Research Framework for Supporting Domestic Rainwater Harvesting in South Africa

Louiza Duncker and Gertrude Matsebe

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EXECUTIVE SUMMARY

Rainwater harvesting (RWH), in its essence, is the collection, conveyance and storage of rainwater. The World Health Organisation (WHO) has identified RWH as an alternative improved water source, along with protected dug wells, boreholes and standpipes, in provision of water directly to the household for drinking and hygiene purposes. Recently, RWH has come into the spotlight again in South Africa, due to the inherent role rainwater as an alternative source of water in rural communities and interest in reducing the demand and consumption of treated and expensive water as stated in the second edition of the National Water Resources Strategy (NWRS 2). To date, the Department of Water Affairs (DWA) has already been instrumental in the implementation of rainwater harvesting programmes in South Africa, involving the installation of large numbers of RWH tanks in 8 provinces in South Africa during 2011/12, mainly for small scale food production. However, the implementation of RWH for drinking purposes has been barred by a number of issues that still need to be researched and clarified in order for rainwater harvesting to augment water services on household level.

The Department of Water Affairs (DWA) and the Water Research Commission (WRC) recognised the value of rainwater harvesting as a measure in providing basic water services to households in South Africa. In this document discussions from a national workshop to engage all rainwater harvesting experts and stakeholders are presented. Recommendations for future strategic actions, including the need for developing a national RWH strategy and guidelines for ensuring the sustainable implementation of rainwater harvesting to assist the sector in the provision of basic water services and water demand management are also presented.

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Mr Siboniso Ndlovu	Department of Water Affairs
Ms Zama Masondo	Department of Water Affairs
Ms Nandi Dube	Department of Water Affairs
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Ms Lauren Bulcock	University of KwaZulu-Natal
Prof Lise Korsten	University of Pretoria
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CONTENTS

1. INTRODUCTION

Rainwater harvesting (RWH) is an ancient technique that dates as far back as 4 000 years ago (Gould and Nissen-Petersen, 1999). Rainwater harvesting, in its essence, is the collection, conveyance and storage of rainwater. The scope, method, technologies, system complexity, purpose and end use vary from rain barrels for garden irrigation in urban areas, to large-scale collection of rainwater for all domestic uses. Rainwater harvesting also includes land-based systems with man-made landscape features to channel and concentrate rainwater in either storage basins or planted areas.

The World Health Organisation (WHO) has identified RWH as an alternative improved water source, along with protected dug wells, boreholes and standpipes, in provision of water directly to the household for drinking and hygiene purposes. Millions of people are currently using RWH for drinking water purposes in both rural and urban users (UNICEF/WHO, 2012). Dobrowski et al. (2014) stated that domestic rainwater harvesting has the potential to improve water availability in rural communities in Southern Africa with 55 000 households utilising a rainwater tank on site as their main source for drinking in 2010 in South Africa. Rainwater harvesting could also provide water for small-scale home based productive activities such as vegetable gardening that could make a positive contribution towards food security for the people from lower social economic groups (Mwenge-Kahinda et al., 2010). Rainwater is has a nearly neutral pH, and is free from disinfection by-products, such as salts, minerals and other natural and man-made contaminants. Plants thrive under irrigation with stored rainwater and appliances last longer when free from the corrosive or scale effects of hard water. Users with potable rainwater harvesting systems prefer the superior taste and cleansing properties of rainwater.

Recently, RWH has come into the spotlight again in South Africa, due to the inherent role rainwater as an alternative source of water in rural communities and interest in reducing the demand and consumption of treated and expensive water. South Africa is fundamentally a semi-arid and water scarce country with an average annual rainfall of about 490mm of rainfall, recurrent droughts and where the demand for water is in excess of natural water availability in river basins (DWAF, 2004). The water scarcity and droughts in many regions of South Africa pose a significant challenge to the availability of water as a resource. Climate change, over-allocated water, concerns about water quality and ageing infrastructure are some of the major issues impacting on the security of water provision in the country. To date, the Department of Water Affairs (DWA) has already been instrumental in the implementation of rainwater harvesting programmes in South Africa, involving the installation of large numbers of RWH tanks in 8 provinces in South Africa during 2011/12, mainly for small scale food production. However, the implementation of RWH for drinking purposes has been barred by a number of issues still need to be researched and clarified in order for rainwater harvesting to augment water services on household level.

The Department of Water Affairs (DWA) and the Water Research Commission (WRC) recognised the value of rainwater harvesting as an interim, and in some cases permanent, measure in providing basic water services to households in South Africa. They thus, initiated discussions around rainwater harvesting for domestic use in South Africa to augment water supply to all citizens in the country in their efforts to address the water backlog and the Millennium Development Goals (MDGs) of providing all South African citizens with access to basic water services by 2014. One of the results of the discussions between the DWA and the WRC was hosting a national workshop to engage all rainwater harvesting (RWH) experts and stakeholders, in order to solicit input on the need for developing a national RWH strategy and guidelines for ensuring the sustainable implementation of rainwater harvesting to assist the sector in the provision of basic water services and water demand management. The knowledge shared, discussions and challenges raised during the workshop, as well as a review of existing literature on the subject were used to compile this document.

2. NATIONAL WORKSHOP ON DOMESTIC RAINWATER HARVESTING

2.1 AIM OF THE WORKSHOP

The aim of the workshop was to engage RWH experts and stakeholders, and share knowledge and experiences on the concept and technology of rainwater harvesting (RWH) for domestic use and how it fits into the overall picture of appropriate rural and urban water supply, in order to initiate a starter document of addressing research gaps in the field of RWH for domestic use. These discussions culminated in a workshop that was held at Birchwood Hotel and OR Tambo Conference Centre in Boksburg on 21 November 2013. The workshop was attended by more than 50 participants of which 18 were from the Departments of Water Affairs, 7 were from municipalities/water boards (eThekwini, Ekurhuleni, City of Johannesburg, Johannesburg Water), 6 were from a non-governmental organisation (Mvula Trust), 5 were from the private sector (Socio-Technical Interface CC, Eon Consulting, Tizagenix, Water Rhapsody, ROCLA, EarthLife), 5 were from research institutions (WRC, CSIR, SABS, Institute for Water Research, Agricultural Research Institute) and 9 were from universities (University of Pretoria, University of KwaZulu-Natal, University of the Western Cape, University of Witwatersrand, University of South Africa, Rhodes University, Durban University of Technology). During the workshop the latest research outputs were presented by the WRC, the Council for Scientific and Industrial Research (CSIR), the University of KwaZulu-Natal (UKZN), The University of Pretoria (UP) and the University of Western Cape (UWC). These presentations are available on the WRC website at:
http://www.wrc.org.za/Pages/KH_ConferenceProceedings.aspx?dt=14&ms=62.

