The Kingdom of Lesotho

TECHNOLOGY NEEDS ASSESSMENT REPORT FOR CLIMATE CHANGE ADAPTATION

Barrier Analysis and Enabling Framework Report

[May 2024]

AGRICULTURE and WATER SECTORS

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List of Acronyms and Abbreviations

ASR	Aquifer storage and recovery
BCR	Benefit-cost ratio
BOS	Bureau of Statistics
CA	Conservation Agriculture
CBEWS	Community based early warning systems
CBOs	Community-Based Organizations
CSA	Climate-smart agricultural
CSR	Corporate social responsibility
DCEWS	Decentralized community run early warning systems
DRWS	Department of Rural Water Supply
DSTI	Department of Science, Technology and Innovation
DWA	Department of Water Affairs
EIA	Environmental Impact Assessment
FFS	Farmer Field Schools
GDP	Gross Domestic Product
GEF	Global Environment Facility
GIS	Geographic Information System
GPS	Global Positioning System
ICTs	Information and communication technologies
IPM	Integrated Pest Management
IRR	Internal rate of return
IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management
LCCI	Lesotho Chamber of Commerce and Industry
LMS	Lesotho Meteorological Services
LoCAL	Local Climate Adaptive Living Mechanism
MAFS	Ministry of Agriculture and Food Security
MCA	Multi-criteria Analysis
MCLs	Maximum Contaminant Levels
MFIs	Microfinance Institutions
MOLGCHP	Ministry of Local Government, Chieftainship, Home Affairs and Police
MoPWT	Ministry of Public Works and Transport
MOUs	Memoranda of Understanding
NCCC	National Climate Change Committee
NDC	Nationally Determined Contribution
NGOs	Non-governmental organizations
NPV	Net present value
NUL	National university of Lesotho
PPPs	Public-Private Partnerships
QMRA	Quantitative microbial risk assessment
ROI	Returns on investment
SMS	Short message services
SOPs	Standard operating procedures
STEM	Science, technology, engineering, and mathematics
TED	Technologies for Economic Development
TNA	Technology Needs Assessment
ToT	Training of Trainers

UNCDF	United Nations Capital Development Fund
UNEP	United Nations Environment Programme
WASCO	Water and Sewage Company
WHO	World Health Organization
WLE	Water, Land and Ecosystems
WRS	Warehouse receipt systems
WUAs	Water User Associations

Foreword

Climate variability and change present challenges in the attainment of Lesotho's sustainable development goals. Over the past decades, the country has experienced an increase in the frequency and intensity of climate-change induced hazards such as droughts, floods, heavy snowfall, and extreme temperatures. These challenges have an impact on the well-being, and sustainable livelihoods of the population, leading to higher levels of poverty and increased strain on social services. To address these threats, a National Climate Change Policy 2017 – 2027 (NCCP) was developed to guide integration of climate change into development planning and implementation at all levels. A climate change implementation strategy was also formulated to enhance coordination and harmonization of climate change issues in the country.

Lesotho's contribution to the global greenhouse gas (GHG) emissions is insignificant. However, it is one of the countries that are severely affected by climate change. The country has an obligation to adopt policies and measures to reduce its GHG emissions and enhance its resilience to the adverse impacts of climate change. This obligation is in conformity with the development priorities outlined in the second National Strategic Development Plan (NSDP II) for 2023-2028, and the Nationally Determined Contribution (NDC) commitments under the 2015 Paris Agreement.

In developing its national priorities, Lesotho has also taken into consideration its international obligations which are ingrained in the 2030 Agenda for Sustainable Development. The alignment with international obligations is supported by NSDP II which embraces the interconnectedness of the Sustainable Development Goals (SDGs). The NSDP II has also considered the economic, social and environmental dimensions of sustainable development.

