodynamics
52	Hydrologic engineering
53	Hydromechanics
54	Water quality monitoring, ecosystem functioning, environmental water quality, animal, human, public, and environmental health <i>Marine Science</i>
56	Agriculture <i>Ecosystems and Environment</i>
57	Aquatic ecosystems
58	Ecology Evolution and Systematics
59	Biodiversity and Conservation
60	Systems ecology
61	Ecological informatics and modelling
62	Corporate social responsibility and environmental management
63	Bioremediation
64	Rehabilitation of contaminated land and water
65	Environmental protection & pollution control
66	Environmental health and ecosystem functioning <i>Water Resources</i>
67	Weather and Forecasting
68	Agricultural meteorology
70	Climate dynamics, resilience, adaptation
71	Environmental health and ecosystem functioning <i>Geology</i>
72	Water quality monitoring, ecosystem functioning, environmental water quality, animal, human, public, and environmental health <i>Earth Science Informatics</i>
73	Subsurface hydrology
74	Contaminant hydrology
75	Unsaturated zone
77	Land surface hydrology
78	Catchment hydrology
79	Hydro-meteorology
80	Ecohydrology
81	Animal, human, public, and environmental health <i>Virology, Bacteriology, Mycology</i>
82	Animal, human, public, and environmental health <i>Toxicity of engineered materials</i>
83	Wastewater and potable treatment, ecosystem functioning, environmental water quality, animal, human, public, and environmental health
84	Animal, human, public, and environmental health <i>pathogens and parasites</i>
85	Public health
86	Water treatment <i>Biological processes</i>
87	Wastewater treatment <i>Biological Processes</i>
88	Wastewater and potable treatment <i>Advanced Biological Processes</i>
89	Wastewater and potable treatment <i>Chemical and Materials Safety</i>
90	Water quality monitoring, ecosystem functioning, environmental water quality, animal, human, public, and environmental health <i>Applied Entomology</i>
91	Improved food security
93	Education
94	Development studies
95	Gender studies
96	History
97	Law
98	Library and information science
99	Bioethics
100	Public policy

RFA no.	RFA name
101	Public administration
102	International relations
103	Security studies
104	Human, public, and environmental health <i>Health Planning</i>
105	Sociology
106	Water quality monitoring, ecosystem functioning, environmental water quality, animal, human, public, and environmental health <i>Land use</i>

The resulting capability maps show us in which RFAs South Africa already has expertise, and where that expertise can be found. The complete maps found on pages 8, 10, 12, 18, 19, 25, 27, 32, 37, 38, 39, 45, 47, 52 and 53, and as an example, Figure 27 shows the relevant RFAs for the water supply cluster, *Run water as a financially sustainable "business" by improving operational performance* across the top of the map, using the numbers in Table 22 above. Each organisation with an individual or an organisational capacity identified through questionnaire response is listed on the left hand side, and the shaded blocks indicate in which RFA their expertise lies, and the level of expertise. Four levels of capacity were used: *Emerging, Building, Established, and Mature*, based on composite score on a scale of 0-10 based on number of people, budget, publications and products and technical services.

The maps enable the prioritization of attention in terms of funding and capacity building over the next ten years. An RFA in red indicates no capacity identified at academic units or in research institutions. For example, Figure 27 shows that expertise in RFA 3, which Table 22 tells us is *Crop production genetics and plant breeding*, was identified as being required in order to frame and carry out the desired RDD response in terms of implementing the interventions that were identified in order to meet the needs which fell into the Cluster, yet we were unable to elicit a response from any South African research group who described themselves as having capacity in this research field.

The questionnaire responses were used to perform analyses of Fit, using a Readiness to do Research™ framework (Figure 28). The framework analyses the depth and diffusion of research knowledge (i.e. how well a RFA is understood, and whether the know-how resides in research only, in pockets of implementation, or is widespread practice).

The questionnaires were sent to all project leaders and collaborators named on proposals submitted to the WRC over the past five years, and were also circulated to all member of the Water Institute of Southern Africa (WISA) via the WISA's member mailshot system.

An additional analysis of water-related intellectual property held by the WRC and NIPMO was also carried out.

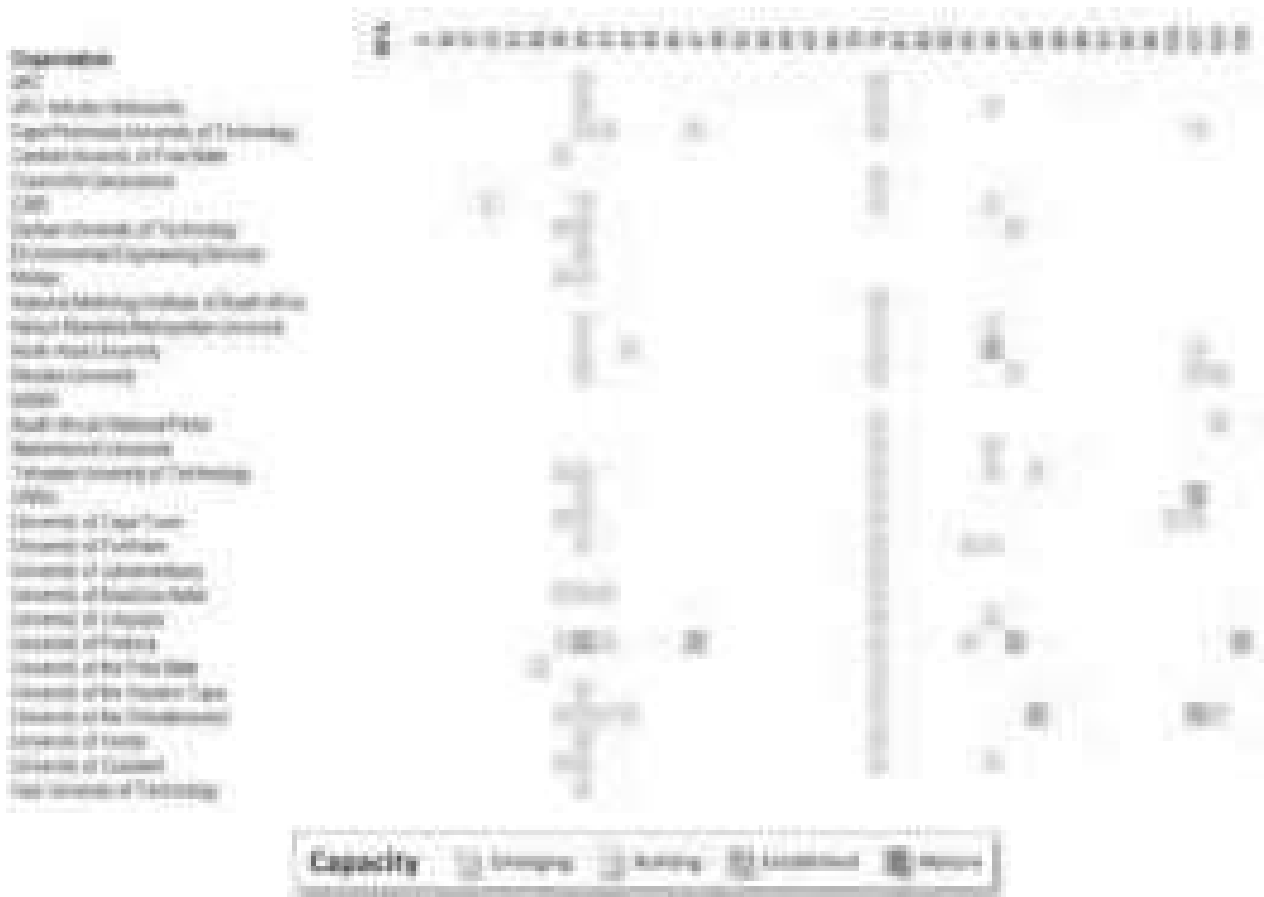


Figure 27: Mapping of capacity in underlying science (RFA) required to conduct research for the Cluster: Operational Performance. An RFA in red indicates no capacity identified at academic units or in research institutions.

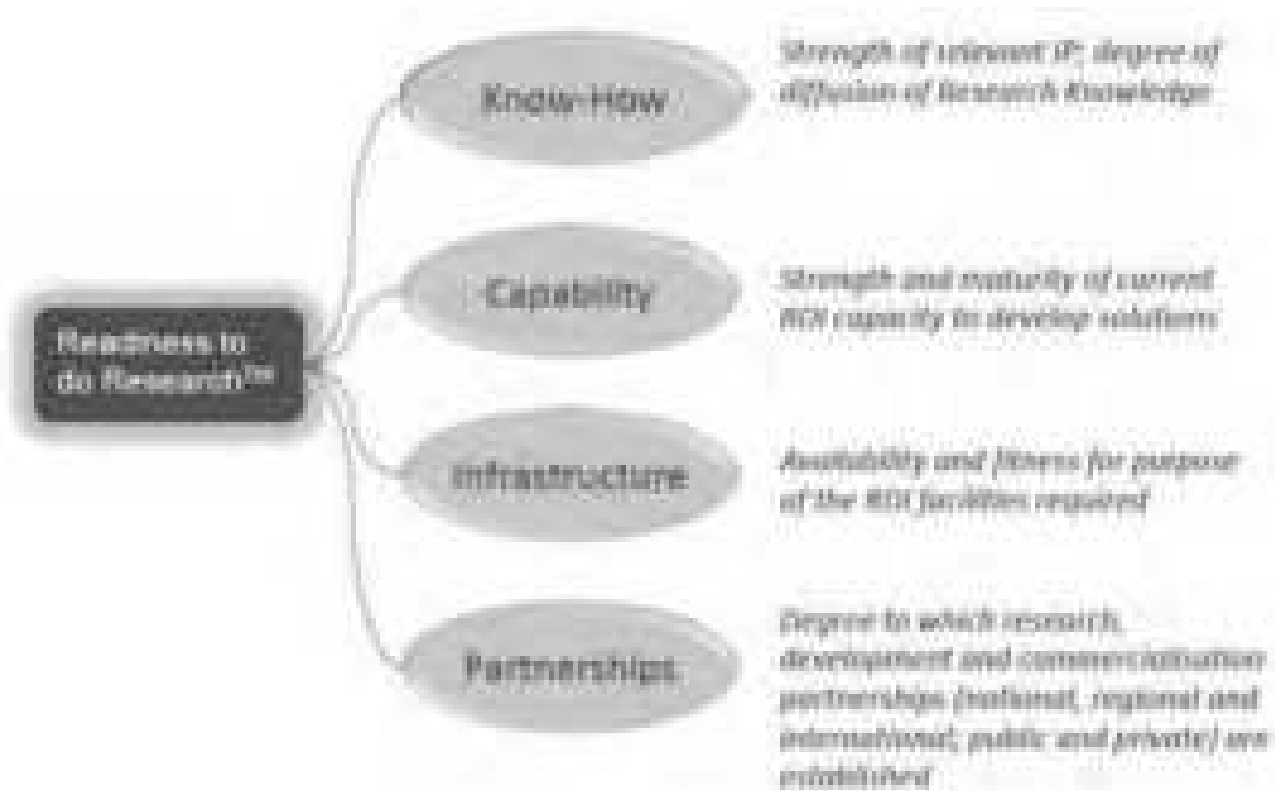


Figure 28: Readiness to do Research™ framework

The resulting data were summarised to indicate two sets of information, the extent of research knowledge diffusion into practice (Appendix D), and the country's RDI capability (Appendix E). These were later used as the basis on which to identify real RDD opportunities that could be taken up, and the additional research capability required to be built in order to take up those opportunities.

#### **4.2.3 Articulate strategic intent**

The participants of the previous work sessions of the four sectors, along with stakeholders who had engaged with the WRC in workshops that preceded the RDI road map project, were invited to review the progress of the road map, and to help define its vision (i.e. ideal future state of affairs), mission (i.e. how the ideal state of affairs has come to pass), and the means by which the vision and mission could be accomplished.

The resulting consensus was:

##### **Vision**

South Africa leads the developing world in the development and deployment of water management practices and technologies. It competes with leading countries in providing sustainable solutions.

##### **Mission**

This has been achieved by means of a National Water RDD Programme focused on: delivery of at least one breakthrough technology every five years; increasing the number of small and medium sized enterprises (SMMEs) operating in the water sector; increasing access to water for rural communities, including provision of sanitation for all in a sustainable manner. Together, this creates significant economic, health, social and environmental benefit

##### **Means**

**RDD** contributes to achieving this Vision, via a focus on four key **Objectives**:

1. Increase the availability of water
2. Improve the governance, planning and management of supply and delivery
3. Operate water and sanitation services as a sustainable "business"
4. Increase the efficiency and productivity of water use

Three key **RDD success factors** are:

1. Faster, more comprehensive deployment of context-appropriate performance improvements
2. Stronger RDI capability and capacity
3. Focused export of SA know-how and technology

The four RDD Objectives distil and summarise the Needs and Interventions documented in Sections 4.1.2, and 4.1.3, and in Appendix A, and were further defined as:

RDD Objectives	Integrating all Target Sector Objectives by 2025
<p><b>1. Increase the availability of water</b></p> <ul style="list-style-type: none"> <li>• Increase the amount of water used of these sources of water (in order to allow a diversification of ground, surface, sea, and wastewater as resources in domestic, industrial and agricultural environments)</li> <li>• Expand the use of surface water to 44% of total use</li> </ul> <p><b>2. Improve governance, planning and management of supply and delivery</b></p> <ul style="list-style-type: none"> <li>• Monitor the ability to water service into water-use from the environment, management and availability</li> <li>• Strengthen the capacity to consistently manage water of sufficient use</li> </ul> <p><b>3. Expand water and sanitation services to a sustainable "baseline"</b></p> <ul style="list-style-type: none"> <li>• Improve the performance of existing, remaining, missing, being and renewed services</li> <li>• Consistent financial and personnel of water services</li> </ul> <p><b>4. Increase the efficiency and productivity of water use</b></p> <ul style="list-style-type: none"> <li>• Reduce water loss</li> <li>• Increase the productive use of water</li> <li>• Reduce the amount of consumption use</li> </ul>	<ul style="list-style-type: none"> <li>• More highly efficient to extend amount of water for the environment</li> <li>• More efficient and energy efficient, consistent management in water consumption and wastewater (domestic, industrial and agricultural)</li> <li>• More water used to increase total groundwater capacity through a knowledge use and change management programme</li> <li>• Renewable surface water to 44% of total use</li> <li>• 20% water supply disruptions managed</li> <li>• Water supply and demand management is managed in sufficient time</li> <li>• Consistent water sustainability programme with efficiency</li> <li>• 20% (2011, 2014 and 2016) are increased in 2025</li> <li>• Sustainable water is increased to 44%</li> <li>• All domestic and industrial water use in consistent countries</li> <li>• Water performance is improved water use reduced</li> <li>• Reduced consumption (using water for water supply)</li> <li>• Sustainable water use increased to the water services</li> <li>• Sustainable water is consistent and use consistent in improved</li> <li>• Water productivity is improved</li> <li>• More highly efficient to extend amount of water for the environment</li> <li>• All water use is consistently increased to 44% of total use</li> </ul>

#### 4.2.4 Define RDD Programmes

The RDD programmes were developed out using the inputs gained during all the preceding steps. The development was guided by a decision tree that led the work groups to make selections from a prescribed short list. The four stages in the programmes are Explore, Build critical mass, Embed capability, and Commercialise. At each stage a choice had to be made from two or more methods by which each stage could be accomplished. An example of this is the choice to be made to build critical mass – this can be achieved through a Targeted Research Programme (TRP) aimed at a single research group, or a Centre of Excellence which would involve a consortium of more than one research group.

An RDD Programme was developed for each of the seven clusters, as shown on pages 6, 16, 23, 31, 36, 43, and 51.

#### 4.2.5 Anticipate Programme Impact

The impacts of each RDD programme were assessed using the expertise of the water community. Participants from all sectors, and the WRC Research Managers, were presented with a list of all the areas in which the RDI Roadmap is intended to make an impact. The five broad areas: *Water Scarcity*, *Economic*, *Health*, *Society*, and *Environment* were subdivided into discrete sub-areas, and the participants deliberated, then indicated whether or not implementing the interventions that had been listed as appropriate responses to the needs would make an impact in each sub-area. The exact nature of the impact and its extent were not necessary at this stage, only an assessment as to whether an impact could reasonably be expected. Inevitably, the debating method used to reach consensus extended to the nature and extent of the impacts that were anticipated as the participants exchanged and justified their personal assessments within the work groups.

- **Water Scarcity**
  - Reduced withdrawal
  - Reduced consumption
  - Improved water quality
  - Improved productivity of use
- **Economic**
  - Wealth
    - Number of jobs created or sustained

- Number of new businesses created or sustained
- Productivity
  - Increased product per drop (water use efficiency (WUE), tonnes/ ton of water)
  - Increased crop yield per drop
  - Reduce down-time (e.g. caused by maintenance)
- Revenue
  - Increased average revenues per unit product and per m<sup>3</sup> delivered
  - Increased average revenue per producer (e.g. farmer, ecosystem, environment)
- Cost reduction
  - Decreased water footprint per unit produced
  - Reduced material inputs (and cost)
  - Reduced energy inputs (and cost)
  - Reduced labour requirement (and cost)
  - Reduced cost of healthcare
- Investment
  - Reduced capex requirements
  - Reduced maintenance costs
- **Health**
  - Reduced incidence of water-borne sickness and disease
  - Reduced incidence of sickness and disease from air pollution
  - Reduced incidence of sickness and disease from chemical contaminants
  - Reduced absenteeism and early retirement – through increased wellness
  - Reduced mortality rate
- **Society**
  - Improved availability and quality of environmental goods and services
  - Increased food security – livestock, crops
  - Reduced loss of animals
  - Increased school attendance (driven by access and quality) and improved educational outcomes
  - Improved relations between all suppliers and consumers in a catchment (e.g. WUAs and farmers)
  - Satisfaction of rights and demands of those without access to water
  - Reduced environmental debt
  - Raised awareness of the value of water, driving increased willingness to pay
- **Environment**
  - Reduction in carbon emissions
  - Reduction in area of salinised land
  - Reduced levels of groundwater contamination
  - Reduced cost of treating process water and potable water
  - Reduced contamination of surface water
  - Reduced downstream pollution
  - Reduced levels of soil erosion
  - Reduced or reversed decline in biodiversity
  - Preservation of riverine habitats
  - Improved health of terrestrial environment

The results of the impact assessment are shown in Appendix F, and they have been summarised per cluster on pages 5, 15, 22, 30, 35, 42, and 50..