2.2 POTENTIAL ROLE OF RAINWATER HARVESTING IN WATER CONSERVATION, WATER DEMAND MANAGEMENT AND WATER SERVICES DELIVERY

The workshop was opened by Mr Siboniso Ndlovu of the DWA with a presentation on the Department of Water Affairs' needs and intentions regarding RWH for domestic use. The key points highlighted in searching for solutions in water services delivery in South Africa were the need for RWH in South Africa, the potential of RWH to provide at least an interim water service, and intermediate water supply options based on research. The DWA indicated that they are intending to develop guidelines for RWH for domestic use that will be based on research conducted in the country. Therefore the purpose of the workshop for the DWA was to network with a wide spectrum of experts in the field, such as researchers, implementers and Water Services Authorities (WSAs) that provide RWH to their communities, especially in difficult geographical areas that are sparsely populated, making water services delivery through pipelines impractical and too expensive. Key focus areas presented by the DWA focussed on installation-appropriate technologies, water storage tanks, water use (point of use and treatment, drinking water quality, monitoring), operation and maintenance, and consumer education on effective water use and ownership. The DWA proposed a project plan they would be following in the next year to mainstream RWH in water services provision. This plan includes consultative meetings with all 9 DWA regions, external stakeholders and other role players in developing RWH in the department.

Water demand is increasing due to population growth, development initiatives and global weather changes. Due to the increasing water demand, water shortages and inferior water quality are major problems for millions of South Africans and a hindrance for economic development. The African Development Bank (undated) states that an estimated 200-500 million cubic meters of rainfall is lost in the form of run-off in Sub-Saharan Africa each year, which could potentially irrigate substantial areas. They also state that in places with less serious water shortages, demand for additional water is also dominant. The water scarcity and droughts in many regions of South Africa pose a significant challenge to the availability of water as a resource. Climate change, over-allocated water, concerns about water quality and ageing infrastructure are some of the major issues impacting on the security of water provision in the country. Researchers project that South Africa will become water scarce by 2020 and indicated that, amongst others, water availability should be improved through for example RWH (Viljoen, Kundhlande, Baiphethi, Esterhuyse, Botha, Anderson & Minkley, 2012).

There is currently a growing interest in applying sustainable solutions and green technology in efforts to address climate change issues. Rainwater harvesting is regarded as a technique for optimising the use of available rainfall in any given location. Smet (2003) indicates that rainwater can be both a key domestic and productive resource, which makes the effects of RWH multiple in terms of health (improved health as excess rainwater used for vegetable and crop growing gives improved diet), poverty reduction (less time spent in collecting water and improved economic status from the income from vegetable and other crops, and other economic activities using excess rainwater), education (more time for education and personal development, particularly for young girls as time saved is now

used for school attendance or homework) and equity (less back problems and growth reduction particularly among children and women as transportation of heavy loads over long distances is reduced and burdens eased). Viljoen et al. (2012) stated that the inclusion of RWH as a strategy for improving water services to the poor and to rural dwellers will offer a number of advantages as it is relatively inexpensive compared to large-scale public conveyance systems in supplying water.

Dobrowsky, Van Deventer, Lombard, Mannel, Prozesky, De Kwaadsteniet, Khan & Cloete (undated) stated that domestic rainwater harvesting has the potential to improve water availability in rural communities in Southern Africa with 55 000 households utilising a rainwater tank on site as their main source for drinking in 2010 in South Africa. Rainwater harvesting could also provide water for small-scale home based productive activities such as vegetable gardening that could make a positive contribution towards food security for the people from lower social economic groups.

Rainwater harvesting is not new, but because municipal water has been plentiful and of a good quality, the practice of harvesting rainwater has become redundant. It is in the process of being rediscovered as a source for drinking water to augment the dwindling water supply in the country. It will require a reform in water management systems, as well as scientific and technological research to assess the status quo and to suggest mitigating measures for the revival of the practice of RWH.

Although current policies recognise RWH, the administration, regulation, monitoring and evaluation of RWH are lagging behind as many officials and technical staff regard RWH as backwards, or belonging in the realm of NGOs, or as part of a household's responsibility. It is more acceptable if the rainwater is used for livestock or for agricultural purposes, but not for drinking water.

2.3 OVERVIEW OF CURRENT RWH RESEARCH IN SOUTH AFRICA

2.3.1 Domestic Rainwater Harvesting in South Africa – challenges and opportunities.

This presentation was made by Dr Jean-Marc Mwenge-Kahinda of the CSIR National Resources and Environment Unit (NRE). The concept of RWH, was described as "the small-scale concentration, collection, storage and use of rainfall for productive purposes" that could address the escalating environmental and economic cost of centralised water supply, climate change challenges, water conservation, money savings and storm water reduction. Challenges highlighted in this presentation were related to the legal status of RWH in South Africa in terms of the National Water Act (No 36 of 1998), the Water Services Act (No 108 of 1997) and municipal by-laws that need to support RWH, especially at domestic level. In addition, the lack of RWH institutionalisation was highlighted as one other challenge in that no national umbrella body exists to coordinate RWH efforts in South Africa, and that there is a lack of guidelines specific to RWH. Technical issues, such as sizing and optimisation of RWH and water contamination through roof types, insects, animals, humans and the environment which would necessitate filtration devices, were presented. Issues around finances were

highlighted as capital costs, operating costs, water treatment costs, maintenance costs, decommissioning costs and disposal costs. Some of the factors that will impact positively on the feasibility of RWH in the future, such as cost of water supply, escalating energy costs and addressing the water backlogs as part of the Reconstruction and Development Programme (RDP) and highlighted that research will support the development and sustainability of RWH were briefly highlighted. Other related research projects, such as the WRC project: Point of use disinfection systems for domestic rainwater harvesting (DRWH), the CSIR projects: Low-income housing in Kleinmond and Rooftop RWH and household water security, the National Research Foundation's (NRF) project: Life cycle costing of RWH in Johannesburg and Nairobi, as well as that conducted by Johannesburg Water was highlighted. This was very important as due to the lack of a coordinating body for RWH, many stakeholders and role players are not aware of what research is being conducted by whom and where. The presentation concluded with a list of questions pertaining to RWH, such as the long-term performance and financial viability of RWH, RWH and storm water, RWH as a buffer against drought, RWH for groundwater recharge, reliability of RWH, regulation for RWH, guidelines for RWH and RWH in informal settlements.