To this end, climate action is crucial in the achievement of Lesotho's national development goals. However, slow mobilization of technology, inadequate knowledge transfer and financial constraints hinder progress in addressing key drivers of climate change vulnerability. The Barrier Analysis and Enabling Framework (BAEF) report for Lesotho has been formulated in accordance with international standards and methodologies, multi-stakeholder participation and feedback. The BAEF report will support the country's initiatives in adapting to the impacts of climate variability and change and building the country's resilience through diffusion and adoption of climate technologies.

Executive Summary

In the first part of the TNA process technologies were prioritized for the key sectors for climate change adaptation (Agriculture and Water). The process of technology prioritization involved review of literature including national documents and consultation with stakeholders and experts to ensure that technologies selected were aligned with national development priorities and potentially effective in enabling adaptation to projected vulnerabilities resulting from climate change. In this second part of the TNA process each of these technologies has been analysed further through literature review, consultation with stakeholders and experts to outline the targets for the technology in the national development process, the critical barriers to the transfer and diffusion of the prioritized technologies, and the potential measures to address these barriers. In each sector, the enabling framework for the transfer and diffusion of the technologies was also assessed. In this report, the findings from this analysis are presented.

Agriculture sector

The technologies prioritized for the agriculture sector are as follows: decentralized community run early warning systems (DCEWS), rain water harvesting and conservation agriculture. These technologies are described in detail in the fact sheets in part one of the report and are abridged in this report.

Decentralized Community Run Early Warning Systems

For the Lesotho context, a decentralized community run early warning system (DCEWS) is “the provision of precise and effective information through identified institutions that allows the farming community, development agents and government officials to prepare for effective response to slow onset disasters including drought to avoid or reduce risks” (UNEP, 2012). Due to the large economic loss and the magnitude, of these disasters the primary focus of DCEWS is mitigating disaster risk from drought which is a slow onset hazard. However, rapid onset hazards such as flood, storms and others are also considered in the technology.

The target is to establish decentralized community based early warning systems (CBEWS) in every district by 2030 starting with CBEWS in six pilot areas supported by upgraded and modernized climate monitoring and forecasting systems. Precise seasonal predictions and proper preparation for various climate hazards including droughts, floods and hailstorms would reduce crop failure by

80% during droughts, reduce livestock mortality and morbidity by 100% during droughts and heavy snow and cold fronts during the winter. This technology belongs to the non-market goods and targets smallholder crop and livestock farmers in rural areas of Lesotho including emerging commercial blocking farmers, fruit producers including semi-commercial to commercial dairy, wool and mohair farmers and poultry farmers throughout Lesotho.

Rainwater Harvesting

Rainwater harvesting is a method for inducing, collecting, storing and conserving local surface runoff for agriculture in arid and semi-arid regions and employs both small and large-scale structures are used for rainwater harvesting collection and storage including water pans, tanks, reservoirs and dams. The catchment area is the area where the rainfall or water runoff is initially captured and is in most cases either the roof-top of a house or building, ground surface or rock surface.

According to the water supply and sanitation targets, by the year 2030, the idea is to avail sanitation to more than 80% of the rural population and adequate and sustainable supply of potable water and sanitation services to all the population of Lesotho. To reach these targets in the advent of climate change and projected droughts, every community in Lesotho should have at least one ground water harvesting infrastructure. These must be augmented by roof water harvesting structures at every household with a corrugated iron sheet roofing. However, research and innovation must develop system for water harvesting from grass thatched building.

Conservation Agriculture

Conservation Agriculture (CA) practice ideally prescribes adoption of three main principles: minimum soil disturbance, maximum soil cover, crop rotation and/or intercropping. However, considering the serious constraints to retaining soil cover in Lesotho, the term CA is used to describe a system entailing the practice of some form of minimum tillage (which in Lesotho is usually the first step to CA) on at least some part of the farm. The rationale for CA in Lesotho is threefold: to stop (and reverse) soil erosion land degradation, to improve soil quality, to improve food security through higher agricultural yields employing minimum input costs.