### 4.3 SETTING UP TO DELIVER SUCCESS

This last stage of the roadmapping process was the stage in which all of the diverse and numerous data gathered during the steps 2 to 9 in Figure 24 (p. 60) were collated and related to one another. The results have already been presented in sections 2.2 to 2.8, so the following sections merely serve to explain the methodology, and not to present the results.

### 4.3.1 Quantify impact and investment

In stage 10 (Figure 24, p. 60), the project team determined the investment required over time, and the anticipated returns in terms of socio-economic value and RDI outputs. The progression paths described in section 4.2.3 were used as the basis of a process in which stakeholders whose expertise was research funding and administration developed out estimates of the type and size of research capacity required to implement the pathways.

The average size and shape of a research group (in academia, or research group equivalent outside of academia) was measured using data about project teams on all proposals submitted to the WRC for funding over the past five financial years. Numbers and roles of team members per team per proposal were used to provide a definition of a "normal" research group. It was not surprising to find that the range of research group size extended from one to almost twenty people, but for investment requirement purposes the modal averages were used to define Small, Medium, and Extended research groups (Table 23).

**Table 23: Numbers of different research group members found in average Small, Medium, and Large Research Groups defined according groups described in WRC proposals received from 2009 to 2014**

Group member type	Small group	Medium (base) group	Extended group, or research centre
Research Chair	0	0	1
Project leader, who is Faculty staff (Prof, A/Prof, Lecturer) or non-academic equivalent	1	1	1 or 2
Principal Researcher (often a Lecturer or Postdoctoral research fellow / officer)	0	1	2
Senior Researcher (often a Postdoctoral research fellow / officer)	1	1 or 2	2
Researcher (often a research officer)	0	1	2
PhD student	1	2-3	4-6
Masters student	1-2	2-4	5-10
Honours student	1-2	1-3	5-10
3rd year student / intern	0-2	1-2	2-4

Research chairs were additionally used in investment and human capacity requirement planning, and were defined as holders of clearly defined, separately funded chairs supported by SARChI or by industrial or other sources, following the SARChI model.

Values for Research Chairs, and researcher costs were predicted based on NRF values for postgraduate and postdoctoral researchers (Appendix G), and on the apocryphal norm of R15 million over five years.

Standard office and communications equipment (but NOT laboratory or other specialised equipment) was included as 1% of the total research capacity costs. Specialised research costs were estimated based on modal equipment and running costs budgeted in proposals submitted to the WRC between 2009 and 2014, and related back to the average research group sizes.

The total investment required to deliver all seven of the Cluster-based ten-year plans is detailed in Table 24. These figures are summarised according to source of funding, to Cluster of needs / interventions, and to investment instrument in section 4.1.2.

The exact international investment ask is not quantified at this point. This figure is currently included in the "Other Govt (government)" funding source in Table 24. This will be a priority task for the Roadmap Project Management Unit to clarify on inception in the first quarter of 2015/2016. Currently, the exact international ask required is dependent of DWS's NWRSII alignment and resourcing process that is underway and the WRC strategic planning process that is required to support roadmap implementation.

### 4.3.2 Design implementation framework

The final stage (box 11, Figure 24, p. 65) was to design an appropriate framework to guide, monitor, and manage the successful execution of the roadmap; five options for managing and co-ordinating the implementation of the RDD programmes were proposed for discussion and do not form part of this report.

**Table 24: Total investment plan for the Water RDI Roadmap**

Investment by Cluster	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total R (million)	Total (%)
<b>Investment Ask</b>	<b>26.3</b>	<b>473.7</b>	<b>332.3</b>	<b>335.6</b>	<b>348.7</b>	<b>335.6</b>	<b>322.4</b>	<b>345.4</b>	<b>329.0</b>	<b>329.0</b>	<b>3178.0</b>	<b>100</b>
Water levy (WRC)	4.9	67.1	52.3	51.5	53.5	51.5	49.5	53.0	50.5	50.5	484.5	15.2
DST instruments inc. NRF and TIA	12.0	162.3	121.7	132.1	134.5	120.2	102.8	95.2	97.1	102.3	1080.3	34.0
Other Gov (int, other depts; WRC leveraged funds)	9.4	130.6	100.7	97.8	101.6	97.8	91.4	95.2	97.1	111.4	933.0	29.4
Industry	0.0	113.8	57.6	54.2	59.0	66.1	78.7	102.0	84.2	64.8	680.2	21.4
<b>Investment Ask</b>	<b>12.9</b>	<b>51.6</b>	<b>51.6</b>	<b>58.0</b>	<b>51.6</b>	<b>54.8</b>	<b>61.2</b>	<b>51.6</b>	<b>83.8</b>	<b>0.0</b>	<b>477.0</b>	<b>100</b>
Water levy (WRC)	2.4	7.3	8.1	8.9	7.9	8.4	9.4	7.9	12.9	0.0	73.2	15.4
DST instruments inc. NRF and TIA	5.9	17.7	18.9	22.8	19.9	19.6	19.5	14.2	24.7	0.0	163.3	34.2
Other Gov (int, other depts; WRC leveraged funds)	4.6	14.2	15.6	16.9	15.0	16.0	17.4	14.2	24.7	0.0	138.7	29.1
Industry	0.0	12.4	8.9	9.4	8.7	10.8	14.9	15.2	21.4	0.0	101.8	21.3
<b>Investment Ask</b>	<b>13.6</b>	<b>115.7</b>	<b>108.9</b>	<b>81.6</b>	<b>71.4</b>	<b>68.0</b>	<b>78.2</b>	<b>61.2</b>	<b>61.2</b>	<b>0.0</b>	<b>660.0</b>	<b>100</b>
Water levy (WRC)	2.5	16.4	17.1	12.5	11.0	10.4	12.0	9.4	9.4	0.0	100.8	15.3
DST instruments inc. NRF and TIA	6.2	39.6	39.9	32.1	27.6	24.4	25.0	16.9	18.1	0.0	229.7	34.8
Other Gov (int, other depts; WRC leveraged funds)	4.9	31.9	33.0	23.8	20.8	19.8	22.2	16.9	18.1	0.0	191.3	29.0
Industry	0.0	27.8	18.9	13.2	12.1	13.4	19.1	18.1	15.7	0.0	138.2	20.9
<b>Investment Ask</b>	<b>6.5</b>	<b>91.1</b>	<b>97.6</b>	<b>94.4</b>	<b>97.6</b>	<b>84.6</b>	<b>84.6</b>	<b>91.1</b>	<b>84.6</b>	<b>84.6</b>	<b>817.0</b>	<b>100</b>
Water levy (WRC)	1.2	12.9	15.4	14.5	15.0	13.0	13.0	14.0	13.0	13.0	125.0	15.3
DST instruments inc. NRF and TIA	3.0	31.2	35.8	37.2	37.7	30.3	27.0	25.1	25.0	26.3	278.5	34.1
Other Gov (int, other depts; WRC leveraged funds)	2.3	25.1	29.6	27.5	28.4	24.7	24.0	25.1	25.0	28.7	240.4	29.4
Industry	0.0	21.9	16.9	15.2	16.5	16.7	20.7	26.9	21.7	16.7	173.1	21.2
<b>Investment Ask</b>	<b>10.3</b>	<b>61.8</b>	<b>48.0</b>	<b>48.0</b>	<b>89.2</b>	<b>78.9</b>	<b>78.9</b>	<b>78.9</b>	<b>75.5</b>	<b>82.4</b>	<b>652.0</b>	<b>100</b>
Water levy (WRC)	1.9	8.8	7.6	7.4	13.7	12.1	12.1	12.1	11.6	12.6	99.9	15.3
DST instruments inc. NRF and TIA	4.7	21.2	17.6	18.9	34.4	28.3	25.2	21.8	22.3	25.6	219.9	33.7
Other Gov (int, other depts; WRC leveraged funds)	3.7	17.0	14.6	14.0	26.0	23.0	22.4	21.8	22.3	27.9	192.6	29.5
Industry	0.0	14.8	8.3	7.8	15.1	15.5	19.3	23.3	19.3	16.2	139.7	21.4
<b>Investment Ask</b>	<b>32.8</b>	<b>282.4</b>	<b>243.0</b>	<b>256.2</b>	<b>243.0</b>	<b>243.0</b>	<b>236.4</b>	<b>236.4</b>	<b>157.6</b>	<b>0.0</b>	<b>1931.0</b>	<b>100</b>
Water levy (WRC)	6.1	40.0	38.3	39.3	37.3	37.3	36.3	36.3	24.2	0.0	295.1	15.3
DST instruments inc. NRF and TIA	15.0	96.7	89.0	100.8	93.8	87.1	75.4	65.2	46.5	0.0	669.5	34.7
Other Gov (int, other depts; WRC leveraged funds)	11.8	77.8	73.7	74.6	70.8	70.8	67.0	65.2	46.5	0.0	558.2	28.9
Industry	0.0	67.8	42.1	41.3	41.1	47.8	57.7	69.8	40.3	0.0	408.1	21.1
<b>Investment Ask</b>	<b>16.4</b>	<b>98.4</b>	<b>75.5</b>	<b>88.6</b>	<b>68.9</b>	<b>78.8</b>	<b>78.8</b>	<b>72.2</b>	<b>52.5</b>	<b>0.0</b>	<b>630.0</b>	<b>100</b>
Water levy (WRC)	3.0	14.0	11.9	13.6	10.6	12.1	12.1	11.1	8.1	0.0	96.4	15.3
DST instruments inc. NRF and TIA	7.5	33.7	27.6	34.9	26.6	28.2	25.1	19.9	15.5	0.0	219.0	34.8
Other Gov (int, other depts; WRC leveraged funds)	5.9	27.1	22.9	25.8	20.1	22.9	22.3	19.9	15.5	0.0	182.4	29.0
Industry	0.0	23.6	13.1	14.3	11.7	15.5	19.2	21.3	13.4	0.0	132.2	21.0
<b>Totals</b>	<b>118.9</b>	<b>1174.8</b>	<b>956.9</b>	<b>962.4</b>	<b>970.5</b>	<b>943.7</b>	<b>940.6</b>	<b>936.9</b>	<b>844.3</b>	<b>496.0</b>	<b>8345.0</b>	
<b>Project management office (PMO)</b>	<b>3.2</b>	<b>4.2</b>	<b>5.5</b>	<b>6.5</b>	<b>7.1</b>	<b>7.9</b>	<b>8.7</b>	<b>9.5</b>	<b>10.4</b>	<b>11.5</b>	<b>74.5</b>	
<b>Totals</b>	<b>122.1</b>	<b>1179.0</b>	<b>962.4</b>	<b>968.9</b>	<b>977.6</b>	<b>951.6</b>	<b>949.3</b>	<b>946.4</b>	<b>854.7</b>	<b>507.5</b>	<b>8419.6</b>	

## APPENDIX A: WORK SESSION DATA

**Table A1: Statements of need (unabridged) and interventions provided during work sessions with the four sectors of the water community.**

Needs Agriculture		Interventions Agriculture
<b>Supply</b>	<b>Increase diversity and optimisation of mix</b>	
1	Increase use of treated effluent	Implement efficient treatment management system. Address public perception issue. Catalyse linkages between those that discharge between producers and users – e.g. mines and farms
2	Increase levels of desalination	Regularise soil sampling at site level, introduce more efficient irrigation system suited to individual farms and particular regions; create detailed soil maps; models: cooperatives and delivery of extension services
3	Increase rainwater harvesting	Increase and sustain water harvesting and conservation methods. Conduct scientific-economic evaluation of alternative approaches
4	Increase use of wastewater	
5	Increase water transfers	
6	Increase storage capacity	Enable transfers between end uses: inter-basin, client-client
7	Increase ground water use	Make use of local water resources
8	Increase stormwater management	Revise legislation on stormwater management and use
9	Increase capture of floodwaters	
10	Improve governance structures – Management	Training and capacity development. Staff turn-over (capacity) sustainable knowledge-transfer. Revised understanding of the policy positions in Water Act. Enforcement and compliance – institutions missing, not capacitated to perform/ mandate ??? Catchment Management Agencies – to be replaced / up and running in 2016
11	Align allocations of water with requirements	
<b>Demand</b>	<b>Reduce Non-consumptive Use</b>	
12	Reduce water transport losses	Refurbish irrigation networks, incentivise improved management of losses
13	Reduce leakages	Detect and repair leakages
<b>Demand</b>	<b>Reduce Consumptive Use</b>	
14	Optimise ground water use	Minimise allocation requirement
15	Reduce volume of water use	Use water-saving crops and varieties
16	Increase the area under irrigation	Use savings in current water use. Change NDP word "irrigation" to "agricultural water use" (in line with the rest of the world)
17	Improve efficiency of land and water use practices (of farmers)	Introduce irrigation systems and improve performance Optimise irrigation: Plan, meter, schedule Optimise irrigation: Monitor soil moisture Optimise irrigation: Reduce evapotranspiration Optimise irrigation: Optimise fertiliser use Increase effectiveness of knowledge transfer
18	Increase levels of wastewater reuse	Reduce volume of wastewater, recover and recycle Reduce wastewater released to sewers
19	Minimise volumes to unrecoverable sources	Reduce rainwater runoff
20	Minimise volume and toxicity of pollution – point-sources and diffuse sources	Reduce downstream pollution
21	Optimise the balance between the right to water and the productive use of this water	
<b>Demand</b>	<b>Improve management of Customer demand and use</b>	
22	Increase transparency over rights, quotas, allocation, transfers	Enable trading and transfer of water entitlement

<b>Needs Agriculture</b>		<b>Interventions Agriculture</b>	
23	Improve quality and effectiveness of context of planning and implementation	Enable water ordering, improve management of distribution	
24	Improve equity of pricing, encourage desirable practice	Introduce tariffs and incentives ("real cost" of water); enforce quotas	
25	Improve accuracy: use monitoring, billing and management	Increase coverage, accuracy of flow monitoring, attribution; introduce management systems	
26	Reduce levels of unmetered water use	Detect and remove unmetered supplies; ensure meters are operating	
27	Increase effectiveness of cross-sectoral planning and implementation (e.g. watershed)		
28	Reduce impediments to implementation		
<b>Needs Industry</b>		<b>Interventions Industry</b>	
<b>Supply</b>	<b>Increase diversity and optimisation of mix</b>		
1	Increase use of treated effluent	Reduce cost of effluent treatment	
2	Increase levels of desalination	Reduce energy requirement and material costs. Increase reclamation.	
3	Increase rainwater harvesting	Incentivise adoption. Use all hard surfaces; separate rain water and polluted water	
4	Increase use of wastewater	Integrate agriculture and energy production	
5	Increase water transfers	Enable easier transfer between uses and users. Enable transfers between end uses: inter-basin, client-client	
6	Increase adaptability of storage capacity	Suitability, availability, capacity, flexibility. Add tanks, man-made dams, underground or alternative storage (e.g. in mining void)	
7	Increase ground water use	Identify groundwater sources, yields and uses	
8	Increase stormwater harvesting and management	Incentivise broader adoption and uptake; Separate clean and dirty (CSO)	
9	Increase capture of floodwaters		
10	Increase protection of existing ecological infrastructure	Rehabilitation and protection. Increase awareness; improve monitoring and evaluation	
11	Increase the reliability of the infrastructure	Improve performance of planning design, operations and maintenance	
12	Increase ecological treatment	Improve performance of alternatives, relative to current solutions (and perception)	
13	Improve the reliability of bulk supply	Enable cooperative solution development and implementation	
14	Increase water quality between uses	Enable more effective and integrated processes – increase competence and capacity	
15	Increase transparency over rights, quotas, allocation, transfers (at a system level)		
<b>Demand</b>	<b>Reduce Non-consumptive Use</b>		
16	Reduce water transport losses	Minimise water tank overflows and bulk supply losses; protect transmission against corrosion	
17	Reduce leakages and evaporative losses	Implement preventive maintenance plans; Introduce monitoring and early warning systems	
<b>Demand</b>	<b>Reduce Consumptive Use</b>		
18	Minimise ground water abstraction (ultimately to zero)	Minimise demand on supplier (e.g. municipality). Reduce rainwater runoff, enforce use of groundwater resources	
19	Reduce volume of water use, avoid the need for water	Minimise ground water abstraction (ultimately to zero) Minimise water use, application and losses in primary processes Primary: Avoid use of water (e.g. optimised or new no-water processes) Ancillary: Recover condensate. Reduce steam leakage. Domestic: Manage water pressure Product water	
20	Improve efficiency of water use	Reduce water use in ancillary processes Reduce demand for domestic water	
21	Increase levels of wastewater reuse	Increase knowledge and sharing of best practices Recover and recycle – at acceptable cost Recover and recycle process, domestic and wastewater	