2.3.2 Domestic Rainwater Harvesting as a Sustainable Water Supply Solution

This presentation was made by Ms Lauren Bulcock of the Centre for Water Resources Research of the UKZN. According to Ms Bulcock, the African Union (AU) signed the Sharm El-Sheikh commitments for accelerating the achievement of water and sanitation goals in Africa and will increase the RWH share of total water supply to 10% by 2015. She highlighted that the accelerated provision of rainwater harvesting tanks in rural and low-income areas will form part of the Water Conservation and Demand Management Flagship Programme of South Africa's White Paper on National Climate Change Response. She presented the research aims of the UKZN project: Sustainability of domestic rainwater harvesting through focussing on measuring the number of days a rainwater tank will be able to provide for the daily water requirements of a household of 6 occupants at 50liter per person per day, using 4 General Circulation Models (GCMs) to predict the future sustainability of DRWH in South Africa. Her conclusions from the project were that the eastern part of South Africa is best suited for DRWH, that DRWH is likely to become more popular in climate change conditions and that the African Union's goal of increasing the source of water supply from RWH to 10% is achievable. She cautioned that RWH in South Africa can only be a supplementary source of water supple as the rainfall in South Africa has too many intra- and inter-seasonal variability.

2.3.3 Performance Evaluation of RWH Systems

The fourth presentation was made by Ms Louiza Duncker from the CSIR Built Environment Unit (BE): *Performance evaluation of RWH systems: a case study from the Northern Cape*. The case study of the RWH interventions at a school in the Northern Cape was part of a transdisciplinary process of improving water services delivery by local municipalities. She presented the process of the RWH intervention through the development of an assessment tool for RWH, which included a needs

assessment (water use and demand), and assessment of the institutional context (policies, regulations, by-laws, municipal capacity and legal factors), the social context (settlement patterns, poverty levels, knowledge, attitudes and practices), the environmental context (water and rainfall, climate, geology and soils, biological systems) and the technical context (existing infrastructure, operation and maintenance, resources). The application of the assessment tool produced results that were provided to the school governing body and the municipality as possible options for the way forward in terms of RWH at the school. She showed that the perceptions of the people at the school were that rainwater harvesting is regarded as a good concept, should be used for drinking water and irrigation, but that it is costly. This indicated that the people were aware of RWH as a concept but were not familiar enough to be able to make informed decisions about implementing RWH at school or household level.

The most interesting finding of the research was that the school's water use and demand (including the hostels) for drinking, bathing, cooking, laundry and irrigation of the vegetable garden could be addressed fully if the amount of rainwater that falls on the roofs of the school and hostel buildings could be harvested and safely stored and used. She showed that the outcome of the project was that the school chose to, in the short term, upgrade their existing RWH system of 8 tanks to 20 tanks of 5 000liter each together with the necessary infrastructure components, training, O&M and budgeting in place. In the long term, the school plan to find the funding for a full-scale comprehensive RWH system that will include rainwater, storm water and grey water harvesting into a wetland system for treatment and recycling to the school for irrigation and flushing toilets. The short term plan was implemented and supported with a manual for the care takers of the RWH system at the school on the operation and maintenance of the system. She indicated that the assessment tool that was developed for the school could be applied as a performance evaluation tool for RWH as it includes the institutional, environmental, social and technical aspects that impacts on RWH.

2.3.4 Evaluation of the Risks Associated With the Use of Rainwater Harvested From Rooftops for Domestic Use

The fifth presentation was made by Prof Lize Korsten (University of Pretoria): *Evaluation of the risks associated with the use of rainwater harvested from rooftops for domestic use*. She presented a definition of RWH by Abdulla & Al-Shareef (2009): 'Rainwater harvesting is a method used for collecting an storing rainwater from rooftops, rock surfaces using tanks and underground storage'. She stated the problem her project was addressing as access to clean water for people and small scale farmers in the rural areas of South Africa, rooftop harvested rainwater (RHRW) is used as an alternative source of water for personal use and food production and RHWR is used for drinking and irrigation of crops without prior treatment as it is assumes to be safe. She indicated that this assumption could be incorrect as research has shown that rooftop rainwater was contaminated with bacteria, including a pathogenic strain of *E.coli*. She discussed the findings of her research project in the Eastern Cape, North West and Limpopo Provinces on the sources of microbial contamination to determine fitness of use of rainwater collected from rooftops for homestead food gardens, livestock

production and domestic use. The research hypothesis was that the Escherichia coli (*E.coli*) strain found in contaminated RHRW is non-pathogenic and the *E.coli* bacterium does not persist on cabbage and leafy greens irrigated with contaminated water'. It showed that *E.coli* 0157:H stays in crops that were irrigated by contaminated water by for example colonising the cell wall of epidermal and cortical cells of spinach. It also showed that *E.coli* was outlived by a number of other pathogens, such as salmonella and campylobacter species. Her conclusion was that more in-depth research need to be conducted on the risk the quality of RWH could pose to the end-user, the safety of crops and animal health and that a risk assessment cannot be based on *E.coli* as an indicator of the presence of pathogens in RHRW.

2.3.5 Domestic rainwater harvesting in South Africa – a social perspective.

Prof Jackie Goldin made the sixth presentation on: *Domestic rainwater harvesting in South Africa – a social perspective*. Her presentation focussed on the issue of understanding people and what participation means in terms of approaches, founding principles and values. She presented that the essence of people-centric participation (by Saxena, 1998) is exercising voice and choice and developing the human organisational and management capacity to solve problems as they arise; and the primary aim for participatory development practitioners is, according to Cornwall (2000), to transform conventional development into a process of engagement with and by local people rather than to use expert knowledge to dictate interventions. She extrapolated this approach and understanding to RWH for domestic use in terms of how RWH is assisting people in making choices and be part of the decision making process in improving their lives and having something useful, keeping in mind diversity, gender, race, social, environmental and personal factors. The crux of the matter is to achieve valued well-being such as dignity, self-esteem, ability to make choices, to be respected, having trust between government and society, as well as amongst social groupings. Her presentation showed that the process of introducing and accepting DRWH should be based on achievements in the human dimension, not as a means to an end (getting water) for people but an end in itself (improving people's capabilities, choices, opportunities).