The long-term target of conservation agriculture is to transform the tillage system from one dominated almost 99 percent by conventional practices to at least 50 percent CA practices in Lesotho by 2045. However, in the short term, by 2030, the target leverages the drought tolerant tillage systems to achieve resilient and diversified agricultural sector with improved and sustainable capacity to respond to climate variability and land degradation (Resilience). The Conservation Agriculture systems will be leveraged to scaling-up climate smart agriculture practices and actions to promote adaptation. and increased food security achieving zero hunger by 2050.

The following tables summarize the barriers and measures to the transfer and diffusion of the technologies in the two sectors.

Table 1 Barriers and measures for Decentralised Community Run Early Warning System

Decentralized Community Run Early Warning System		
Barrier Category	**Barrier**	**Measures**
Financial	**High costs of procurement, installation, and on-going maintenance costs**	➢ **Dedicated funding:** Allocate specific and reliable budgets for the establishment, maintenance, and upgrading of climate change monitoring and early warning systems. This ensures a consistent financial commitment. ➢ **Public-Private Partnerships (PPPs):** Foster collaboration between governments, academia and private sector entities to share costs, leverage expertise, and enhance financial resources for implementing and sustaining these systems. ➢ **International Aid and Grants:** Lesotho must hone its capacity to leverage and seek international assistance through grants and aid from developed nations, climate funds and global organizations for support to acquire and maintain climate monitoring technologies
	Data management costs	➢ **Data Prioritization:** Prioritize essential data collection and storage to minimize costs. Focus on capturing key parameters relevant to early warning objectives while avoiding unnecessary data collection that may inflate storage and processing expenses. ➢ **Open-Source Technologies**: Utilize open-source software solutions for data management to reduce licensing fees and dependence on proprietary platforms. Open-source options often offer robust functionality and community support without the associated costs. ➢ **Cloud Services and Infrastructure:** Leverage cloud computing services to store, process, and analyze data. Cloud platforms offer scalable and cost-effective solutions, allowing communities to pay only for the resources they use, without the need for significant upfront investment in hardware infrastructure. ➢ **Data Sharing and Collaboration:** Foster data sharing and collaboration among multiple stakeholders, including government agencies, NGOs, research institutions, academia and other communities. Sharing resources and expertise can help distribute data management costs and improve the effectiveness of early warning systems.

Decentralized Community Run Early Warning System		
Barrier Category	**Barrier**	**Measures**
	Training capacity building	➢ **Community Workshops and Training Sessions:** Organize regular workshops and training sessions within the community to educate residents on the importance of early warning systems, their components, and how to use them effectively. These sessions can cover topics such as system operation, maintenance, data interpretation, and emergency response procedures. ➢ **Train-the-Trainer Programs:** Implement train-the-trainer programs to build a cadre of local leaders and experts who can then train others within the community. This cascading model maximizes the reach and sustainability of training initiatives while empowering community members to take ownership of the process ➢ **Partnerships with Educational Institutions:** Collaborate with local schools, colleges, and universities to integrate early warning system training into formal education curricula. This not only enhances the knowledge and skills of students but also promotes long-term sustainability by embedding awareness from an early age.
Non-Financial	**Technical Challenges**	➢ **Technical Training and Capacity Building:** Provide technical training and capacity building programs for community members, local authorities, and relevant stakeholders on the operation, maintenance, and troubleshooting of early warning system components. This includes training on sensor installation, data analysis, communication protocols, and emergency response procedures.
		➢ **Technical Assistance and Mentoring:** Provide ongoing technical assistance, mentoring, and coaching to community members and local authorities responsible for operating and maintaining early warning systems. Expert guidance and support can help troubleshoot technical issues, address challenges, and enhance system performance.
		➢ **Partnerships with Technical Institutions:** Forge partnerships with technical institutions, universities, research centres, and professional associations to access specialized expertise, resources, and training facilities for decentralized community early warning systems. Collaborative initiatives can enrich training programs and provide access to state-of-the-art technologies and methodologies.