South Africa's Research Development and Innovation Roadmap

	Needs Industry	Interventions Industry
22	Minimise volumes to unrecoverable sources	Recycle waste streams from water and wastewater treatment Cleaner production
23	Minimise volume and toxicity of discharge; increase beneficiation	Minimise production of waste (e.g. cleaner production methods) Reduce volume of wastewater released to sewers Cleaner production, process optimisation Minimise liquid discharge, sludge; improve brine handling Minimise production of effluent (e.g. cleaner production methods) Minimise discharge of poor quality water
24	Minimise poor water quality discharge	
<b>Demand</b>	<b>Improve management of Customer demand and use</b>	
25	Increase transparency over rights, quotas, allocation, transfers	
26	Improve quality of planning	Systematically increase water independence: map footprint, develop reduction strategy
27	Improve equity of pricing, encourage desirable practice	Tariffs, incentives. Ensure prices are a better and full reflection of economic value. Review and remodel pricing structure Introduce tariffs and incentives ("real cost" of water) Increase cost of discharge to sewer Increase precision of attribution, granularity of the impact evaluation Install meters, monitor use and target reductions Detect and remove unmetered supplies; ensure meters are operating; Manage collection Detect and remove unmetered supplies; ensure meters are operating Technology and institutional efficiencies
28	Increase knowledge and sharing of best practices	
29	Improve accuracy of monitoring and billing (both raw and within municipal services)	
30	Reduce levels of unmetered water use	
31	Improve co-operative governance and management of supply	
32	Increase security of supply	
	<b>Needs Environment</b>	<b>Interventions Environment</b>
<b>Supply</b>	<b>Increase diversity and optimisation of mix</b>	
1	Increase /Encourage ground water use sources	Investigate groundwater potential as a conjunctive source Optimise Mix for context (mgmt. consumptive use)
2	Increase runoff	Improve control of alien invasive plants and wetland rehabilitation
3	Increase recharge of Groundwater sources (Biodiversity, vegetation, land use mgmt.	Improve control of alien invasive plants and wetland rehabilitation Improve good land use practices Increase artificial recharge Improve performance and cost of purification
4	Increase reuse of used water (Treated, Returned artificial	
5	Encourage rainwater capture and use	
6	Increase effectiveness of Governance (authorisation, governance, enforcement, compliance)	Introduce legislation and incentives to encourage uptake Up-rate competence and increase capacity
7	Ensure conservation of Priority Water areas	Identify, map declare and adopt. Design and introduce regulation and management mechanisms
8	Protect – Reduce/minimise Quantity & Quality	Improve regulatory frameworks; improve the quality of decision-making information
9	Increase /substitute levels of desalination	Improve performance and cost of purification
10	Enhance Rainfall	Identify suitable sites; improve yields
11	Harvest fog for strategic use water	Identify suitable sites; improve yields
12	Increase effective management of water reticulation & treatment infrastructure	Raise priority of this activity. Augment capacity, increase funding (improve access to funding), management
13	Quantity & characteristic of Groundwater & Surface water	Develop clear understanding for variety of geological settings

South Africa's Research Development and Innovation Roadmap

	<b>Needs Environment</b>	<b>Interventions Environment</b>
	interaction – minimise pollution & contaminants	Account for allocation of water
14	Increase retention (source control/local control) of water in: wetlands, flood plains, percolation	Develop and implement national design philosophy for storm water management – provide terms of reference (SUDS) (larger metros) Neil Armitage UCT
15	Increase the effectiveness, efficiency and cost of the production of ecological goods and services	Ensure sustainable use of Ecological Infrastructure – wetlands, floodplains, estuaries
16	Increase adaptability and flexibility to plan for respond to the water effects of climate change	Recognise volatility; introduce adaptive practices
<b>Demand</b>	<b>Reduce Non-Consumptive Use</b>	
17	Reduce Evaporative and transpiration losses (alien invasion)	Reduce consumption by alien invasive species
18	Reduce water transport losses	Reduce in-situ evaporation (e.g. abandoned sand mining operations)
<b>Demand</b>	<b>Reduce Consumptive Use</b>	
19	Minimise ground water abstraction (ultimately to zero)	
20	Optimise flow regime (flow, water quality, sediment transport processes) Biotic	
21	Reduce volume of water use , avoid the need for water	
22	Improve efficiency of water use	
23	Increase levels of wastewater reuse	
24	Minimise volumes to unrecoverable sources	
25	Minimise toxicity discharged to next use (dilution & concentration)	Maximise natural water resource function (aquatic response)
26	Minimise poor water quality discharge	
<b>Demand</b>	<b>Improve management of Customer demand and use</b>	
27	Improve coverage and effective use of decision-making information for water quality and quantity	Improve resourcing: competence, capacity, funding; improve collaboration; enhance data basis and data integration Availability, quality of information – National water integrated resources system
28	Deliver better on negotiated water resource quality objectives	Encourage levels of cooperation; increase levels and effectiveness of compliance and enforcement
29	Reduce excessive lawful, unlawful use, verification and validation	Encourage levels of cooperation; increase levels and effectiveness of compliance and enforcement
30	Quantify with more precision and objectively the customer value proposition of providing and maintaining ecological infrastructure	Develop ability to value
31	Encourage and incentivise self-regulation at all levels	(certification); increase understanding, demystify
32	Reduce levels of unmet water use	
33	Increase security of supply	
	<b>Needs Public Sector</b>	<b>Interventions Public Sector</b>
<b>Supply</b>	<b>Increase diversity and optimisation of mix</b>	
1	Increase / Encourage ground water use and sources	Investigate groundwater potential as a conjunctive source Optimise Mix for context (mgmt. consumptive use)
2	Increase runoff	Improve control of alien invasive plants and wetland rehabilitation
3	Increase recharge of Groundwater sources	Improve control of alien invasive plants and wetland rehabilitation Improve good land use practices Increase artificial recharge

	Needs Public Sector	Interventions Public Sector
4	Increase reuse of used water (Treated, Returned, artificial – from industry and mining)	Improve performance and cost of purification
5	Encourage rainwater capture and use	Increase proportion captured; incentivise uptake
6	Increase effectiveness of Governance (authorisation, governance, enforcement, compliance)	Up-rate competence and increase capacity
7	Ensure conservation of Priority Water areas	Identify, map declare and adopt. Design and introduce regulation and management mechanisms
8	Protect – Reduce/minimise Quantity & Quality	Improve regulatory frameworks; improve the quality of decision-making information
9	Increase /substitute levels of desalination	Increase recovery from sources (wastewater, seawater, process and brackish) Improve performance and cost of purification
10	Increase stormwater harvesting and management	Incentivise broader adoption and uptake; Separate clean and dirty (CSO)
11	Increase effective management of water reticulation & treatment infrastructure	Raise priority of this activity. Augment capacity, increase funding (improve access to funding), management
12	Quantity & characteristic of Groundwater & Surface water interaction – minimise pollution & contaminants	Develop clear understanding for variety of geological settings
13	Increase water transfers	Enable, strengthen interbasin transfers
14	Increase retention (source control/local control) of water in: wetlands, flood plains, percolation	Develop and implement national design philosophy for storm water management – provide terms of reference (SUDS) (larger metros) Neil Armitage UCT
15	Water loss -reduce water loss in the distribution system - abstraction, distribution, reticulation	Maintenance ? Prioritise the funds, improve allocation of funds for operations. Ring fence – "Run water as a business in municipality"
16	Improve visibility and management of asset base	Develop a plan to optimise the investment in Infrastructure – plan and develop (flexible and responsive)
17	Improve the financial sustainability of the water system	Remove political interference in enforcement, reduce undesirable or unproductive political involvement
18	Increase proportion of water that is paid for	No confidence in Billing system – able to pay but don't trust it
19	Increase the accuracy of attribution of water use	Improve metering, billing systems, attitudes, prepaid meters. Improve the monitoring throughout the system – inflow. At system level improve the ability to monitor the flow use and quality (water balance)
20	Improve revenue collection performance	Revise policy around requirement to pay? Increase the range of tariffs
21	Improve the equity of pricing	Refine accountability along the value chain
22	Institutional landscape in the country? Governance, management,	Refine accountability along the value chain
23	Optimise the ability to manage from source to source in an integrated way	Refine accountability along the value chain
24	Improve water resource management -	implementing current legislation – WRN NWA NWRS
25	Improve the resource mix – groundwater effluent reuse, desalination	
26	Improve Planning for the future – ability to respond to volatility	Integrated planning – water reconciliation plans? Are they based on lowest cost or strategic consideration Social systems and demand – Development of rural areas
27	Improve performance and optimise investment in Infrastructure	Roll of Technology?
28	Increase the ability in identifying alternative supplies	
29	Increase non potable water	
30	Improve the ability to manage water flows	Improve Incentives for good operational practices
	<b>Reduce Non-consumptive Use</b>	
31	Reduce water transport losses	Refurbish and maintain distribution infrastructure
32	Reduce water leakages and evaporative losses	Increase detection and repair performance; improve management of pressure; maintain appliances
	<b>Reduce Consumptive Use</b>	

	Needs Public Sector	Interventions Public Sector
33	Minimise groundwater abstraction (ultimately to zero)	Introduce dual-piped water supply systems; align water quality better with use
34	Reduce volume of water use	Reduce demand for water (domestic and commercial (showers, taps, toilets)
35	Improve efficiency of water use	Increase use of water-saving appliances
36	Increase levels of wastewater reuse	Increase levels of recovery and recycling
37	Minimise volumes to unrecoverable sources	
38	Minimise volume and toxicity of discharge; increase beneficiation	
39	Minimise poor water quality discharge	
40	Minimise toxicity discharged to next use (dilution & concentration)	
41	Improve quality – increase the alignment of the quality of water with use	
42	Improve the pricing structures – full cost pricing "real cost" Equitable pricing	
43	Ring fencing money	
44	Improve operational efficiencies	Define, implement and support Billing control policy
45	Reduce level of consumption of illegal water	
46	Improve encourage acceptable wider water acceptable on dry solution systems	Highlight the importance of water (scarcity)
47	Encourage consumers to reduce demand	
48	Improve management of Customer demand and use	
49	Stimulate growth more economically (use of water)	
<b>Demand</b>	<b>Improve management of Customer demand and use</b>	
50	Increase transparency over rights, quotas, allocation, transfers	
51	Improve coverage and effective use of decision-making information relating to water quality and quantity	
52	Increase knowledge and sharing of best practices	
53	Improve equity of pricing, encourage desirable practice	Tariffs, incentives. Ensure prices are a better and full reflection of economic value. Review and remodel pricing structure Increase cost of discharge to sewer
54	Improve accuracy of monitoring and billing (within municipal services)	Install more accurate metering; monitor flow; improve billing and collection performance
55	Reduce levels of excessive lawful, unlawful use, verification and validation	Detect and remove unmetered supplies; ensure meters are operating
56	Improve co-operative governance and management of supply	
57	Encourage and incentivise self-regulation at all levels	
58	Improve quality of planning	
59	Improve the understanding of water consumption by consumers	Campaigning
60	Improve metering – similar to electricity metering	Institutional structures
61	Increase willing and ability to absorb and use new approaches – co-create, co-responsibility, earlier involvement in dev of solution	– co-create, co-responsibility, earlier involvement in dev of solution

**Table A2: Statements of need grouped into clusters, indicating which sectors expressed which needs.**

	Agriculture	Industry	Public Sector	Environment
<b>SUPPLY: Increase ability to make use of more sources of water, including alternatives</b>				
1 Increase the ability to identify and make use of alternative supplies	•		•	
2 Increase use of treated effluent	•	•	•	•
3 Decrease levels of salinity	•	•	•	•
4 Increase levels of desalination	•	•	•	•
5 Increase rainwater harvesting	•	•	•	•
6 Increase use of wastewater	•	•	•	•
7 Increase levels of groundwater use	•	•	•	•
8 Increase stormwater harvesting and management	•	•	•	•
9 Increase capture of floodwaters	•			•
<b>SUPPLY: Improve governance, planning and management of supply and delivery</b>				
10 Enable optimised reallocation and distribution	•	•		•
13 Improve effectiveness of Institutional landscape in respect of governance, planning and supply management (actors, management, institutions)	•	•	•	
14 Improve the ability to manage water flows. Align allocation and mix to requirements	•	•	•	
15 Improve quality and resilience of planning for the future – ability to respond to volatility			•	
16 Optimise the ability to manage water resources from source to source in an integrated way			•	
<b>SUPPLY: Improve adequacy and performance of supply infrastructure</b>				
11 Increase adaptability of storage capacity	•	•	•	•
12 Increase protection and reliability of ecological infrastructure			•	•
23 Improve performance, optimise investment in infrastructure			•	
<b>SUPPLY: Run water as a financially sustainable “business” by improving operational performance</b>				
18 Improve the financial sustainability of the water system			•	
19 Improve the equity of pricing			•	
20 Increase the accuracy of attribution of water use			•	
21 Increase proportion of water that is paid for			•	
22 Improve performance of revenue collection			•	
24 Improve operational efficiencies			•	
<b>DEMAND: Improve governance planning and its implementation in the management of demand and use</b>				
36 Increase transparency over rights, quotas, allocation and transfers	•	•		•
37 Improve co-operative governance with respect to planning and management. Cross-sectoral.	•	•		
38 Improve quality and effectiveness of context-specific planning and implementation	•	•	•	
<b>DEMAND: Reduce losses and increase efficiency of productive use</b>				
25 Reduce water transport losses	•	•	•	•
26 Reduce leakages	•	•	•	
27 Optimise conjunctive use of water	•	•	•	
28 Reduce volume of water use	•	•	•	
29 Increase the area under irrigation	•			
30 Improve efficiency of water use	•	•	•	
31 Increase levels of water reuse	•	•	•	
32 Minimise output to unrecoverable sources	•	•	•	
33 Minimise volume and toxicity of pollution	•	•	•	
34 Optimise balance between the right to water and productive use of this water	•			•
35 Minimise discharge of poor quality water		•	•	
<b>DEMAND: Improve performance of pricing, monitoring, metering, billing and collection</b>				
39 Improve equity of pricing, encourage desirable practice	•	•	•	
40 Improve accuracy: use monitoring, billing and management	•	•	•	•
41 Reduce levels of unmetered use	•	•	•	

**Table A3: Assessment of RDD potential according to the stage and nature of each identified opportunity.**

	Legend for stage: E = Exploration; T = Testing; DM = DeMonstration; DP = DePloyment	Management	Information	Technology	Capacity
<b>S</b>	Increase ability to make use of more sources of water, including alternatives				
1	Increase the ability to identify and make use of alternative supplies	E T DM DP	DM DP	E T DM DP	DM DP
2	Increase use of treated effluent	E T DM DP	DM DP	E T DM DP	DM DP
3	Decrease levels of salinity				
4	Increase levels of desalination	E T DM DP	DM DP	E T DM DP	DM DP
5	Increase rainwater harvesting	E T DM DP	DM DP	E T DM DP	DM DP
6	Increase use of wastewater	E T DM DP	DM DP	E T DM DP	DM DP
7	Increase levels of groundwater use	DM DP	DM DP	DM DP	DM DP
8	Increase storm water harvesting and management	E T DM DP	DM DP	E T DM DP	DM DP
9	Increase capture of floodwaters				
<b>S</b>	<b>Improve governance, planning and management of supply and delivery</b>				
10	Enable optimised reallocation and distribution	T DM DP	DM DP	T DM DP	DP
13	Improve effectiveness of Institutional landscape in respect of governance, planning and supply management	DM DP	DM DP	No	DP
14	Improve the ability to manage water flows. Align allocation and mix to requirements	T DM DP	DM DP	T DM DP	DP
15	Improve quality and resilience of planning for the future – ability to respond to volatility	T DM DP	DM DP	T DM DP	DP
16	Optimise the ability to manage water resources from source to source in an integrated way	DM DP	DM DP	No	DP
<b>S</b>	<b>Improve adequacy and performance of supply infrastructure</b>				
11	Increase adaptability of storage capacity	DM DP	DM DP	E	DM DP
12	Increase protection and reliability of ecological infrastructure	E DM DP	DP	E DM DP	DP
23	Improve performance, optimise investment in infrastructure	E DM DP	DP	E DM DP	DP
<b>S</b>	<b>Run water as a financially sustainable “business” by improving operational performance</b>				
18	Improve the financial sustainability of the water system	DP	DP	No	DM DP
19	Improve the equity of pricing	DT DM DP	DM DP	No	DP
20	Increase the accuracy of attribution of water use	DM DP	DM DP	T DM DP	DP
21	Increase proportion of water that is paid for	DM DP	DM DP	T DM DP	DP
22	Improve performance of revenue collection	DM DP	DM DP	T DM DP	DP
24	Improve operational efficiencies	DM DP	DM DP	No	DP
<b>D</b>	<b>Improve governance planning and its implementation in the management of demand and use</b>				
36	Increase transparency over rights, quotas, allocation and transfers	DT DM DP	DM DP	No	DP
37	Improve co-operative governance with respect to planning and management. Cross-sectoral.	DT DM DP	DM DP	No	DP