3. FEEDBACK FROM EXPERT AND STAKEHOLDER DISCUSSIONS

The second part of the workshop consisted of break-away groups to identify and discuss the challenges for the implementation of RWH in South Africa and make recommendations for overcoming the identified challenges. The specific topics for the group discussions were the following (but not limited to):

- Regulatory requirements for rainwater harvesting in South Africa.
- Water quality from domestic rainwater systems.
- Funding sources, including incentives and appropriate partnerships for rainwater harvesting in South Africa.

- Sustainability of domestic rainwater harvesting systems (how can it be achieved?) and Climate change and rainwater harvesting.

From these discussions it was evident that there are many challenges for mainstreaming RWH in the water sector in South Africa. The identified challenges, research gaps and other deliberations have been consolidated and grouped into a number of themes with research topics listed under each theme. These themes and the research topics are highlighted below:

3.1 POLICIES AND LEGISLATION FOR RAINWATER HARVESTING

- A review of the past regarding rainwater harvesting in South Africa needs to be conducted to inform the policies, legislation, strategies and interventions for the future.
- SA climate change policy acknowledges RWH as one of the strategies defined for adaptation to climate change.
- Even though the Second National Water Resources Strategy (NWRS2) incorporated RWH as one of the ways to combat current water losses in the country and spelled out the mitigating factors that include water conservation, RWH needs greater emphasis in the Water Resources Management Strategy and needs to be linked with flood mitigation and water conservation, especially in water-stressed areas.
- RWH needs to be highlighted as part of the flood mitigating strategy, therefore, be sold to municipalities and other institutions. For instance, capturing a certain amount of water for domestic use can mitigate the issue of flooding, therefore, ensuring sustainability of the drainage systems.
- Commercial use/application of RWH needs to be investigated and incorporated in the National water Act.
- A regulatory framework needs to be developed for the different categories of use of rainwater, such as:
    - drinking water, i.e. for potable use (humans and livestock);
    - irrigation and gardening;
    - commercial use; and
    - industry.
- There is a need for specific regulations (e.g. municipal by-laws) to support RWH for domestic use. For instance, in some countries, water from RWH system should be filtered, disinfected and comply with certain health regulations before it could be used for drinking water.
- The regulations to be put in place need to investigate whether distinction will be made between affluent people and indigent people in the use of rainwater.
- Monitoring and enforcement of regulations: It is of no use if regulations exist but is not enforced. A monitoring and support group to implement, enforce and revise regulations need to be in place.

- Guidelines for domestic RWH systems need to be developed. A large number of companies are installing RWH systems that are not regulated.
- The social aspect (community participation, users' perceptions, beliefs, needs, etc.) of using RWH needs to be investigated to optimise the sustainability of the concept of DRWH.
- Government sees RWH as an interim/supplementary measure in addressing service delivery, since rainfall patterns in South Africa varies a lot (in and out of season). A household has to have another source of water, which has to be taken into account in the cost benefit. Another source of water is also crucial for dry periods. The reasons why RWH is not a long-term strategy needs to be investigated.
- Government has developed guidelines for RWH, with a focus on food production not human consumption. Guidelines are needed for human consumption of rainwater.
- How to ensure RWH systems are implemented together with storm water management.
- How to ensure water is used for the correct need, i.e. avoid using drinking quality water to flush the toilet.
- Integrate RWH into Water Resources Management Strategy and plans. It is better to implement regulations for new developments rather than targeting existing infrastructure to comply with regulations. There is a great need for developing a RWH Strategy as part of the regulations for builders and contractors.
- Development of a policy with a rating for RWH (such as BlueDrop) and to obtain a RainDrop rating.
- What mechanisms are in place to promote RWH in policy and legislation in case it becomes compulsory to include it when doing an environmental assessment?
- Develop of a policy document from available research conducted by CSIR, WRC and others.

3.2 KNOWLEDGE/INFORMATION MANAGEMENT AND ADVOCACY OF RAINWATER HARVESTING

- Consumer awareness raising, training and knowledge dissemination on RWH are critical for the success of the concept.
- Currently there are no institutions that formally coordinate RWH research between different departments, research organisations, institutions, etc. Consequently, there is lack of knowledge on research conducted by other institutions.
- A need was identified for an updated knowledge sharing platform and a RWH association. A need for accurate figures to support the motivation for funding for RWH projects. There is also a need for further research – publication of case studies (dissemination) to share knowledge and supply figures and data.
- There is a belief that RWH systems are sustainable, a green technology and an interim solution for water services.

- Build a body of knowledge on RWH – either companies or government. Can cross reference with other countries (learn from others). Can also use existing knowledge platforms such as the Technical Knowledge Centre (TKC at DWA) and the DST water platforms.
- Establish gateways for learning about RWH in rural communities – TV, radio, cell phone, social media (Facebook, Twitter groups) and investigate the best ways of reaching the majority of people in rural areas.
- Disseminate knowledge of what has worked/not worked? E.g. water quality aspect, infrastructure, O&M and monitoring. From the research conducted thus far, what are the findings in terms of quality, type of materials used?
- A need was identified for an updated knowledge sharing platform and a RWH association. A need for accurate figures to support the motivation for funding for RWH projects. There is also a need for further research – publication of case studies (dissemination) to share knowledge and supply figures and data.

3.3 INFRASTRUCTURE FOR DOMESTIC RAINWATER HARVESTING

- Norms and standards need to be developed for the infrastructure of rainwater harvesting systems and need to be compulsory in building regulations. Local municipalities should ensure enforcement of these regulations in new developments.
- SABS standards to be formulated for the development and production of RWH tanks, as well as for the entire process (storage, installation, construction, water treatment, maintenance, etc.). These standards should be reflected in the building regulations and need to be backed by support from the municipalities.
- The installation RWH systems needs clear objectives, for example, installing RWH systems in an area with little rainfall.
- New housing developments? Do developers need to submit a building plan (by-laws) or impact assessment to install a RWH system? Should monitoring be part of the building plan?
- For sustainability of the RWH system, it would be ideal to involve institutions at local and catchment level whereby Catchment Management Agencies (CMAs) are looking at the totality of water allocation in different areas. At a strategic level, involve water user associations who are in touch with the community and collaborate with NGOs and other cooperatives
- Possible incentives should be considered in comparison with current initiatives, e.g. subsidy for solar geysers (rebate), JoJo tanks, etc. Bulk purchasing could be an incentive where a group of cooperatives buy a number of JoJo tanks at a discounted rate (similar to the arrangements around DSTVs in rural areas).
- Optimise the RWH system – focus on other factors over and above the quantity (size of the tank), i.e. the whole system:
    - What is the end use of water?
    - Quality standard for water is needed.
    - The technology to be used to reach the quality.