Table 2 Barriers and measures for Conservation Agriculture technology

Conservation Agriculture		
Barrier Category	**Barrier**	**Measures**
Financial	**High Initial Costs**	➢ Government Subsidies: Provide targeted subsidies for the adoption of conservation agriculture practices, reducing the financial burden on farmers and incentivizing investment in new technologies. ➢ Low-Interest Loans: Establish accessible and low-interest loan programs to support farmers in financing the adoption of CA technology, facilitating affordability and reducing financial barriers.
	Operation costs	➢ **Conservation Tillage Practices:** Adopt conservation tillage practices, such as no-till or reduced tillage, to minimize soil disturbance, erosion, and fuel consumption associated with conventional ploughing. Preserve soil moisture, structure, and fertility while reducing labour, machinery, and fuel costs over time. ➢ **Cover Crops and Crop Rotation:** Integrate cover crops and crop rotation into the farming system to improve soil health, suppress weeds, and reduce the need for synthetic inputs. Select cover crops that provide multiple benefits, such as nitrogen fixation, erosion control, and pest management, while minimizing operational costs. ➢ **Integrated Pest Management (IPM):** Implement integrated pest management (IPM) strategies to control pests, diseases, and weeds using a combination of biological, cultural, and chemical control methods. Reduce reliance on synthetic pesticides and herbicides by promoting natural predators, crop diversification, and sanitation practices.
Non-Financial	**Knowledge Awareness**	➢ **Education and Extension Services:** Develop comprehensive educational programs and extension services to increase awareness and understanding of conservation agriculture practices among farmers. ➢ **Demonstration Farms:** Establish demonstration farms where farmers can observe successful implementation of conservation agriculture, providing tangible examples and building confidence in the effectiveness of these practices. ➢ **Partnerships with NGOs:** Collaborate with NGOs, CBOs and academia to provide on-the-ground support, knowledge transfer, and assistance in implementing conservation agriculture. ➢ **Extension Services:** Strengthen extension services to provide ongoing support and guidance to farmers adopting conservation agriculture by ensuring that they have the necessary knowledge and resources for successful implementation.; helping them establish platforms for sharing experiences and networking.
	Technology literacy	➢ **Extension Services:** Strengthen extension services and advisory systems to deliver tailored information and technical support to farmers on adopting and utilizing agricultural technologies in conservation agriculture. Train extension agents, agronomists, and community facilitators to provide on-site assistance, troubleshooting, and guidance on technology adoption. ➢ **Technology Demonstrations:** Organise technology demonstrations, field days, and farmer field schools that showcase the performance and benefits of agricultural technologies in conservation agriculture. Allow farmers to observe, interact with, and evaluate different technologies in action to better understand their potential and applicability

Conservation Agriculture		
Barrier Category	**Barrier**	**Measures**
	Perceived Risk	➢ **Risk Assessment and Management:** Conduct comprehensive risk assessments to identify and prioritize potential risks and uncertainties associated with conservation agriculture, such as weather variability, market fluctuations, pest outbreaks, and agronomic challenges. Develop risk management plans and strategies to mitigate, transfer, or absorb risks through diversification, insurance, and contingency planning. ➢ **Technical Assistance and Support:** Provide farmers with technical assistance, agronomic support, and advisory services to address technical challenges and agronomic uncertainties related to conservation agriculture practices. Offer training, mentoring, and on-farm demonstrations to build farmers' capacity and confidence in implementing sustainable farming techniques. ➢ **Trial and Demonstration Plots:** Establish trial plots, demonstration farms, or adaptive management sites where farmers can experiment with new conservation agriculture practices, test different crop varieties, and observe firsthand the performance and benefits of sustainable farming methods. Encourage participatory learning, adaptive management, and farmer-led experimentation to reduce perceived risks and uncertainties.
	Policy and Regulatory Framework	➢ **Policy Advocacy:** Engage in policy advocacy efforts to raise awareness, build consensus, and mobilize support for conservation agriculture among policymakers, legislators, government agencies, and relevant stakeholders. Advocate for the inclusion of conservation agriculture objectives, principles, and practices in national agricultural policies, strategies, and action plans. ➢ **Capacity Building for Policymakers:** Provide capacity building and training programs for policymakers, government officials, and regulatory authorities to enhance their understanding of conservation agriculture concepts, principles, and best practices. Organize workshops, seminars, and training sessions on sustainable land management, agroecology, and climate-smart agriculture to build technical expertise and policy literacy. ➢ **Policy Integration and Mainstreaming:** Integrate conservation agriculture considerations into sectoral policies, plans, and programs across relevant policy domains, such as agriculture, environment, natural resource management, rural development, and climate change adaptation. Mainstream sustainable farming practices into broader policy agendas to ensure coherence, alignment, and synergies across different policy areas.