Legend for stage: E = Exploration; T = Testing; DM = DeMonstration; DP = DePloyment					
		Management	Information	Technology	Capacity
38	Improve quality and effectiveness of context-specific planning and implementation	DT DM DP	DM DP	No	DP
<b>D</b>	<b>Reduce losses and increase efficiency of productive use</b>				
25	Reduce water transport losses	T DM DP	DM DP	E DM DP	DP
26	Reduce leakages	T DM DP	DM DP	E DM DP	DP
27	Optimise conjunctive use of water	E DM DP	DP	No	DP
28	Reduce volume of water use	E DM DP	E DM DP	E DM DP	DP
29	Increase the area under irrigation	??	??	??	??
30	Improve efficiency of water use	DM DP	DM DP	??	??
31	Increase levels of water reuse	DM DP	T E DM DP	T E DM DP	DM DP
32	Minimise output to unrecoverable sources	E DM	E DM DP	E DM DP	DM DP
33	Minimise volume and toxicity of pollution	T E DM	DM DP	E DM DP	DM DP
34	Optimise balance between the right to water and productive use of this water	E DM	E DM DP	E DM DP	DM DP
35	Minimise discharge of poor quality water	E DM	E DM DP	E DM DP	DM DP
<b>D</b>	<b>Improve performance of Pricing, Monitoring, Metering, Billing and Collection</b>				
39	Improve equity of pricing, encourage desirable practice	E DM DP	E DM DP	E DM DP	E DM DP
40	Improve accuracy, use monitoring, billing and management	E DM DP	E DM DP	E DM DP	E DM DP
41	Reduce levels of unmetered use	E DM DP	E DM DP	E DM DP	E DM DP

**Table A4: Assessment of RDD Performance Measures according to the seven Clusters of Needs, Interventions, and RDD Potential**

		Performance Measures defined at Cluster Level (with reference to the Needs)	With respect to the identified Performance Measures, what is the minimum (quantified) change required?
<b>S</b>	<b>Increase ability to make use of more sources of water, including alternatives</b>		
1	Increase the ability to identify and make use of alternative supplies	More treated effluent is reused instead of discharged to the environment	75% of treated wastewater reused
2	Increase use of treated effluent		
3	Decrease levels of salinity	Seawater desalination in coastal communities and wastewater desalination inland are routine operations	Coastal communities obtain 5% of the water supply from seawater; inland 75% of wastewater is desalinated and reused
4	Increase levels of desalination		
5	Increase rainwater harvesting	More treated effluent is reused instead of discharged to the environment	75% of treated wastewater reused
6	Increase use of wastewater	More water used is sourced from groundwater supplies	5-10% of water is abstracted from groundwater
7	Increase levels of groundwater use	Stormwater in urban areas is harvested	All metropolitan areas have stormwater drainage and storage
8	Increase stormwater harvesting and management		
9	Increase capture of floodwaters		
<b>S</b>	<b>Improve governance, planning and management of supply and delivery</b>		
10	Enable optimised reallocation and distribution	DWA water allocations remapped	A new map completed by 2016
13	Improve effectiveness of institutional landscape in respect of governance, planning and supply management	Governance is managed at catchment level	Nine functional Catchment Management Agencies
14	Improve the ability to manage water flows. Align allocation and mix to requirements		
15	Improve quality and resilience of planning for the future – ability to respond to volatility		
16	Optimise the ability to manage water resources from source to source in an integrated way	DWA water allocations remapped	The new map includes groundwater, seawater, and wastewater
<b>S</b>	<b>Improve adequacy and performance of supply infrastructure</b>		
11	Increase adaptability of storage capacity	Storage for treated effluent is available	Storage facilities similar to Joburg Water's Northern Works exist in all metropolitan areas.
12	Increase protection and reliability of ecological infrastructure	Ecological reserve is redefined and sufficient	New rainfall maps have led to a new limit for the ecological reserve, which is protected by regulation
23	Improve performance, optimise investment in infrastructure		
<b>S</b>	<b>Run water as a financially sustainable "business" by improving operational performance</b>		
18	Improve the financial sustainability of the water system	Non-revenue water is better controlled	Non-revenue water is below 15%
19	Improve the equity of pricing		
20	Increase the accuracy of attribution of water use	All domestic and industrial users are on metered supplies	All domestic and industrial users are on metered supplies
21	Increase proportion of water that is paid for		
22	Improve performance of revenue collection	Non-revenue water is better controlled	Non-revenue water is below 15%
24	Improve operational efficiencies	Leak detection is improved	All leaks are detected in under 12 hours and repaired in under 48
<b>D</b>	<b>Improve governance planning and its implementation in the management of demand and use</b>		
36	Increase transparency over rights, quotas, allocation and transfers	Consumers within catchments know everyone's water allocation	Nine functional Catchment Management Agencies

South Africa's Research Development and Innovation Roadmap

	Performance Measures defined at Cluster Level (with reference to the Needs)	With respect to the identified Performance Measures, what is the minimum (quantified) change required?
37	Improve co-operative governance with respect to planning and management. Cross-sectoral.	Nine functional Catchment Management Agencies
38	Improve quality and effectiveness of context-specific planning and implementation	Nine functional Catchment Management Agencies
<b>D</b>	<b>Reduce losses and increase efficiency of productive use</b>	
25	Reduce water transport losses	Non-revenue water is below 15%
26	Reduce leakages	All leaks are detected in under 12 hours and repaired in under 48
27	Optimise conjunctive use of water	
28	Reduce volume of water use	PICWAT and SAPWAT, or equivalents, are in use on all commercial farms and 30% of family farms
29	Increase the area under irrigation	
30	Improve efficiency of water use	
31	Increase levels of water reuse	75% of treated wastewater reused
32	Minimise output to unrecoverable sources	75% of treated wastewater reused
33	Minimise volume and toxicity of pollution	
34	Optimise balance between the right to water and productive use of this water	90% of wastewater treatment works attain Green Drop status
35	Minimise discharge of poor quality water	90% of wastewater treatment works attain Green Drop status
<b>D</b>	<b>Improve performance of Pricing, Monitoring, Metering, Billing and Collection</b>	
39	Improve equity of pricing, encourage desirable practice	Free basic water remains free; reasonable use is reasonably priced; wasted water is prohibitively expensive
40	Improve accuracy: use monitoring, billing and management	All domestic and industrial users are on metered supplies
41	Reduce levels of unmetered use	Non-revenue water is below 15%

## APPENDIX B: ATTRACTIVENESS OF RDD OPPORTUNITIES ACCORDING TO EACH SECTOR, PER CLUSTER.

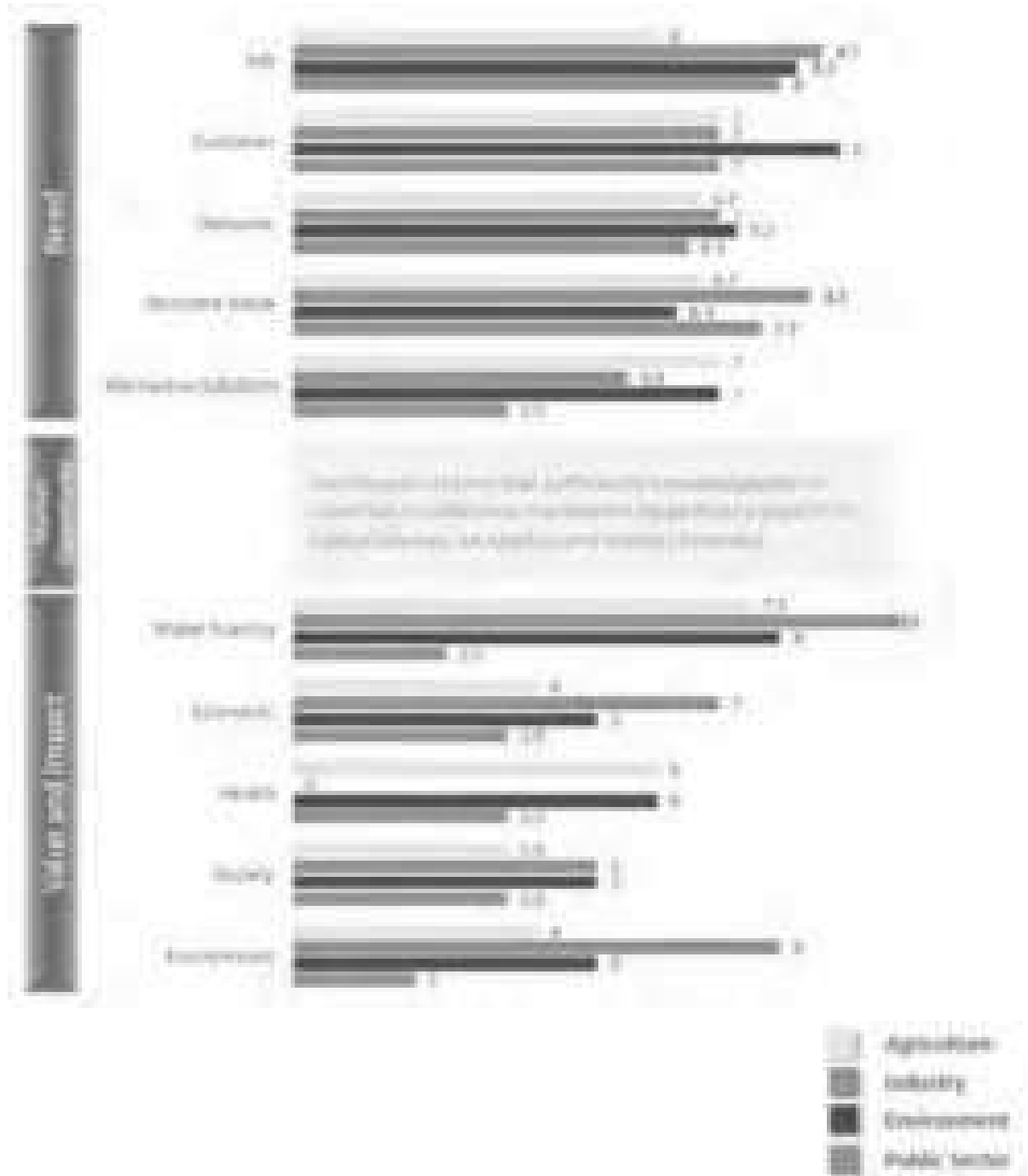


Figure B1: Increase ability to make use of more sources of water, including alternatives

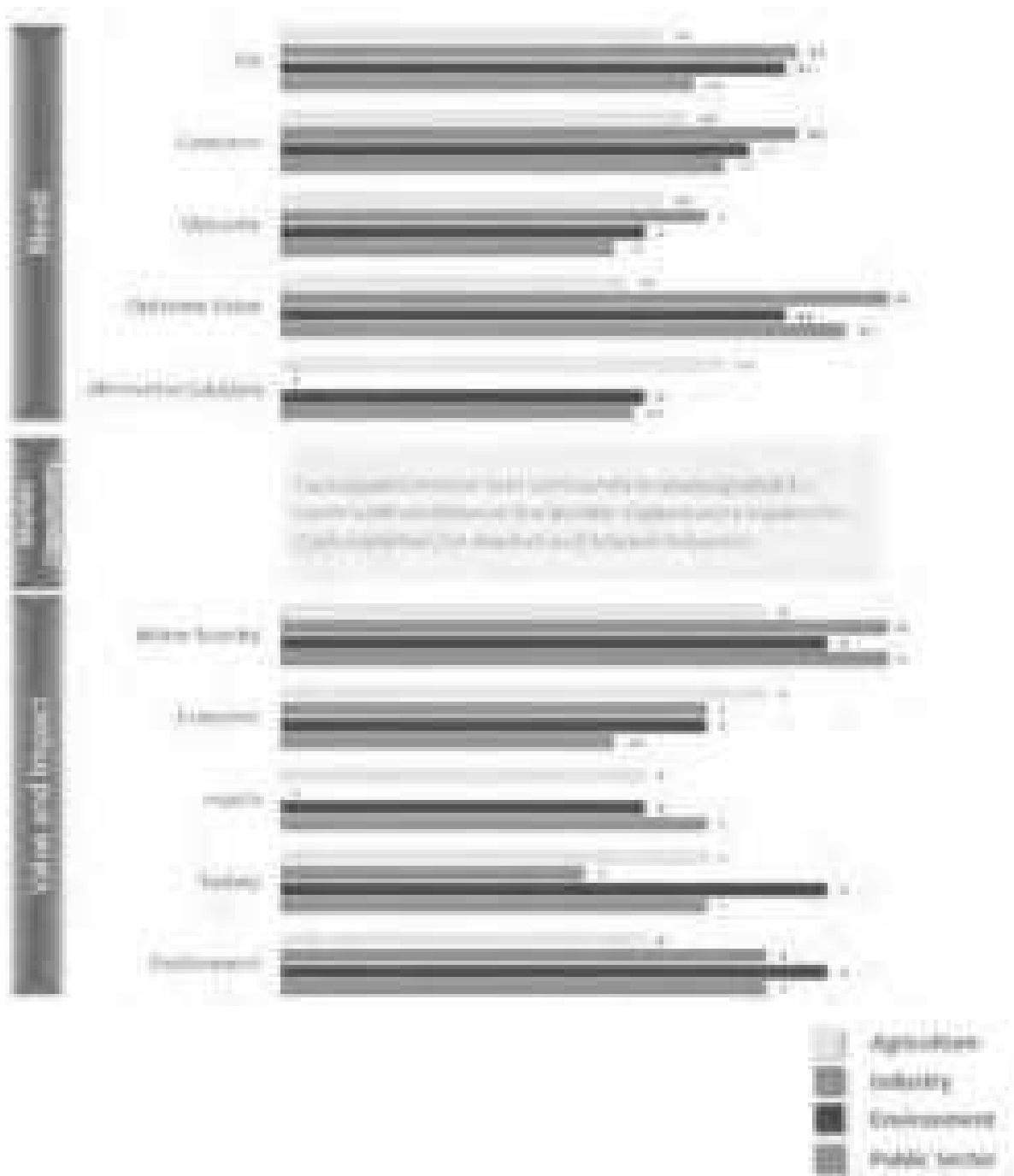


Figure B2: Improve governance, planning and management of supply and delivery

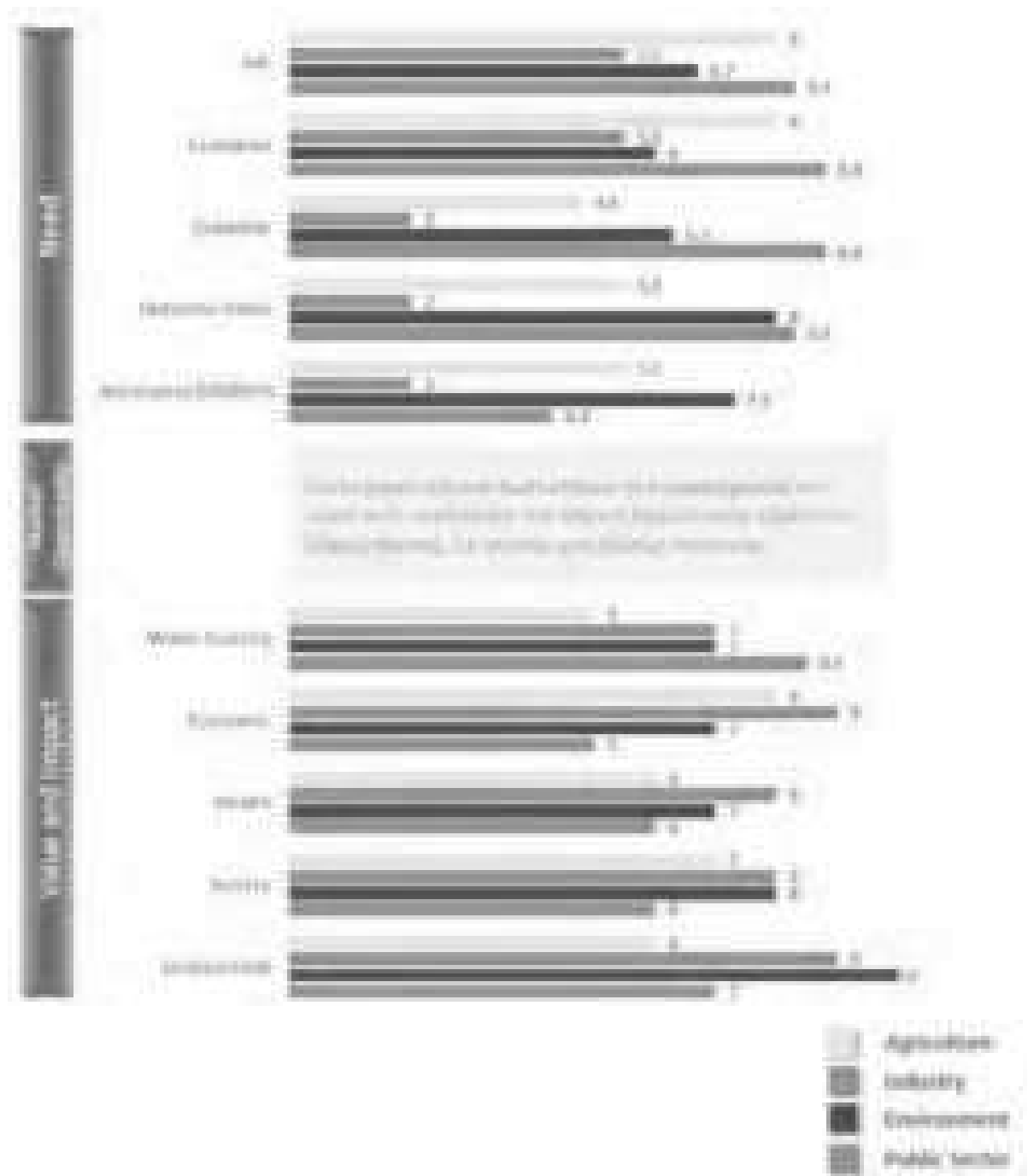


Figure B3: Improve adequacy and performance of supply infrastructure



**Figure B4: Run water as a financially sustainable “business” by improving operational performance**

This cluster was identified as a set of needs only by the public sector, so estimates of the needs' attractiveness, opportunity, value, and impact were not sought from the other three sectors.