- Address the infrastructure challenge for the poorest households without the ideal roof type for RWHs, e.g. thatch).
- Regarding RWH implementation, investigate optimal or economic use of RWH in terms of the relationship between roof size, rainfall pattern and the size of the tank. What would be the best combination to get optimal results from the RWH project?
- Develop a way of channelling water from a household tank into a centralised dam in order to treat water and distribute back to the users. Any study on the transportation of water from the central dam back to the household?

3.4 WATER QUALITY OF RAINWATER HARVESTING FOR DOMESTIC USE

- Is RWH safe for drinking?
- The pathway of contamination in a RWH tank needs to be investigated, for example, underground tanks that are receiving water from surface catchment tend to be more polluted.
- The effects of pollution from roof tops into rainwater harvesting systems need to be investigated and quantified, such as:
    - wind carrying pollutants and contaminants;
    - birds, animals and insects on the roof;
    - dust, debris, paint and rust;
    - chemical contaminants (from mining, heavy metal fall out, pesticide, nitrates, sulphates, etc.);
    - environmental contaminants (acid rain, ocean); and
    - microbial contaminants that may affect water quality (E-coli, protozoa, viruses, water borne pathogens)
- Sources of contamination need to be investigated, such as impact of mining, agricultural activities, industrial activities, waste management treatment, traffic, urbanisation, wildlife and the type of roof material. Investigate air quality, fall out and the extent of the chemical pollution of rainwater and the effect on DRWH.
- Roof top material in use, which include fibre glass, galvanised sheets, cement, tiles, thatch, corrugated iron, painted roof, asbestos, waterproof material, aluminium gutters, etc., needs to be researched in terms of optimal harvesting potential and least pollutants.
- The impact of the geographic area (rainfall pattern, moisture – intermittent vs seasonal, temperature changes, wind speed and direction, vegetation – desert vs rain/fog, over hanging trees, etc.) on rainwater harvesting needs to be investigated.
- Effective filtration devices need to be developed, such as nano membranes, meshes, etc., for the prevention of debris (leaves/insects) and pollutants entering the rainwater tanks.
- Materials for storage tanks (plastic, cement, sealant & corrugated iron, pre-filter, flushing system to remove debris, etc.) need to be investigated, specifically for contamination of the water.

- The position of the rainwater collection point needs to be investigated in terms of control and treatment (filtration, UV light, boiling, chemical filtration (Jik or chlorine), reverse osmosis). Control will be system maintenance, which is done twice a year or as a need arises.
- Methods for the detection of microbes: standard microbiological methods, molecular methods, standard lab testing, API testing, rapid testing, etc.
- Catchment/storage management: Social practices, households do not remove water from the tank, consequently there is no information on the limits/duration period for water stored in the tank.
- Water treatment – from the source or in the tank? Standards have been set on how installation should be done to minimise the need for water treatment/purification.
- Vector contaminants: mosquitos, SANS 241, algae, etc., need to be investigated.
- Water safety nets need to be researched and developed for RWH systems in South Africa.
- Water quality monitoring – how should it be done? At what stage should the quality be monitored and who will be responsible for this function? Is it a household or institutional function?
- Sustained water quality. The contamination point might not necessary be the collection or storage points, but, containers used to collect water from the tanks to inside the house. Does the research on water quality cover health and hygiene within the household as it has the influence on water quality. No research conducted yet that has measured such impact on RWH.
- Sustainability. RWH tanks are only used when there is emergency water provision (in areas with drought or infrastructure related challenges). Provide households with tanks, but there is no rainfall. For instance, there are financial constraints in terms of distributing water into household tanks, which eventually led to empty tanks. How is the RWH system sustained when there is no rainfall?

3.5 OPERATION AND MAINTENANCE OF RAINWATER HARVESTING SYSTEMS FOR DOMESTIC USE

- Operation and maintenance – Determine who should be responsible for the O&M of RWH in case of poor households?
- Installation of tanks without monitoring. E.g. one household with three tanks, therefore, a need for monitoring (O&M including quality and quantity of the system).
- Sustainability. RWH tanks are only used when there is emergency water provision (in areas with drought or infrastructure related challenges). Provide households with tanks, but there is no rainfall. For instance, there are financial constraints in terms of distributing water into household tanks, which eventually led to empty tanks. How is the RWH system sustained when there is no rainfall?
- The priority is the financial sustainability of RWH. Since the systems initiatives are implemented at a local level, the interest will be on the financial sustainability of the systems.

- RWH at a household level is not financially sustainable; more focus is needed on commercial, corporation, industry, private company levels with the main aim of focusing on the city as whole rather than individual households. This research will have a focus on broader water uses (e.g. companies, municipalities, mines, etc.) as opposed to individual households.
- RWH can be used for purposes that do not warrant good quality water, such as firefighting and cleaning the city. Link RWH with sustainable sanitation, i.e. promoting the use of RWH for non-consumption purposes. It will also address the strain put on water resources for waterborne sanitation.

3.6 MONITORING AND EVALUATION OF RWH

- Monitoring, risk assessment, develop guidelines, training and awareness in the communities of issues around water quality in RWH systems.
- Installation of tanks without monitoring. E.g. one household with three tanks, therefore, a need for monitoring (O&M including quality and quantity of the system).
- Regulation or monitoring. What approach to take in terms of regulating the quality of RWH system?

3.7 SOCIAL PERCEPTIONS, ATTITUDES AND PRACTICES RE RWH

- The acceptance of RWH systems by the beneficiaries/consumers in both rural and urban contexts needs to be investigated.
- Test all the assumptions for RWH currently available, especially in terms of implementing DRWH.
- Test/validate people's (parliament to households) beliefs/assumptions around RWH, e.g. RWH conserves water and is economical.
- Investigate the aesthetics and acceptance of RWH systems by end-users and consumers.
- Research on social aspects/users/community – Participatory research on the needs of the communities (demand responsive), their perceptions, beliefs around RWH systems, thus the impact on the implementation of RWH systems.
- Communities with limited literacy level in rural areas that lack understanding on safe use of RWH for human consumption. What measures can be taken to instil an understanding of the concept? This to be extended to politicians and government officials. Can also learn from the communities, looking at history and indigenous knowledge of the case study area.