Table 3 Enabling framework for overcoming barriers in the agriculture sector

The following are key components of an enabling framework for overcoming barriers in the agricultural sector.		
Barrier	**Enabling Framework**	**Responsible Entity**
Policy and Regulatory Support	Developing and implementing supportive policies, strategies, and regulatory frameworks that prioritize climate change adaptation in agriculture.	Ministry of Agriculture and Food Security
	The requisite framework must integrate adaptation considerations into national agricultural policies, plans, and programs, ensuring coherence with broader climate adaptation and sustainable development agendas.	
	In addition, the framework shall establish clear regulatory guidelines, standards, and incentives to promote the adoption of climate-resilient agricultural practices and technologies.	
Stakeholder Engagement and Participation	Fostering multi-stakeholder engagement and collaboration across government agencies, agricultural extension services, research institutions, farmers' organizations, civil society groups, and private sector entities.	Integrated Catchment Management
	Involve stakeholders in the planning, decision-making, and implementation of agricultural adaptation initiatives, ensuring their perspectives, needs, and knowledge are incorporated into adaptation strategies	Ministry of Agriculture and Food Security
Capacity Building and Knowledge Sharing	Enhance technical capacity, skills, and knowledge among agricultural practitioners, policymakers, and extension workers through training, capacity-building programs, and knowledge-sharing platforms.	
	Promote research, innovation, and learning in climate-resilient agricultural practices, technologies, and adaptation strategies, facilitating the exchange of best practices and lessons learned	Department of Agricultural Research, Academia
Investment and Financing Mechanisms	Mobilize financial resources, investments, and funding mechanisms to support climate-resilient agriculture, including investments in agricultural infrastructure, research and development, extension services, and farmer support programs	Ministry of Agriculture and Food Security (MAFS)
	Develop innovative financing models, public-private partnerships, and risk-sharing mechanisms to attract private sector investment and leverage public funds for agricultural adaptation	Ministry of Finance and Development Planning
Technology Transfer and Innovation	Facilitate technology transfer, diffusion, and adaptation of climate-resilient agricultural technologies, tools, and practices suitable for local contexts and conditions.	Department of Agricultural Research, Academia
	Promote research and development in climate-smart agriculture, including drought-tolerant crops, climate-resilient livestock breeds, precision agriculture technologies, and sustainable soil and water management practices	
Risk Assessment and Management	Conduct comprehensive risk assessments to identify climate-related hazards, vulnerabilities, and impacts on agricultural systems, livelihoods, and food security.	Disaster Management Authority and Lesotho Meteorological Services
	Develop risk management strategies, early warning systems, and contingency plans to enhance resilience to climate risks and ensure adaptive capacity in the face of uncertainty	