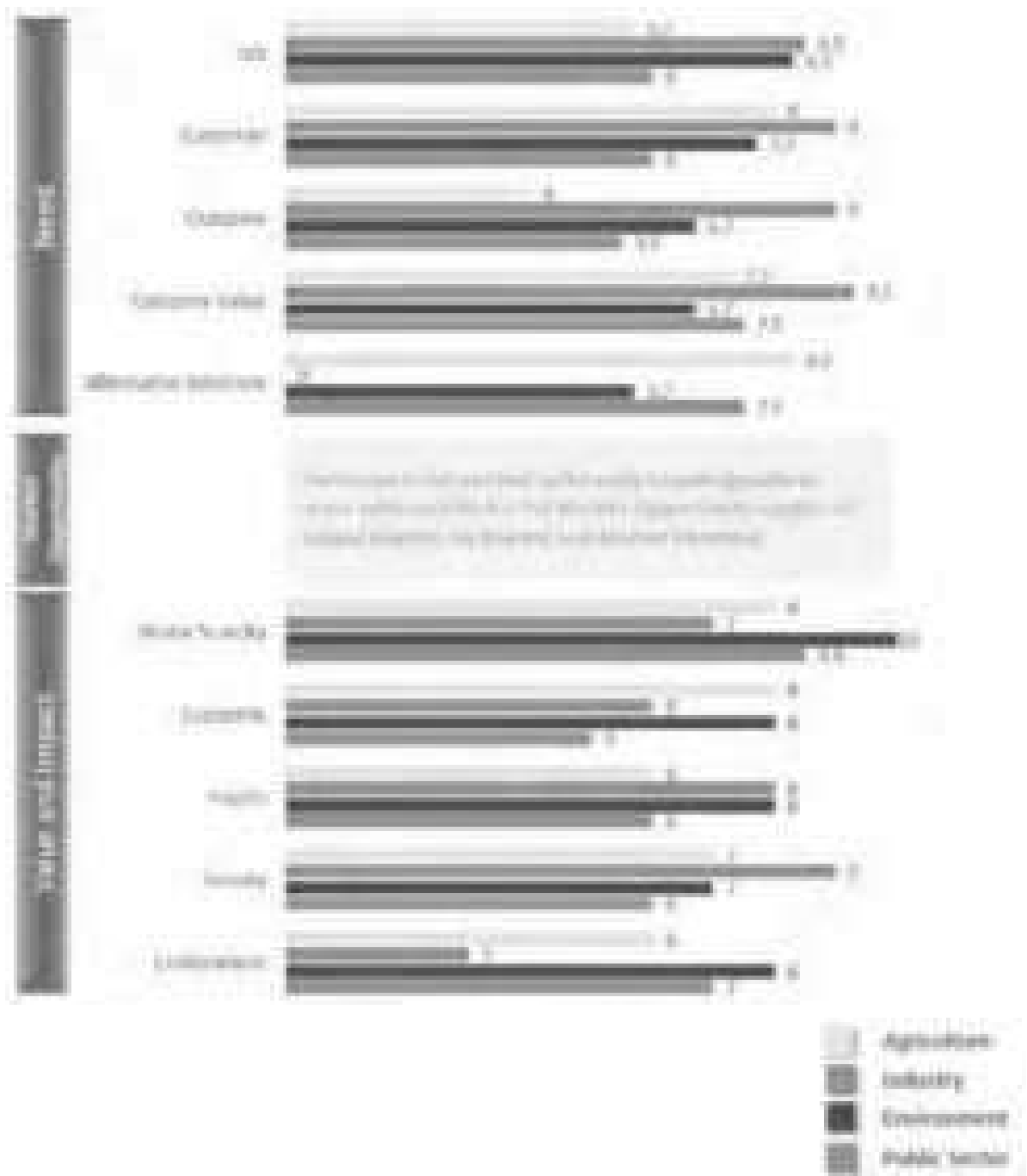


Figure B5: Improve governance, planning, and management of demand and use

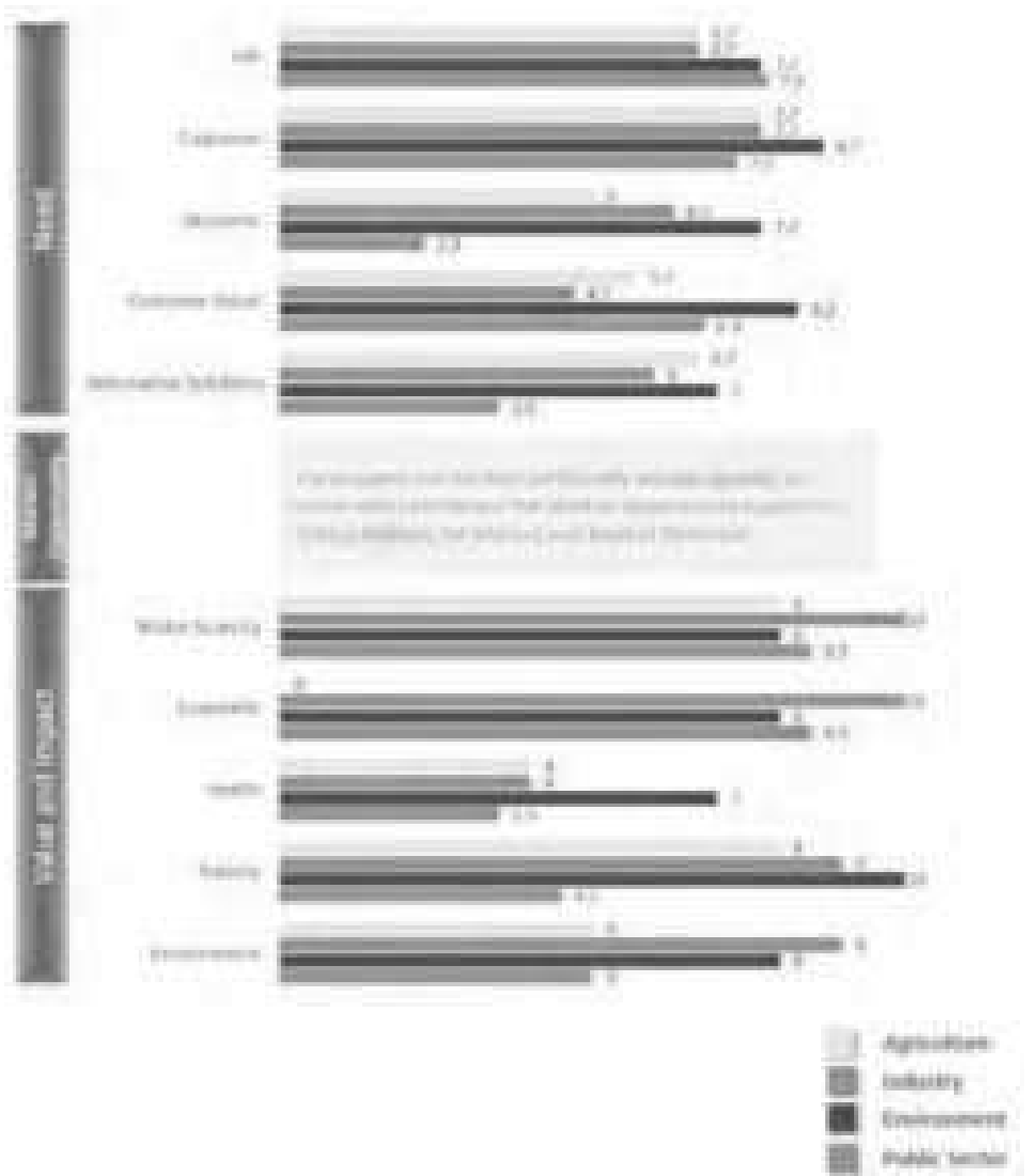


Figure B6: Reduce losses and increase efficiency of productive use

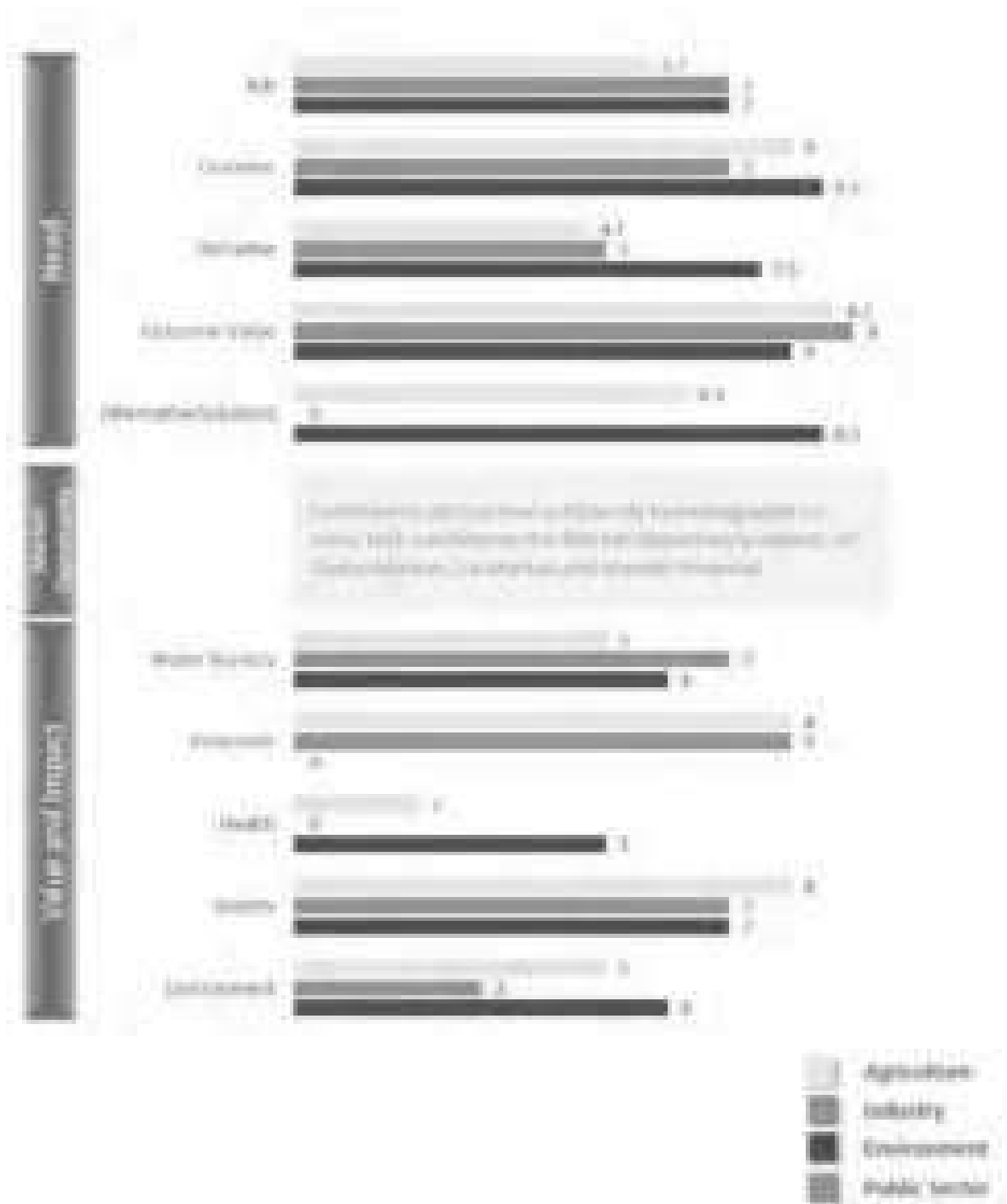


Figure B7: Improve performance of pricing, monitoring, billing, metering and collection

## APPENDIX C: RESEARCH FOCUS AREAS AND THEIR UNDERLYING DISCIPLINES, MAPPED TO THE SEVEN CLUSTERS OF NEEDS AND INTERVENTIONS

Discipline level 1	Discipline level 2	Discipline level 3	Research focus area / field of research	Sources	Governance, Planning & Management – Supply	Infrastructure	Op performance	Governance, Planning & Management – Demand	Productive use	Pricing, monitoring, billing
Agricultural sciences	Agribusiness	Agrichemicals	Improved food production	X						
Agricultural sciences	Agribusiness	Crop production	Improved food production	X	X			X	X	
Agricultural sciences	Agribusiness	Distribution	Food security and business efficiency		X	X	X	X		
Agricultural sciences	Agribusiness	Machinery	Efficient agriculture						X	
Agricultural sciences	Agribusiness	Marketing	Business efficiency		X			X	X	
Agricultural sciences	Agribusiness	Processing	Efficient agriculture						X	
Agricultural sciences	Agribusiness	Sales	Business efficiency		X			X		
Agricultural sciences	Agribusiness	Seed supply	Crop production							
Agricultural sciences	Agroforestry	Agroforestry	Agroforestry			X				
Agricultural sciences	Agronomy	Horticulture	Horticulture	X					X	
Agricultural sciences	Agronomy	Precision agriculture	Improved food production						X	
Agricultural sciences	Crop science	Crop production and physiology	Crop production	X					X	
Agricultural sciences	Crop science	Genetics and plant breeding	Crop production						X	
Agricultural sciences	Irrigation and drainage science engineering	Irrigation and drainage science engineering	Irrigation and drainage	X	X	X	X	X	X	
Agricultural sciences	Soil science	Soil chemistry	Soil chemistry	X					X	
Agricultural sciences	Soil science	Soil fertility	Soil fertility	X					X	
Agricultural sciences	Soil science	Soil management	Soil management	X	X			X	X	
Agricultural sciences	Soil science	Soil microbiology and biochemistry	Soil microbiology and biochemistry	X					X	
Agricultural sciences	Soil science	Soil morphology and genesis	Soil morphology and genesis						X	

South Africa's Research Development and Innovation Roadmap

Discipline level 1	Discipline level 2	Discipline level 3	Research focus area / field of research	Sources	Governance, Planning & Management – Supply	Infrastructure	Op performance	Governance, Planning & Management – Demand	Productive use	Pricing, monitoring, billing
Agricultural sciences	Soil science	Soil physics	Soil physics						X	
Agricultural sciences			Natural resource management	X	X	X	X	X	X	
Agrometeorology			Agrometeorology	X	X			X	X	
Aquaculture			Aquaculture		X	X	X	X	X	
Beneficial agricultural use of municipal sludge			Beneficial agricultural use of municipal sludge				X		X	
Biological science			Biological science							
Biology and Biochemistry	Genetics	Microbial ecology	Ecosystem functioning	X						
Biology and Biochemistry	Genetics	Microbial ecology	Wastewater treatment	X						
Biology and Biochemistry	Marine, Freshwater Biology	Ecosystem functioning	Ecosystem functioning	X		X				
Biology and Biochemistry	Marine, Freshwater Biology	Nutrient cycling	Ecosystem functioning	X						
Biology and Biochemistry	Metagenomics	Microbial ecology	Ecosystem functioning	X						
Biology and Biochemistry	Metagenomics	Microbial ecology	Wastewater treatment	X						
Biology and Biochemistry	Molecular biology	Microbial ecology	Ecosystem functioning	X					X	
Biology and Biochemistry	Molecular biology	Microbial ecology	Wastewater treatment	X						
Biology and Biochemistry	Physiology and endocrinology	Endocrinology	Animal, human, public, and environmental health	X						
Chemistry	Inorganic Chemistry	Fate and behaviour of metals in the environment	Animal, human, public, and environmental health	X						
Chemistry	Inorganic Chemistry	Metals: toxicity and micronutrient value	Animal, human, public, and environmental health	X						
Chemistry	Organic Chemistry	Degradation of priority pollutants	Animal, human, public, and environmental health	X						
Chemistry	Organic Chemistry	Fate and behaviour of pollutants	Animal, human, public, and environmental health	X					X	
Chemistry			Water treatment	X			X		X	
Chemistry			Environmental and Analytical Chemistry	X			X		X	
Clinical medicine	Chemicals in potable water	Fluoridosis	Human health	X	X			X		
Clinical medicine	Health-related microbiology	Emerging pathogens	Human health	X					X	

South Africa's Research Development and Innovation Roadmap

Discipline level 1	Discipline level 2	Discipline level 3	Research focus area / field of research	Sources	Governance, Planning & Management – Supply	Infrastructure	Op performance	Governance, Planning & Management – Demand	Productive use	Pricing, monitoring, billing
Clinical medicine	Health-related microbiology	Potable water safety	Human health	X	X			X	X	
Computer sciences	Analytics and visualisation	Pattern recognition, machine learning	Process automation and control – potable and waste water treatment							
Computer sciences	Modelling and simulation	Dynamic systems	Environmental water quality	X	X	X	X	X	X	
Computer sciences	Presentation and user interaction		Process automation and control – potable and waste water treatment	X	X			X		
Computer sciences	Remote sensing		Environmental health and ecosystem functioning	X						
Computer sciences	Scientific programming	Bioinformatics	Wastewater treatment	X			X			
Computer sciences	Scientific programming	Computational geosciences	Environmental water quality	X						
Desalination			Desalination	X	X	X	X	X	X	
Economics and Business	Agricultural and Resource Economics		Food security and business efficiency	X	X	X	X	X		
Economics and Business	Applied Economics			X	X			X		
Economics and Business	Behavioural Finance				X			X		
Economics and Business	Business and Economic Statistics				X	X		X		
Economics and Business	Computational Economics		Technoeconomics		X			X		
Economics and Business	Decision Sciences			X	X	X		X		
Economics and Business	Development Economics		Technoeconomics		X			X		
Economics and Business	Econometrics				X			X		
Economics and Business	Economic Modelling			X	X		X	X		
Economics and Business	Entrepreneurship and Management			X	X			X		
Economics and Business	Environmental Economics		Technoeconomics	X	X	X		X		
Economics and Business	Forecasting and Game Theory									
Economics and Business	Insurance Mathematics and Economics				X			X		
Economics and Business	Macroeconomics			X	X			X		
Economics and Business	Microeconomics				X			X		