3.8 FINANCIAL ASPECTS OF RWH

- Approach to implementing incentives for any initiative (e.g. RWH). What approach is followed to make it the best/optimal way of succeeding?

- Possible sources for funding for RWH were listed as:
    - Donor funds;
    - Subsidies, specifically housing subsidies;
    - the Municipal Infrastructure Grant (MIG);
    - the Municipal Water Infrastructure Grant (MWIG);
    - the Regional Bulk Infrastructure Grant (RBIG);
    - etc.
- Partnership with private companies as part of their social responsibility should be investigated and explored. Developers could donate part of their profits to subsidise JoJo tanks as part of their social responsibility initiatives.
- The Equitable Share of each municipality should be considered and used for the operation and maintenance of RWH systems.
- Funding mechanisms should not only consider funding for infrastructure, but should also earmark/ring-fence funding for research in RWH, especially to address the gaps in research.

3.9 WATER DEMAND MANAGEMENT AND WATER CONSERVATION

- Determine the role of RWH in water conservation, demand management, its impact on revenue generation in municipalities and the development of a costing model for planning & budgeting purposes.
- Provide guidance on the suitability of RWH system per locality or geographical space (e.g. district municipality level).
- Assess whether or not RWH can be used as a mechanism to address drought relief.
- Provide decision making processes under severe conditions, such as drought, floods, disasters, etc.
- More research into alternative RWH technologies as opposed to conventional storage:
    - Collaboration with the regional players, such as the SADC. For example, collaborate with Namibia in terms of groundwater recharge.
    - Investigate different ways of harvesting rainwater other than using a roof.
    - Learn from others (Africa).
    - Find the right technology for the right location – RWH not a one size fits all.
- What would be the selection criteria for places to install RWH?
- Understand the nexus of RWH and storm water in urban setting. What would be the benefits to upscale RWH in a city in terms of reduction in storm water?
- RWH and artificial groundwater recharge in South Africa. Any excess or overflow from the tank into the aquifer and use it later in the system?
- A link between municipal water system and RWH system to be considered (particularly in small towns) since they use the same storage system for both. If the municipal system goes down, there is water available from RWH system.

- A need for research so as to ascertain if the local municipalities are really struggling to meet water demands. The findings will address the question on how much will RWH system be a threat to municipalities in terms of sustaining their revenues.
- The WRC funded research project by Wits University on the possibilities of using grey water for flushing toilets to save water since SA is one of the water stressed countries.
- For sustainability of the RWH system, it would be ideal to involve institutions at local and catchment level whereby Catchment Management Agencies (CMAs) are looking at the totality of water allocation in different areas. At a strategic level, involve water user associations who are in touch with the community and collaborate with NGOs and other cooperatives.

3.10 RWH IN URBAN SETTINGS AND INDUSTRY

- Informal settlement context. Different dynamics in suburbs and informal settlements. Is RWH viable is informal settlements?
- Is RWH viable for industries? This will depend on the reliability of the source; alternatively, make provision for supplementary source/s.

4. TOWARDS A RESEARCH FRAMEWORK FOR SUPPORTING RAINWATER HARVESTING IN SOUTH AFRICA

4.1 VISION FOR RAINWATER HARVESTING IN SOUTH AFRICA

In order to be able to respond to climate change and achieve sustainable water services delivery in South Africa though research, the RWH sector needs to agree to a common vision for the sector that is supported by a directed aim with the resultant objectives and outputs. A framework for research in RWH for domestic use is proposed to guide and inform the water sector in initiating research and investment in research on RWH in South Africa. The research framework is intended to provide a high level framework in the development of policies and programmes related to research in RWH by the government. It is intended to be sufficiently broad and flexible to provide the basis for a coordinated and integrated approach for funding research in RWH. This document contains a research framework that proposes the vision, the aim, the objectives and outputs/deliverables for rainwater harvesting in South Africa. This framework will be used as a basis by the WRC and the DWA in their preparation of the National RWH Strategy for South Africa.

The vision for RWH in South Africa needs to be articulated by sector stakeholders and role players in the context of the South African policies and legislation. The Second National Water Resources Strategy (NWRS2) states that: "*South Africa has to prioritise, considering the mix of options available, to supply the huge water demands for equitable allocation for development and economic growth. The country will thus consider other potential sources, which include water re-use, desalination, groundwater utilisation, water conservation and water demand management measures, rainwater*

harvesting, recovering water from acid mine drainage, and the import of water intensive goods" (NWRS2, 2013: iii). This provides the water sector with the mandate to explore the application and implementation of RWH for domestic use in South Africa.

4.2 RECOMMENDED STRATEGIC ACTIONS FOR A NATIONAL RWH PROGRAMME IN SOUTH AFRICA

The results from the workshop that was held by the WRC and the DWA in November 2013 articulated the need for a number of key strategic actions and research on several levels in order to ensure that RWH becomes an important element of water services delivery in the country. These actions were categorised into different strategic areas. A series of outputs/deliverables within each component have been identified that will lead to the creation of an enabling environment to support the implementation of sustainable RWH as a viable water supply augmentation measure in South Africa.

4.2.1 Enabling institutional environment

The creation of an enabling environment for the application and implementation of RWH, which is regulated and monitored by appropriate policies and legislation at all tiers of government.

4.2.1.1 Objective 1: Water demand management and water conservation

To include RWH in water demand management and water conservation to alleviate the pressure on water services delivery.

Outputs/Deliverables:

- Research results on the role of RWH in water conservation and water demand management.
- Data and results on the impact of RWH on revenue generation in municipalities and a costing model for planning and budgeting purposes.
- Research results on local municipalities meeting their water demands in terms of RWH systems posing a threat to municipalities sustaining their revenues.
- Guidelines on the suitability of RWH systems per locality or geographical space (e.g. district municipality level).
- Research results on RWH as a mechanism to address drought relief.
- Guidelines on decision making processes regarding RWH under severe conditions, such as drought, floods, disasters, etc.
- Research results and data regarding alternative RWH technologies as opposed to conventional technologies in collaboration with regional role players for:
    - groundwater recharge;
    - different ways of harvesting rainwater other than using a roof;
    - the right technology for the right location – RWH not a one size fits all.
- Selection criteria for places to install RWH.
- Research results on RWH and artificial groundwater recharge in South Africa.