The following are key components of an enabling framework for overcoming barriers in the agricultural sector.		
Barrier	**Enabling Framework**	**Responsible Entity**
Ecosystem-based Approaches	Promote ecosystem-based approaches to agricultural adaptation that integrate nature-based solutions, agroforestry, conservation agriculture, and biodiversity conservation into farming systems	Ministry of Agriculture and Academia
	Protect and restore natural ecosystems, such as forests, wetlands, and watersheds, to enhance agricultural resilience, soil fertility, water availability, and ecosystem services	MAFS
Market Access and Value Chains	Strengthen agricultural value chains, market access, and rural livelihoods by supporting climate-resilient farming practices, diversification of crops and income sources, and access to markets, credit, and insurance services.	
	Promote inclusive business models, farmer cooperatives, and agribusiness partnerships that enhance the economic viability and resilience of smallholder agriculture in the face of climate change.	
Monitoring, Evaluation, and Learning	Establish monitoring and evaluation frameworks to track progress, measure performance, and assess the effectiveness of agricultural adaptation interventions.	MAFS and Academia
	Foster a culture of learning, innovation, and continuous improvement through knowledge exchange, participatory research, and farmer-to-farmer learning networks.	
Cross-sectoral Coordination	Promote cross-sectoral coordination and integration of agricultural adaptation with other sectors, such as water management, land use planning, disaster risk reduction, and social protection, to address interconnected challenges and maximize co-benefits.	MAFS
	Foster collaboration between agriculture-related sectors and stakeholders to promote integrated land and water resources management, climate resilience, and sustainable rural development.	

Water sector

The technologies prioritized for the water sector are as follows: water reuse, rainwater collection from ground water surfaces and boreholes as a drought intervention for domestic water supply. These technologies are described in detail in fact sheets in part one of the report and are abridged in this report.

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Preliminary targets for technology transfer and diffusion

Water reclamation, treatment and reuse technology

Recent estimates of the total volume of wastewater generated by the domestic, municipal, and industrial sectors in Lesotho is 7.2 million cubic meters. Wastewater in Lesotho is mainly produced from pollution caused by anthropogenic waste products, namely urine and faeces which are carried away by water to form sewerage from domestic and municipal sector as well as the effluent from the industrial sector. In Lesotho, primary treatment type is the dominant wastewater treatment. Water and Sewage Company (WASCO) is the only institution involved in wastewater collection, conveyance, and treatment in the country. After being treated to required standards wastewater is normally disposed into the Mohokare (Caledon) River System.

The target is to reclaim, treat and reuse a minimum of 20 percent of treated wastewater (Effluent) for industrial use and agriculture.

Rainwater Collection from Surface Water

Rainwater collection from surface water is a method for inducing, collecting, storing and conserving local surface runoff for agriculture in arid and semi-arid regions and employs both small and large-scale structures are used for rainwater harvesting collection and storage including water pans, tanks, reservoirs and dams. The catchment area is the area where the rainfall or water runoff is initially captured and is in most cases either the roof-top of a house or building, ground surface or rock surface.

The target is to supply water and sanitation services to at least 50 percent of the population of rural and drought-stricken areas using rain water collected from surface waters.

Boreholes as a drought intervention for domestic water supply

Boreholes play a crucial role as a drought intervention for domestic water supply, particularly in regions prone to water scarcity. During droughts, surface water sources may become unreliable, making it necessary to tap into groundwater reservoirs through boreholes. As a drought intervention for domestic water supply, boreholes can take three major strategies: drilling new boreholes /deepening existing ones; repairing damage boreholes; and /or constructing relief boreholes with restricted used for drought periods only.

The long-term target is to drill three monitoring boreholes in each of the three main hydrometric catchments of Lesotho especially targeting drought areas. The entry point is to rehabilitate or revive 100 percent of the existing community boreholes and increasing them 10-fold by drilling new ones in the drought prone southern lowlands and Senqu river valley. Tables 4 to 6 show the barriers and measures to the transfer and diffusion of technologies.