South Africa's Research Development and Innovation Roadmap

Discipline level 1	Discipline level 2	Discipline level 3	Research focus area / field of research	Sources	Governance, Planning & Management – Supply	Infrastructure	Op performance	Governance, Planning & Management – Demand	Productive use	Pricing, monitoring, billing
Economics and Business			Development Economics		X			X		X
Economics and Business			Urban Economics		X			X		X
Ecosystem services and ecological infrastructure										
Engineering			Water Engineering	X		X	X		X	
Engineering			Non-Newtonian fluid mechanics				X		X	
Engineering			Plant life extension Technologies						X	
Engineering	(Urban) Water Management / Engineering		Wastewater and potable treatment	X	X	X	X	X	X	X
Engineering	Analytical Sciences		Wastewater and potable treatment	X		X	X		X	
Engineering	Applied Engineering in Agriculture		Crop production	X		X				
Engineering	Chemical		Wastewater and potable treatment	X		X	X			
Engineering	Civil	Safety	Civil engineering aspects of water cycle	X	X	X	X	X		
Engineering	Civil	Structural and Materials	Civil engineering aspects of water cycle	X		X	X		X	
Engineering	Coastal Engineering		Flood defence	X		X	X			
Engineering	Desalination and Water Treatment		Wastewater and potable treatment	X		X			X	
Engineering	Environmental Systems		Civil engineering aspects of water cycle	X		X				
Engineering	Hydrology and hydrogeology	Hydrodynamics	Hydrodynamics	X		X				
Engineering	Hydrology and hydrogeology	Hydrologic engineering	Hydrologic engineering			X	X			
Engineering	Hydrology and hydrogeology	Hydromechanics	Hydromechanics	X		X				
Engineering	Hydrology and hydrogeology	WRC – Water at work				X				
Engineering	Industrial		Wastewater and potable treatment	X		X	X			
Engineering	Irrigation and Drainage		Crop production	X		X				
Engineering	Marine science		Water quality monitoring, ecosystem functioning, environmental water quality, animal, human, public, and environmental health	X		X				

South Africa's Research Development and Innovation Roadmap

Discipline level 1	Discipline level 2	Discipline level 3	Research focus area / field of research	Sources	Governance, Planning & Management – Supply	Infrastructure	Op performance	Governance, Planning & Management – Demand	Productive use	Pricing, monitoring, billing
Engineering	Nanoscience and Nanotechnology		Wastewater and potable treatment, ecosystem functioning, environmental water quality, animal, human, public, and environmental health	X		X				
Engineering	Ocean and Coastal Management		Water quality monitoring, ecosystem functioning, environmental water quality, animal, human, public, and environmental health	X	X	X		X		
Engineering	Waterway, Port, Coastal and Ocean Engineering		Flood defence	X	X	X	X	X		
Environment			Environment		X	X	X	X		
Environmental pollution			Environmental pollution	X	X	X	X	X		
Environmental sciences	Corporate social responsibility and environmental management	Corporate social responsibility and environmental management	Corporate social responsibility and environmental management	X	X			X	X	X
Environmental sciences	Earth observation	Remote sensing and gis	Environmental health and ecosystem functioning	X	X			X		
Environmental sciences	Ecology	Agriculture ecosystems and environment	Agriculture ecosystems and environment	X		X				
Environmental sciences	Ecology	Aquatic ecosystems	Aquatic ecosystems							
Environmental sciences	Ecology	Aquatic ecosystems	Aquatic ecosystems							
Environmental sciences	Ecology	Aquatic ecosystems	Aquatic ecosystems							
Environmental sciences	Ecology	Biodiversity and conservation	Biodiversity and conservation							
Environmental sciences	Ecology	Ecohydrology	Ecohydrology							
Environmental sciences	Ecology	Ecological informatics and modelling	Ecological informatics and modelling							
Environmental sciences	Ecology	Ecology evolution and systematics	Ecology evolution and systematics							
Environmental sciences	Ecology	Systems ecology	Systems ecology							
Environmental sciences	Environmental / resources management	Environmental law	Environmental protection & pollution control	X	X			X	X	X
Environmental sciences	Environmental / resources management	Protection	Environmental protection & pollution control	X						
Environmental sciences	Environmental / resources management	Water resources	Environmental health and ecosystem functioning	X	X	X	X	X	X	X
Environmental sciences			Sustainability in mining	X	X	X	X	X	X	X

South Africa's Research Development and Innovation Roadmap

Discipline level 1	Discipline level 2	Discipline level 3	Research focus area / field of research	Sources	Governance, Planning & Management – Supply	Infrastructure	Op performance	Governance, Planning & Management – Demand	Productive use	Pricing, monitoring, billing
Environmental sciences			Climatology	X	X	X		X	X	
Environmental sciences			Ecosystem services and ecological infrastructure	X	X			X	X	
Environmental sciences			Water science	X			X		X	
Environmental sciences			Water resource governance and management	X	X	X	X	X		
Geomembrane linings and covers for potable water storage			Geomembrane linings and covers for potable water storage		X	X	X	X	X	
Geosciences	Atmospheric Sciences	Climatology	Climate dynamics, resilience, adaptation	X	X			X	X	
Geosciences	Atmospheric Sciences	Meteorology	Weather and Forecasting	X	X	X		X		
Geosciences	Atmospheric Sciences	Meteorology	Agricultural Meteorology	X						
Geosciences	Atmospheric Sciences	Meteorology	Hydrometeorology							
Geosciences	Earth Sciences	Earth Science Informatics	Water quality monitoring, ecosystem functioning, environmental water quality, animal, human, public, and environmental health	X	X			X		
Geosciences	Earth Sciences	Geology	Environmental health and ecosystem functioning	X						
Geosciences	Earth Sciences	Geomorphology	Environmental health and ecosystem functioning							
Geosciences	Earth Sciences	Ichthyology	Water quality monitoring, ecosystem functioning, environmental water quality, animal health							
Geosciences	Earth Sciences	Mineralogy	Environmental health and ecosystem functioning							
Geosciences	Geography		Water quality monitoring, ecosystem functioning, environmental water quality, animal, human, public, and environmental health							
Geosciences	Hydrology	Ecohydrology	Ecohydrology	X						
Geosciences	Hydrology	Subsurface hydrology	Subsurface hydrology	X			X		X	
Geosciences	Hydrology	Subsurface hydrology	Hydrology	X	X	X		X		
Geosciences	Hydrology	Subsurface hydrology	Contaminant hydrology	X						
Geosciences	Hydrology	Subsurface hydrology	Unsaturated zone							
Geosciences	Hydrology	Surface hydrology	Catchment hydrology	X		X	X		X	
Geosciences	Hydrology	Surface hydrology	Land surface hydrology	X					X	
Geosciences	Hydrology	Surface hydrology	Hydrometeorology	X						

South Africa's Research Development and Innovation Roadmap

Discipline level 1	Discipline level 2	Discipline level 3	Research focus area / field of research	Sources	Governance, Planning & Management – Supply	Infrastructure	Op performance	Governance, Planning & Management – Demand	Productive use	Pricing, monitoring, billing
Geosciences	Limnology		Water quality monitoring, ecosystem functioning, environmental water quality, animal, human, public, and environmental health							
Geosciences	Oceanography		Water quality monitoring, ecosystem functioning, environmental water quality, animal, human, public, and environmental health							
Geosciences			Water Resources Management	X	X	X		X	X	X
Governance			Governance		X			X		
Health			Health	X	X	X	X	X		
Hydrology and Water Resources			Hydrology and Water Resources	X	X	X	X	X		
Hydrometeorology			Hydrometeorology	X	X	X		X	X	
Immunology	Health-related microbiology	Bacteriology	Animal, human, public, and environmental health	X			X			
Immunology	Health-related microbiology	Mycology	Animal, human, public, and environmental health	X						
Immunology	Health-related microbiology	Virology	Animal, human, public, and environmental health	X			X			
Integrated water resources management (IWRM)	Integrated water resources management (IWRM)		Integrated water resources management (iwrn)	X	X	X	X	X		
Local government			Local government		X			X		X
Management			Management							
Materials science	Materials safety	Emerging engineered nanomaterials	Wastewater and potable treatment, ecosystem functioning, environmental water quality, animal, human, public, and environmental health	X						
Materials science	Materials safety	Toxicity of engineered materials	Animal, human, public, and environmental health	X						
Membrane technology			Membrane technology	X		X	X		X	
Microbiology	Health-related microbiology	Beneficial microbes	Animal, human, public, and environmental health	X						
Microbiology	Health-related microbiology	Pathogens and parasites	Animal, human, public, and environmental health	X						
Microbiology	Wastewater treatment	Biological processes	Wastewater treatment	X		X	X		X	
Microbiology	Water treatment	Biological processes	Water treatment	X		X	X		X	
Microbiology	Water treatment	Oxidation and disinfection	Public health	X		X	X		X	
Microbiology			Water and Wastewater Microbiology				X		X	

South Africa's Research Development and Innovation Roadmap

Discipline level 1	Discipline level 2	Discipline level 3	Research focus area / field of research	Sources	Governance, Planning & Management – Supply	Infrastructure	Op performance	Governance, Planning & Management – Demand	Productive use	Pricing, monitoring, billing
Mining hydrogeology			Mining hydrogeology	X	X	X	X	X	X	X
Molecular Biology and Genetics	Biomolecular engineering	Advanced biological processes	Wastewater and potable treatment	X						
Molecular Biology and Genetics			Waterborne Pathogen characterisation	X	X		X	X		
Molecular Biology and Genetics			Ecosystem functioning and health	X			X			
Ocean wave power			Ocean wave power	X	X	X	X	X	X	
Om rural water services			Om rural water services	X			X		X	
Pharmacology & toxicology	Water treatment	Chemicals and materials safety	Wastewater and potable treatment	X			X			
Pharmacology & toxicology			Enzymes	X			X			
Plant and Animal Science	Aquaculture and Ichthyology	Aquaculture Research	Improved food security	X						
Plant and Animal Science	Aquatic biology	Aquatic Biology	Water quality monitoring, ecosystem functioning, environmental water quality, animal, human, public, and environmental health	X						
Plant and Animal Science	Botany	Aquatic Botany	Water quality monitoring, ecosystem functioning, environmental water quality, animal, human, public, and environmental health	X						
Plant and Animal Science	Entomology	Applied Entomology	Water quality monitoring, ecosystem functioning, environmental water quality, animal, human, public, and environmental health							
Plant and Animal Science	Entomology	Aquatic Insects	Water quality monitoring, ecosystem functioning, environmental water quality, animal, human, public, and environmental health	X						
Plant and Animal Science	Herpetology	Applied Herpetology	Water quality monitoring, ecosystem functioning, environmental water quality, animal, human, public, and environmental health							
Plant and Animal Science	Living resources	Aquatic Living Resources	Water quality monitoring, ecosystem functioning, environmental water quality, animal, human, public, and environmental health	X						
Plant and Animal Science	Mammalian biology	Aquatic Mammals	Water quality monitoring, ecosystem functioning, environmental water quality, animal, human, public, and environmental health	X						

South Africa's Research Development and Innovation Roadmap

Discipline level 1	Discipline level 2	Discipline level 3	Research focus area / field of research	Sources	Governance, Planning & Management – Supply	Infrastructure	Op performance	Governance, Planning & Management – Demand	Productive use	Pricing, monitoring, billing
Plant and Animal Science	Microbial ecology	Aquatic Microbial Ecology	Water quality monitoring, ecosystem functioning, environmental water quality, animal, human, public, and environmental health	X						
Plant and Animal Science	Toxicology	Aquatic Toxicology	Water quality monitoring, ecosystem functioning, environmental water quality, animal, human, public, and environmental health	X						
Public participation			Public participation		X			X		
River Basin management			River Basin management	X	X	X	X	X		
Sanitation			Sanitation		X	X	X	X		X
Social Science and Humanities	Anthropology		Human, public, and environmental health	X	X		X	X		
Social Science and Humanities	Communications	Science Communication	Education	X	X	X	X	X	X	X
Social Science and Humanities	Development Studies				X			X		
Social Science and Humanities	Education	Agriculture	Education		X			X		
Social Science and Humanities	Education	Science Education	Education	X	X	X		X		
Social Science and Humanities	Gender Studies				X			X		
Social Science and Humanities	History				X			X		
Social Science and Humanities	Law			X	X	X	X	X		
Social Science and Humanities	Library and information science	Digital records management and archival studies								X
Social Science and Humanities	Philosophy		Bioethics	X						
Social Science and Humanities	Political Science	International Relations		X	X	X		X		
Social Science and Humanities	Political Science	Public Administration		X	X	X	X	X	X	X
Social Science and Humanities	Political Science	Public Policy		X	X	X	X	X	X	X
Social Science and Humanities	Political Science	Security Studies		X	X	X		X		
Social Science and Humanities	Public Health	Health Planning	Human, public, and environmental health	X	X	X	X	X	X	

South Africa's Research Development and Innovation Roadmap

Discipline level 1	Discipline level 2	Discipline level 3	Research focus area / field of research	Sources	Governance, Planning & Management – Supply	Infrastructure	Op performance	Governance, Planning & Management – Demand	Productive use	Pricing, monitoring, billing
Social Science and Humanities	Public Health	Population Health Management	Human, public, and environmental health	X	X			X		
Social Science and Humanities	Public Health	Population Health Management	Human, public, and environmental health		X			X		
Social Science and Humanities	Sociology		Water quality monitoring, ecosystem functioning, environmental water quality, animal, human, public, and environmental health	X	X			X		X
Space science	Land observation and remote sensing	Land use	Water quality monitoring, ecosystem functioning, environmental water quality, animal, human, public, and environmental health	X	X	X		X		X
Space science	Land observation and remote sensing	Pollution detection and control	Sustainability	X		X				
Sustainability			Water and wastewater treatment	X	X	X	X	X		
Water and wastewater treatment			Water infrastructure development	X		X	X		X	
Water infrastructure development			Water quality and water resources	X	X	X		X	X	X
Water quality and water resources			Water science management, policy and legislations	X	X			X		
Water science management, policy and legislations			Wave powered desalination	X	X	X	X	X	X	
Oceanography	Wave and tidal energy	Wave powered desalination								