- Data and research results on the link between municipal water system and RWH system (particularly in small towns since they use the same storage system for both) in terms of supplementary services.
- Expanded research results apart from the WRC project conducted by Wits University on the possibilities of using grey water for flushing toilets to save water in a water-stressed country.
- Guidelines for the involvement of institutions and water user associations at local and catchment level in considering the totality of water allocation in different areas.

4.2.1.2 Objective 2: Appropriate and effective policies, legislation and regulations

To provide information and data in order to guide the development of appropriate and effective policies, legislations, regulations and guidelines for the implementation of rainwater harvesting for domestic use.

Outputs/Deliverables:

- Policy statement of rainwater harvesting for domestic use on:
    - RWH as interim/supplementary solution;
    - RWH as a long term strategy;
    - RWH as a green initiative;
    - Commercial use/application of RWH.
- RWH for domestic use included in national acts and legislation.
- National acts across departments aligned to support RWH implementation in South Africa.
- RWH addressed in national and local strategies and plans.
- Regulations and municipal by-laws to support and enhance rainwater harvesting for domestic use:
    - specific regulations (e.g. municipal by-laws) for water quality and health;
    - infrastructure
    - operation and maintenance
    - monitoring and evaluation.
- A regulatory framework for the different categories of use of rainwater, such as:
    - drinking water, i.e. for potable use (humans and livestock);
    - irrigation and gardening;
    - commercial use; and
    - industry.
- Institutions, cooperatives, NGOs, CBOs and water user associations at local and catchment levels are involved in the totality of water allocation in different areas.
- Guidelines for domestic RWH systems to assist installation of RWH systems according to regulations.
- A monitoring and reporting system (similar to the BlueDrop) for RWH (could be called the RainDrop).

4.2.1.3 Objective 3: Appropriate and effective funding and funding streams

To optimise and make available the necessary funding, funding streams and funding processes for implementation of RWH in general, and specifically for domestic use.

Outputs/Deliverables:

- An approach to implementing incentives for RWH initiatives to make it the best/optimal way of succeeding.
- Research results on possible incentives for RWH, such as:
    - rebates;
    - bulk purchasing;
    - subsidies;
    - discounts.
- List of possible sources for funding for RWH:
    - donors;
    - subsidies;
    - government grants;
    - research grants.
- Research results on possible partnerships with private companies and developers as part of their social responsibility initiatives.
- Research results on the use of the Equitable Share of each municipality for the operation and maintenance of RWH systems.
- Funding mechanisms for research in RWH, especially to address the gaps in research.

4.2.2 Knowledge/information management and advocacy

The establishment of knowledge and information management systems to advocate RWH to all citizens of South Africa.

4.2.2.1 Objective: Knowledge resource centres

To establish and manage knowledge, information and resource centres for the dissemination of best practices and lessons learnt in order to improve the RWH knowledge levels of all citizens in South Africa.

Outputs/Deliverables:

- Resource centre/information platform for RWH that becomes a body of knowledge on RWH in South Africa.
- Knowledge management strategy for RWH.
- Advocacy campaign for RWH for domestic use.
- User-friendly research outputs for different target groups (decision makers to community members).
- Guidelines and tools for best practices in RWH, specifically for domestic use.
- Mechanisms to promote RWH in policies and legislation.

- Consumer awareness raising, training and knowledge dissemination events.
- Gateways for learning about RWH in rural communities – TV, radio, cell phone, social media (Facebook, Twitter groups).
- Disseminated knowledge of what has worked/not worked, especially regarding water quality, infrastructure, O&M and monitoring.
- Published and disseminated research data, results and findings of past and existing projects in terms of infrastructure quality, type of materials used, case studies.
- A RWH association with accurate figures to support the motivation for funding for RWH projects.

4.2.3 Rainwater harvesting systems design, operation and maintenance

The setting of regulations, norms and standards for RWH systems design, operation, maintenance and asset management.

4.2.3.1 Objective 1: Norms and standards

To ensure that infrastructure for RWH is designed and developed to comply with policy requirements, legislation, norms and standards of the country in order to accomplish sustainability and effectiveness in water services delivery through RWH.

Outputs/Deliverables:

- Norms and standards for RWH infrastructure, which are compulsory in building regulations and to be enforced in new developments by local municipalities.
- Formulated SABS standards for the development and production of RWH tanks, as well as for the entire process (storage, installation, construction, water treatment, maintenance, etc.) of RWH.
- SABS standards reflected in building regulations and supported by municipalities.
- Clear objectives for the installation of RWH systems, for example, installing RWH systems in appropriate areas where it will be of use.
- Clear standards and guidelines for new housing developments in terms of by-laws, building plans, impact assessments and quality monitoring?
- Optimise the RWH system – focus on other factors over and above the quantity (size of the tank), i.e. the whole system:
    - End use of water.
    - Quality standard for water.
    - The technology to be used to reach the quality.
    - The ideal roof type, size rainfall pattern and the size of the tank.
- Alternative ways of channelling water from a household tank into a centralised dam for treatment and distribution back to the users.

4.2.3.2 Objective 2: Guidelines

To provide clear instructions and guidance on operation and maintenance matters of RWH systems for domestic use.

Outputs/Deliverables:

- Results from studies on who should be responsible for the O&M of RWH systems in case of poor households.
- Data and figures on the financial sustainability of the RWH systems at local levels.
- Data and research results on RWH at household level
- Data and research results on RWH at commercial, corporation, industry, private company levels with the main aim of concentrating on the city as whole rather than individual households.
- Research results on the use of rainwater for purposes that do not warrant good quality water, such as firefighting and cleaning the city.
- Research results on linking RWH with sustainable sanitation, i.e. promoting the use of rainwater for non-consumption purposes such as waterborne sanitation.

4.2.4 Water quality aspects of harvested rainwater

The requirements, regulations, standards and monitoring of water quality in RWH systems to ensure sustainability and appropriateness.

4.2.4.1 Objective: Water quality

To provide clarification and possible solutions for water quality concerns in RWH, especially regarding domestic use.