## APPENDIX D: DEGREE OF DIFFUSION IN RESEARCH FOCUS AREAS, CATEGORISED BY CLUSTER AND SECTOR

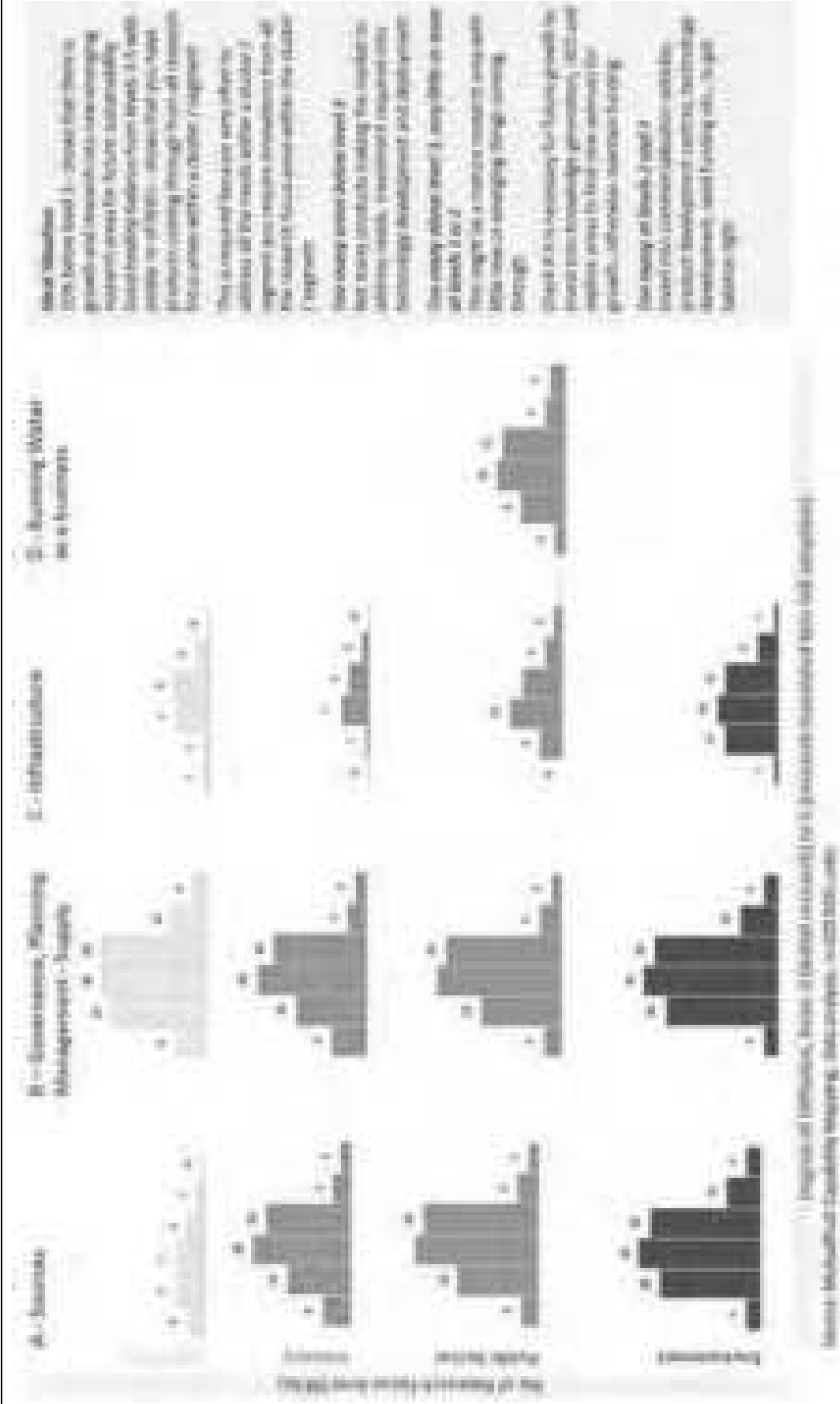


Figure D1: Degree of diffusion in water supply Clusters

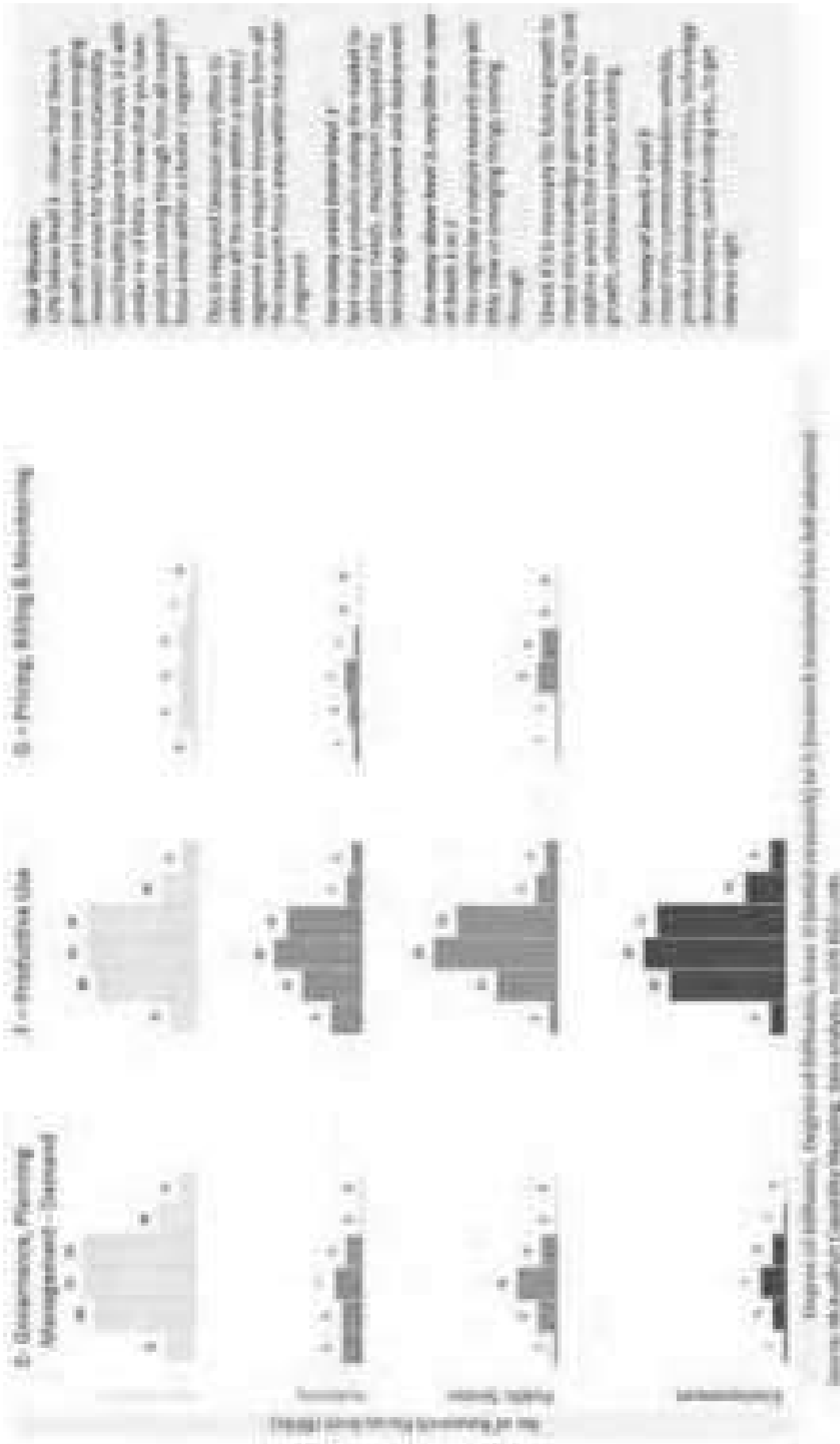


Figure D2: Degree of diffusion in water demand clusters

## APPENDIX E: LEVEL OF RESEARCH STRENGTH OF INSTITUTES, CATEGORISED BY CLUSTER AND SECTOR

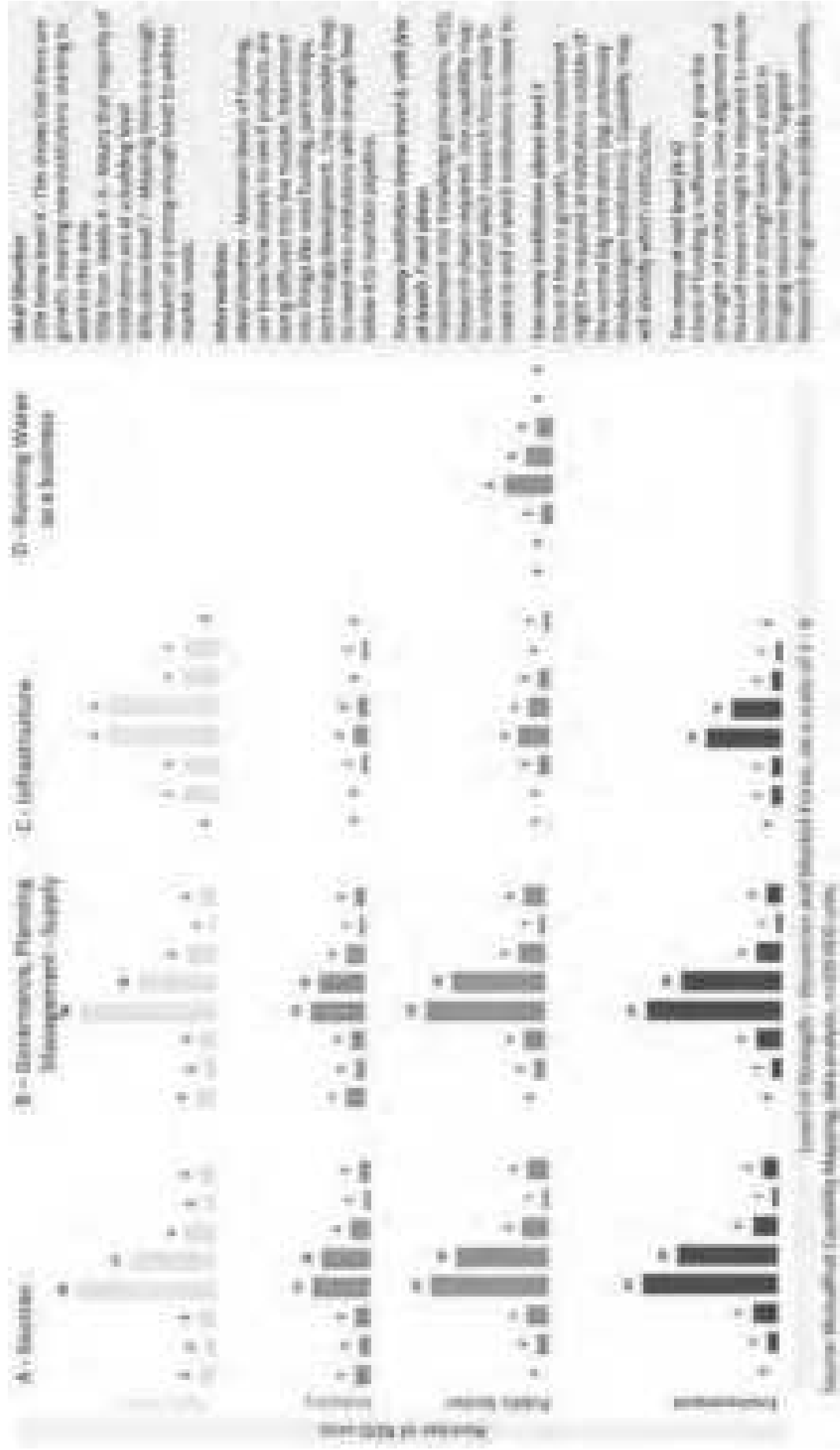


Figure E1: Level of strength in water supply Clusters

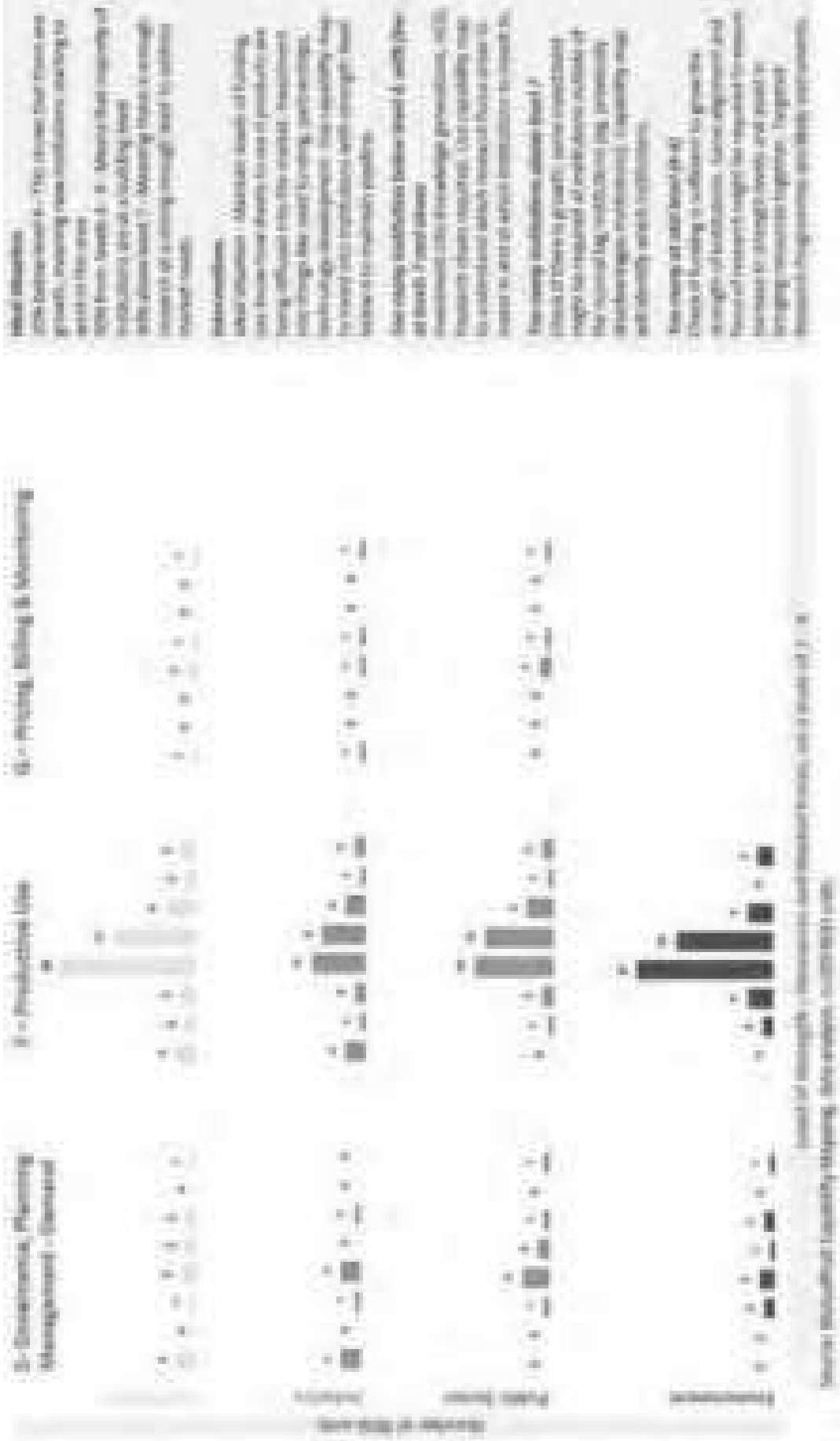


Figure E2: Level of strength in water demand clusters

## APPENDIX F: IMPACT ANTICIPATED, BASED ON FIVE IMPACT AREAS – SUMMARY

The Impact Assessment Framework used required assessment of anticipated impacts in a set of nine areas:

**Table F1: Impact assessment: Water Scarcity**

	Reduced withdrawal	Reduced consumption	Improved water quality	Improved productivity of use	Overall score /10
Increase ability to make use of more <u>sources</u> of water, including alternatives	1	1	1	1	10
Improve <u>governance, planning and management</u> of supply and delivery	1	0	0	1	5.0
Improve adequacy and performance of supply <u>infrastructure</u>	1	1	0	1	7.5
Run water as a financially sustainable “business” by improving <u>operational performance</u>	1	1	1	1	10
Improve <u>governance, planning, and management</u> of demand and use	1	0	1	1	7.5
Reduce losses and increase efficiency of <u>productive use</u>	1	1	0	1	7.5
Improve performance of <u>pricing, monitoring, billing, metering and collection</u>	1	1	0	1	7.5

A 0 in the box for a sub-area / cluster combination indicates that no impact is anticipated, whereas a 1 indicates that an impact in the area is anticipated. (The nature and extent of the impact was not required for this framework). The proportion of sub-areas in which impact was anticipated was then used to provide the overall score.

For example, the top row indicates that implementing the interventions listed under the cluster of needs, *Increase ability to make use of more sources of water, including alternatives*, was anticipated to make an impact in all four areas under Water Scarcity. Since all four boxes contain a 1, the overall score is 4/4 = 10/10. The interventions to meet the needs listed in the cluster, *Improve performance of pricing, monitoring, billing, metering and collection*, were anticipated to make impacts in three of the four areas, so the overall score was 3/4 = 7½/10.

**Table F2: Impact assessment: Economic**

	Wealth	Productivity	Revenue	Cost reduction	Overall score /10
Increase ability to make use of more <u>sources</u> of water, including alternatives	1	1	1	1	10
Improve <u>governance, planning and management of supply and delivery</u>	1	1	0	1	7.5
Improve adequacy and performance of supply <u>infrastructure</u>	1	1	1	1	10
Run water as a financially sustainable “business” by improving <u>operational performance</u>	1	1	1	1	10
Improve <u>governance, planning, and management of demand and use</u>	1	1	0	1	7.5
Reduce losses and increase efficiency of <u>productive use</u>	0	1	1	1	7.5
Improve performance of <u>pricing, monitoring, billing, metering and collection</u>	1	1	1	1	10

**Table F3: Impact assessment: Health**

	Reduced incidence of water-borne sickness and disease	Reduced incidence of sickness and disease from air pollution	Reduced incidence of sickness and disease from chemical contaminants	Reduced absenteeism and early retirement – through increased wellness	Reduced mortality rate	Overall score /10
Increase ability to make use of more <u>sources</u> of water, including alternatives	0	0	0	0	0	0
Improve <u>governance, planning and management of supply and delivery</u>	1	0	0	1	1	6
Improve adequacy and performance of supply <u>infrastructure</u>	1	1	1	1	1	10
Run water as a financially sustainable “business” by improving <u>operational performance</u>	1	0	0	1	1	6
Improve <u>governance, planning, and management of demand and use</u>	1	0	0	1	1	6
Reduce losses and increase efficiency of <u>productive use</u>	0	0	0	0	0	0
Improve performance of <u>pricing, monitoring, billing, metering and collection</u>	0	0	0	0	0	0

**Table F4: Impact assessment: Society**

	Improved availability and quality of environmental goods and services	Increased food security – livestock, crops	Reduced loss of animals	Increased school attendance (driven by access and quality) and improved educational outcomes	Improved relations between all suppliers and consumers in a catchment (e.g. WUAs and farmers)	Satisfaction of rights and demands of those without access to water	Reduced environmental debt	Raised awareness of the value of water, driving increased willingness to pay	Overall score /10
Increase ability to make use of more <u>sources</u> of water, including alternatives	1	1	1	0	1	1	1	0	7.5
Improve <u>governance, planning and management of supply and delivery</u>	0	1	1	1	1	1	1	1	9
Improve adequacy and performance of supply <u>infrastructure</u>	1	1	1	1	1	1	1	1	10
Run water as a financially sustainable “business” by improving <u>operational performance</u>	1	1	1	1	0	1	1	1	9
Improve <u>governance, planning, and management of demand and use</u>	1	1	1	1	1	1	1	1	10
Reduce losses and increase efficiency of <u>productive use</u>	1	0	0	0	1	1	1	0	5
Improve performance of <u>pricing, monitoring, billing, metering and collection</u>	0	0	0	0	1	1	1	1	5

**Table F5: Impact assessment: Society**

	Reduction in carbon emissions	Reduction in area of salinised land	Reduced levels of groundwater contamination	Reduced cost of treating process water and potable water	Reduced contamination of surface water	Reduced downstream pollution	Reduced levels of soil erosion	Reduced or reversed decline in biodiversity	Preservation of riverine habitats	Improved health of terrestrial environment	Overall score /10
Increase ability to make use of more <u>sources</u> of water, including alternatives	1	1	1	1	1	1	0	1	1	1	9
Improve <u>governance, planning and management of supply and delivery</u>	0	1	1	1	1	1	0	0	0	1	6
Improve adequacy and performance of supply <u>infrastructure</u>	1	1	1	1	1	1	1	1	1	1	10
Run water as a financially sustainable “business” by improving <u>operational performance</u>	1	0	1	1	1	1	1	0	0	0	6
Improve <u>governance, planning, and management of demand and use</u>	1	1	1	1	1	1	1	1	1	1	10
Reduce losses and increase efficiency of <u>productive use</u>	1	0	1	1	1	1	0	0	1	1	7
Improve performance of <u>pricing, monitoring, billing, metering and collection</u>	1	0	0	1	1	1	0	0	0	0	4



**1.1.1 DAAD – South Africa's Research Development and Innovation Roadmap**  Deutscher Akademischer Austausch Dienst  
German Academic Exchange Service

The German Academic Exchange Service (DAAD) in partnership with the NRF offers DAAD bi-lateral scholarships for postgraduate students in South Africa studying towards a master's or doctoral degree. The programme is coordinated by the German Federal Ministry of Economic Cooperation and Development (GIZ). The aim of the programme is to increase the number of postgraduate students, improve quality education and training and contribute towards national efforts of human capital development in the country. The programme also focuses on staff development of students and to build capacity within South African tertiary institutions. Successful students can also apply to DAAD for continuation and funding of any German university under the programme.

Sub-category	Value (ZAR)	Duration
Master's degree	R 10 000	1 year
Doctoral degree	R 18 000	3 years

**1.1.2 Department of Science and Technology (DST) – Energy**



The Energy Research Fund is a private-public partnership of research and business funds focusing on research and training for and towards a sustainable energy sector in the NRF the staff NRF energy, research fund areas, for universities are offered to universities that do a service to research on the following areas:

- Energy-related development, including clean coal technologies;
- Renewable energy financing, including wind, solar energy, small hydro etc.);
- Energy efficiency in government;
- Energy for socio-economic development;
- Energy related policy and modelling; and
- Energy policy research.

Sub-category	Value (ZAR)	Duration
Master's degree	R 10 000	1 year
Doctoral degree	R 18 000	3 years

**1.1.3 SASSI – Water**



SASSI aims at supporting the government's vision to expand water supply in the South African energy sector, mainly funding R&D for the water sector. The programme was initiated by the Department of Science and Technology. The funds administered range from basic and applied research and engineering disciplines in manufacturing and domestic aspects of water management. The strategy also takes on other water related activities like human and institutional capacities, food preservation, raising awareness amongst others. The funding focuses on water related projects, research and training in the water sector (capacity development).

Topic	Value (ZAR)	Duration
Water-related research	Research related financing	1 year
Human and institutional capacity	no research	1 year
Master's degree	R 10 000	1 year
Doctoral degree	R 18 000	3 years



**ii. Research Career Advancement Programme**



The Department of Science and Technology (DST) has implemented funding for Research Career Advancement Programme in order to strengthen research capacity and promote research excellence in Science, Engineering and Technology by creating positions for senior researchers who have direct interest in furthering careers in research and innovation and have demonstrated the potential and ability for career advancement. This is a targeted funding aimed for those already enjoying successful or partial success in research and other ongoing activities to be nurtured and provided by career progression. The programme programme aims to develop researchers to strengthen their research team based on research-independent researchers.

Research Position	Value (R 100)	Duration
Research Career Advancement Programme	R 100 000 000	3 years
Continuing research funding increases	R 100 000 000	3 years

**Table 10: Research Career Advancement Programme**

Category	Duration	Inputs	Outputs	Estimated Amount
Science/Engineering	3-10 years	4-10 staff	4-10 staff	1-100 staff
Life Sciences	3-10 years	4-10 staff	4-10 staff	1-100 staff
Technology/Innovation			4-10 staff	1-100 staff
<b>Infrastructure and Operational costs (DST)</b>				
Infrastructure	Investment in research infrastructure including equipment and facilities			
Operational Costs	Investment in operational and support services			

**iii. Research Grants**

The research grants program supports development of researchers and their research teams under the programme support amount R3 million.

**iv. South African Medical Research Council**

The National Research Foundation (NRF) and South African Medical Research Council (SAMRC) entered into a partnership in delivering the research and medical knowledge programme to the health, allied sciences and related fields of study under strategic partnership in 2014. The programme is intended to contribute to the production of high-quality research outcomes, generation of high-quality knowledge, as well as the development and transfer of this knowledge to address health-related issues, especially in the health and allied research areas of Special and Biomedical Research, Translational Research, Health Care, Health Services, Research, and all other disciplines related to health and allied sciences in general.

Technology	Value (R 100)	Duration
Health Research	R 100 000 000	3 years
Health Services	R 100 000 000	3 years

Type of Project/Grant	Value of Grant	How to Apply
NSRF Research and Innovation Project Grant	R 2.5M	Focus on applicable forms, annexes, and financial and funding requirements. Also refer to the implementation and evaluation.
NSRF Research and Innovation Project Grant	R 2.5M	
NSRF Research and Innovation Project Grant	R 2.5M (max) R 1.5M (min)	
NSRF Research and Innovation Project Grant	R 2.5M (max) R 1.5M (min)	
NSRF Research and Innovation Project Grant	R 2.5M (max) R 1.5M (min)	
NSRF Research and Innovation Project Grant	R 2.5M (max) R 1.5M (min)	
NSRF Research and Innovation Project Grant	R 2.5M (max) R 1.5M (min)	
NSRF Research and Innovation Project Grant	R 2.5M (max) R 1.5M (min)	

Number of years for submitting applications/rounds	Total for submitting rounds/rounds	Remaining funding
1	100,000	100,000
2	200,000	100,000
3	300,000	100,000

- Each application has to be accompanied by a certificate signed by the institution certifying that the:
- a) Applicant is a registered higher learning institution of the state or that is not registered as a higher learning institution;
  - b) Applicant is not barred by the preceding academic year; and
  - c) Applicant is working in the field of the project.
- Research and Innovation Project Grants are awarded according to the following criteria: 50% Staff Salary (including pension/retirement), 20% RDC, 20% cost of other resources and 10% other non-staff resources.
  - Intellectual Property: No restrictions.
  - Staff Development Grants: Only for South African staff members of a recognized South African research institution.



**2. National Integrated Programme**

The four (three) themes are considered the national and research priority areas as follows:

Level / National Programme	Value (ZAR)	Duration (years) (2014-2020)
Research Support (R100)	R 100 000 000 000	7 (2014-2020)
Researcher Mobility (R100)	R 100 000 000 000	7 (2014-2020)

**2.1.1.1.1.1**

- The strategy will be managed as a sub-theme, which will be awarded to the national scientists. The National Strategy will involve the R&D activities in the R&D system and their impact on the growth of the economy.
- The research costs (equipment for the period for the research) for the scientists, but not for the R&D system, will be covered.

Category	Value (ZAR)	Duration
Researcher Mobility	R 100 000 000 000	7 years
Researcher Mobility	R 100 000 000 000	7 years
Research Support	R 100 000 000 000	7 years
Research Support	R 100 000 000 000	7 years
Researcher Mobility	R 100 000 000 000	7 years
Researcher Mobility	R 100 000 000 000	7 years

**2.1.1.1.1.2**

Category	Value (ZAR)	Duration
Researcher Mobility	R 100 000 000 000	7 years
Researcher Mobility	R 100 000 000 000	7 years
Research Support	R 100 000 000 000	7 years
Research Support	R 100 000 000 000	7 years
Researcher Mobility	R 100 000 000 000	7 years
Research Support	R 100 000 000 000	7 years
Research Support	R 100 000 000 000	7 years
Researcher Mobility	R 100 000 000 000	7 years
Researcher Mobility	R 100 000 000 000	7 years

**2.1.1.1.1.3**

Category	Value (ZAR)	Duration
Researcher Mobility	R 100 000 000 000	7 years
Research Support	R 100 000 000 000	7 years
Research Support	R 100 000 000 000	7 years
Researcher Mobility	R 100 000 000 000	7 years
Researcher Mobility	R 100 000 000 000	7 years



Research Areas				
<p><b>Research Area 1: Information and Communication Technology</b></p> <p>Developing world-class ICT infrastructure, including 4G/LTE networks, for the next generation of ICT products and services. The focus is on the development of the ICT ecosystem (software, hardware, services).</p>	R 10 000	R 10 000	R 10 000	R 10 000
<p><b>Research Area 2: Manufacturing</b></p> <p>Developing world-class manufacturing infrastructure, including advanced manufacturing technologies, for the next generation of manufacturing products and services. The focus is on the development of the manufacturing ecosystem (infrastructure, technology, services).</p>	R 10 000	R 10 000	R 10 000	R 10 000
<p><b>Research Area 3: Health and Life Sciences</b></p> <p>Developing world-class health and life sciences infrastructure, including advanced medical technologies, for the next generation of health and life sciences products and services. The focus is on the development of the health and life sciences ecosystem (infrastructure, technology, services).</p>	R 10 000	R 10 000	R 10 000	R 10 000
<p><b>Research Area 4: Energy</b></p> <p>Developing world-class energy infrastructure, including advanced energy technologies, for the next generation of energy products and services. The focus is on the development of the energy ecosystem (infrastructure, technology, services).</p>	R 10 000	R 10 000	R 10 000	R 10 000
<p><b>Research Area 5: Environmental and Earth Sciences</b></p> <p>Developing world-class environmental and earth sciences infrastructure, including advanced environmental technologies, for the next generation of environmental and earth sciences products and services. The focus is on the development of the environmental and earth sciences ecosystem (infrastructure, technology, services).</p>	R 10 000	R 10 000	R 10 000	R 10 000
<p><b>Research Area 6: Space</b></p> <p>Developing world-class space infrastructure, including advanced space technologies, for the next generation of space products and services. The focus is on the development of the space ecosystem (infrastructure, technology, services).</p>	R 10 000	R 10 000	R 10 000	R 10 000
<p><b>Research Area 7: Transport</b></p> <p>Developing world-class transport infrastructure, including advanced transport technologies, for the next generation of transport products and services. The focus is on the development of the transport ecosystem (infrastructure, technology, services).</p>	R 10 000	R 10 000	R 10 000	R 10 000
<p><b>Research Area 8: Agriculture</b></p> <p>Developing world-class agriculture infrastructure, including advanced agricultural technologies, for the next generation of agriculture products and services. The focus is on the development of the agriculture ecosystem (infrastructure, technology, services).</p>	R 10 000	R 10 000	R 10 000	R 10 000
<p><b>Research Area 9: Marine and Maritime</b></p> <p>Developing world-class marine and maritime infrastructure, including advanced marine and maritime technologies, for the next generation of marine and maritime products and services. The focus is on the development of the marine and maritime ecosystem (infrastructure, technology, services).</p>	R 10 000	R 10 000	R 10 000	R 10 000
<p><b>Research Area 10: Other</b></p> <p>Developing world-class other infrastructure, including advanced other technologies, for the next generation of other products and services. The focus is on the development of the other ecosystem (infrastructure, technology, services).</p>	R 10 000	R 10 000	R 10 000	R 10 000
Total Areas				
<p><b>Industry Areas</b></p>	R 10 000	R 10 000	R 10 000	R 10 000
<p><b>Academic Areas</b></p>	R 10 000	R 10 000	R 10 000	R 10 000
<p><b>Government Areas</b></p>	R 10 000	R 10 000	R 10 000	R 10 000

**6. Operational Excellence**

Operational Excellence (OE) is the physical manifestation of research, development, innovation, quality and process excellence. It is achieved by continuous, cross-functional and continuous improvement projects that are fully, sustainably and systematically integrated. It is used to enhance the quality of research, products and services, to improve the business of business, to improve the efficiency of operations, to improve the value of the business and to improve the value of the business.

**6.1. Capacity (2020-2025)**

Capacity Dimension	Value (2020)	Target
Research Capacity	1.5 (2020)	2.0 (2025)
Innovation Capacity	1.5 (2020)	2.0 (2025)
Operational Excellence Capacity	1.5 (2020)	2.0 (2025)
Commercial Excellence Capacity	1.5 (2020)	2.0 (2025)

**6.2. Innovation Strategy**

OE Area Dimension	Value (2020)	Target
Research & Development	1.5 (2020)	2.0 (2025)
Product Design	1.5 (2020)	2.0 (2025)
Process Design	1.5 (2020)	2.0 (2025)
Commercial Excellence	1.5 (2020)	2.0 (2025)
Operational Excellence	1.5 (2020)	2.0 (2025)

**6.3. Innovation**

Innovation is the process of creating new products, services, processes, or business models. It is the process of creating new value, which is the process of creating new value. It is the process of creating new value, which is the process of creating new value.

**6.4. Strong Markets**

Capacity Dimension	Value (2020)	Target
Research Capacity	1.5 (2020)	2.0 (2025)
Innovation Capacity	1.5 (2020)	2.0 (2025)

**6.5. Innovation**

OE Area Dimension	Value (2020)	Target
Research & Development	1.5 (2020)	2.0 (2025)
Product Design	1.5 (2020)	2.0 (2025)
Process Design	1.5 (2020)	2.0 (2025)
Commercial Excellence	1.5 (2020)	2.0 (2025)
Operational Excellence	1.5 (2020)	2.0 (2025)

**8. Skills as Key to Productivity (Pharmaceuticals)**

Full-time Entrepreneurs	Value (ZAR)	Duration
Research/Pharmaceuticals	R 20 000	1 year
Master's Degree	R 10 000	1 year
Doctoral Degree	R 20 000	1 year
<b>Postgraduate Fellowships</b>	<b>Value (ZAR)</b>	<b>Duration</b>
Postgraduate Fellowship	R 10 000	1 year

**9. National Research for Mathematical Physics**

Full-time Entrepreneurs	Value (ZAR)	Duration
Research/Pharmaceuticals	R 20 000	1 year
Master's Degree	R 10 000	1 year
Doctoral Degree	R 20 000	1 year
<b>Postgraduate Fellowships</b>	<b>Value (ZAR)</b>	<b>Duration</b>
Postgraduate Fellowship	R 10 000	1 year

**10. New Health Biotechnology**

Full-time Entrepreneurs	Value (ZAR)	Duration
Research/Pharmaceuticals	R 20 000	1 year
Master's Degree	R 10 000	1 year
Doctoral Degree	R 20 000	1 year
Postgraduate Fellowship	R 10 000	1 year

**11. Mathematics**

Full-time Entrepreneurs	Value (ZAR)	Duration
Research/Pharmaceuticals	R 20 000	1 year
Master's Degree	R 10 000	1 year
Doctoral Degree	R 20 000	1 year
<b>Postgraduate Fellowships</b>	<b>Value (ZAR)</b>	<b>Duration</b>
Postgraduate Fellowship	R 10 000	1 year

**12. Biotechnology (Food/Bio and Agritech)**

Full-time Entrepreneurs	Value (ZAR)	Duration
Research/Pharmaceuticals	R 20 000	1 year
Master's Degree	R 10 000	1 year
Doctoral Degree	R 20 000	1 year
<b>Postgraduate Fellowships</b>	<b>Value (ZAR)</b>	<b>Duration</b>
Postgraduate Fellowship	R 10 000	1 year

**13. Mathematics (Engineering/Physics)**

Full-time Entrepreneurs	Value (ZAR)	Duration
Research/Pharmaceuticals	R 20 000	1 year
Master's Degree	R 10 000	1 year
Doctoral Degree	R 20 000	1 year
<b>Postgraduate Fellowships</b>	<b>Value (ZAR)</b>	<b>Duration</b>
Postgraduate Fellowship	R 10 000	1 year

**14. Applied Science for Climate and Earth Systems**

Full-time Entrepreneurs	Value (ZAR)	Duration
Research/Pharmaceuticals	R 20 000	1 year
Master's Degree	R 10 000	1 year
Doctoral Degree	R 20 000	1 year
<b>Postgraduate Fellowships</b>	<b>Value (ZAR)</b>	<b>Duration</b>
Postgraduate Fellowship	R 10 000	1 year

**G.2 EXCERPTS FROM “OVERVIEW OF NRF FUNDING OPPORTUNITIES, GRANT MANAGEMENT, AND THE RATING OF RESEARCHERS 2015 TO 2017”**

(NRF, 2014. Available at

[http://www.nrf.ac.za/sites/default/files/documents/Overview%20of%20NRF%20Funding%20Opportunities%20C%20Grant%20Management%2C%20and%20the%20Rating%20...\\_0.pdf](http://www.nrf.ac.za/sites/default/files/documents/Overview%20of%20NRF%20Funding%20Opportunities%20C%20Grant%20Management%2C%20and%20the%20Rating%20..._0.pdf) (Accessed 11 November 2014).

Table G.2: Overview of grants

Grant programme / sub-programme	Funding programme	Open (2015/2016)	Number of calls for applications	Total amount (R-million)
<b>Researcher's grants</b>				
<b>Researcher's grants</b>	Researcher's grant for the promotion of research in science, technology and innovation (R&I)	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
<b>Researcher's grants</b>	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
<b>Researcher's grants</b>	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
<b>Researcher's grants</b>	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
<b>Researcher's grants</b>	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
<b>Researcher's grants</b>	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1
	Researcher's grant for the promotion of research in science, technology and innovation (R&I) - Special	1	1	1