Outputs/Deliverables:

- Empirical data to show whether harvested rainwater is safe for drinking.
- Sources of contamination, such as impact of mining, agricultural activities, industrial activities, waste management treatment, traffic, urbanisation, wildlife and the type of roof material.
- The effects of pollution from roof tops into RWH systems from:
    - wind carrying pollutants and contaminants;
    - birds, animals and insects on the roof;
    - dust, debris, paint and rust;
    - chemical contaminants (from mining, heavy metal fall out, pesticide, nitrates, sulphates, etc.);
    - environmental contaminants (acid rain, air quality, ocean); and
    - microbial contaminants (E-coli, protozoa, viruses, water borne pathogens).
- Figures and data on vector contaminants: mosquitos, SANS 241, algae, etc.
- Research results on the pathway of pollution and contamination in a RWH tank.

- Data on the effects of roof top material in use, (fibre glass, galvanised sheets, cement, tiles, thatch, corrugated iron, painted roof, asbestos, waterproof material, aluminium gutters, etc.,) on optimal RWH potential and least pollutants.
- The impact of the geographic area (rainfall pattern, moisture – intermittent vs seasonal, temperature changes, wind speed and direction, vegetation – desert vs rain/fog, over hanging trees, etc.) on RWH.
- Data and information on effective filtration devices, such as nano membranes, meshes, etc., for the prevention of debris (leaves/insects) and pollutants entering the rainwater tanks.
- Figures and data on materials for storage tanks (plastic, cement, sealant & corrugated iron, pre-filter, flushing system to remove debris, etc.), specifically regarding active/passive contamination of the water.
- Optimal rainwater collection point positioning and system maintenance in terms of control and treatment (filtration, UV light, boiling, chemical filtration (Jik or chlorine), reverse osmosis).
- Comparison between methods for the detection of microbes (standard microbiological methods, molecular methods, standard lab testing, API testing, rapid testing, etc.) for different situations and contexts.
- Data and figures in catchment/storage management in terms of the use and limits/duration period for water stored in the tank.
- Standards on how RWH installation should be done to minimise the need for water treatment/purification.
- Research results on the efficacy of water safety nets for RWH systems in South Africa.
- Water quality monitoring processes and procedures in terms of responsibilities and functions between institutions and households.
- Research results on the influence of health and hygiene within the household on sustained water quality from RWH in terms of contamination points (collection, transport, storage, use).
- Training and awareness campaigns in the communities on issues around water quality in RWH systems.
- Studies on the sustainability of RWH in areas with drought, areas of infrastructure related challenges or emergency water provision and financial constraints in terms of distributing water into household tanks.

4.2.5 Social perceptions, attitudes and practices towards RWH

The understanding of social perceptions, attitudes and practices of users of RWH systems and rainwater in order to support policy, implementation processes and achieving sustainable drinking water supply.

4.2.5.1 Objective: Social sustainability of RWH

To ensure that RWH is acceptable, affordable and sustainable for all citizens of South Africa.

Outputs/Deliverables:

- Research results on the beliefs/assumptions of RWH that are currently commonplace (e.g. RWH conserves water and is economical), especially in terms of implementing RWH for domestic use.
- Research results on the acceptance of RWH systems by the beneficiaries/consumers in both rural and urban contexts.
- Research results on the impact of social/user/community aspects in terms of participatory needs assessments, demand responsiveness, perceptions and beliefs on RWH systems.
- Measures and tools to instil an understanding of the RWH concept in communities with limited literacy levels.
- Case studies on the effect of history and indigenous knowledge of communities on RWH in project areas.

4.2.6 Monitoring and evaluation of RWH systems

The monitoring and evaluation of RWH as a mechanism for water demand management, water services delivery, user satisfaction, improved health and economic growth.

4.2.6.1 Objective: Monitoring and evaluation

To ensure the monitoring and evaluation in RWH initiatives in order to measure water demand management.

Outputs/Deliverables:

- Guidelines on monitoring, risk assessment and evaluation of RWH in the country.
- Research results of the lack of monitoring and evaluation in RWH, e.g. installation of multiple tanks per household, thus wasteful expenditure.
- Results of monitoring and evaluation of the quality and the quantity of a RWH system.
- Study results on what approach (regulation or monitoring) to take in terms of regulating the quality of a RWH system.

4.2.7 RWH for urban settings and industry

The potential of RWH in urban settings to augment municipal water supply, as well as the use of rainwater for industrial purposes.

4.2.7.1 Objective: Urban and industrial settings

To understand the benefits, complications and obstacles for RWH for domestic use in urban settings and for industry.

Outputs/Deliverables:

- Research results and data on the benefits of up-scaling RWH in a city in terms of reduction in storm water, therefore understanding the interconnection of RWH and storm water in urban settings.
- Research results on the difference in dynamics in an informal settlement context to suburban context.

- Research results on the viability of RWH in informal settlements.
- Data and research results on the viability of RWH for industries in terms of reliability of the source.

4.3 ROLES AND RESPONSIBILITIES

Different stakeholders have different parts to play in the development of the RWH sector. The DWA and the WRC will ascertain the roles, responsibilities and timeframes for the deliverables and outputs by all tiers of government, water boards, catchment management agencies, WSAs, WSPs, NGOs, private consultants, research institutions and the private sector. These roles and responsibilities will be set out in the Strategic Framework for Research in RWH.

4.4 IMMEDIATE RESEARCH NEEDS

The DWA, the WRC and the participants at the WRC/DWA workshop identified a number of research topics that need to be addressed as a matter of urgency in order to respond to the pressing need for sustainable water services delivery. These topics are listed below.

- Overview of RWH research utilisation and impact (status quo):
    - Mapping of existing, planned and on-going research in South Africa and Africa – a desk review of published/grey literature.
    - Most effective practices in disseminating research findings to maximise their use.
    - Most effective mechanisms to ensure that the right people access the information.

- Policy support and political buy-in:
    - Policy and legislation alignment at national and local levels made public through a policy statement regarding RWH from the DWA.
    - Regulations for RWH at household level for domestic use in rural and urban settings.
    - Norms and standards for RWH for domestic use.

- Guidelines specific to RWH for domestic use:
    - Decision-making processes and criteria.
    - Infrastructure implementation, norms and standards.
    - Water quality for domestic use of harvested rainwater.
    - Operation and maintenance.
    - Monitoring and evaluation of RWH infrastructure.
    - Monitoring and evaluation of RWH as a programme for water services delivery.

- Financial support and mechanisms:
    - Subsidy streams and processes.
    - Grant allocations and incentives.
    - Ring-fenced funding for research and piloting.

5. CONCLUSION AND WAY FORWARD

This framework for research in rainwater harvesting for domestic use should be continually updated in order to commission research to address the research gaps in the field of rainwater harvesting for domestic use.

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