Table 4 Barriers and measures for water reclamation, treatment and reuse

Water reclamation, treatment and reuse		
Barrier Category	**Barrier**	**Measures**
Financial	**Operational and maintenance costs**	➢ **Government Subsidies and Grants:** Providing financial support through subsidies or grants can help offset the initial capital costs of implementing water reuse technologies, encouraging widespread adoption. ➢ **Tax Incentives**: Offering tax credits or deductions for investments in water reuse infrastructure can stimulate private sector participation and attract capital to fund projects. ➢ **User Fees and Tariffs:** Implementing fair and transparent user fees or tariffs for water services, including water reuse, ensures that the costs are appropriately distributed among users, supporting project sustainability. ➢ **Performance-Based Contracts:** Introducing performance-based contracts can align the financial interests of service providers with the efficiency and effectiveness of water reuse technologies, promoting accountability.

Water reclamation, treatment and reuse		
Barrier Category	**Barrier**	**Measures**
	Lack of financial incentives	➢ **Economic Valuation of Water Resources:** Conduct economic valuation studies to quantify the economic benefits and cost savings associated with water reuse, including reduced water supply costs, avoided wastewater treatment expenses, and enhanced water security. Highlight the financial value of water reuse in terms of resource conservation, risk mitigation, and economic productivity to attract investment. ➢ **Cost-Benefit Analysis:** Perform cost-benefit analyses to assess the financial viability and return on investment of water reuse projects compared to conventional water supply and wastewater treatment options. Evaluate the economic feasibility, net present value, and internal rate of return of water reuse initiatives to demonstrate their financial attractiveness to investors and decision-makers. ➢ **Regulatory Reform:** Advocate for regulatory reform and policy incentives that promote water reuse, streamline permitting processes, and remove regulatory barriers to investment. Lobby policymakers to enact legislation, regulations, and standards that facilitate the development, financing, and operation of water reuse infrastructure and projects.
	Lack of standardized economic valuation	➢ **Development of Economic Valuation Guidelines:** Establish comprehensive guidelines, frameworks, or protocols for conducting economic valuation studies of water reuse projects, including cost-benefit analysis, cost-effectiveness analysis, and financial feasibility assessments. Develop standardized methodologies, data requirements, and reporting formats to ensure consistency, comparability, and transparency in economic valuation practices. ➢ **Lifecycle Cost Analysis:** Perform lifecycle cost analysis to estimate the total costs of water reuse projects over their operational lifespan, including capital expenditures, operating expenses, maintenance costs, and financing charges. Compare the lifecycle costs of water reuse options with conventional water supply and wastewater treatment alternatives to assess their economic viability and long-term affordability. ➢ **Standardization of Economic Metrics:** Standardize economic metrics, performance indicators, and financial benchmarks for water reuse projects to facilitate cross-project comparisons, benchmarking exercises, and industry best practices. Define common economic indicators, such as levelized cost of water, water productivity, and economic value added, to assess the economic performance and competitiveness of water reuse options.

Water reclamation, treatment and reuse		
Barrier Category	**Barrier**	**Measures**
Non-Financial	**Public perception and acceptance**	➢ **Public Awareness Campaigns:** Implementing educational initiatives and awareness campaigns to inform the public about the safety and benefits of water reuse can address concerns and build acceptance. ➢ **Demonstration Projects:** Launching pilot or demonstration projects can showcase the effectiveness and safety of water reuse technologies, helping to build confidence and trust among stakeholders. ➢ **Community Engagement and Consultation:** Actively involving local communities in the decision-making process, seeking their input, and addressing their concerns can contribute to the successful implementation of water reuse initiatives.
	Water quality standards and regulation	➢ **Risk-Based Approach:** Adopt a risk-based approach to setting water quality standards and regulations for recycled water that assesses potential risks to human health, environmental quality, and public safety based on scientific evidence, risk assessments, and exposure pathways. Establish risk-based targets, guidelines, and performance criteria that prioritize protection of public health while allowing for beneficial reuse of recycled water. ➢ **Health-Based Standards:** Develop health-based water quality standards and guidelines for recycled water that establish maximum contaminant levels (MCLs) or action levels for priority pollutants, pathogens, and chemical constituents of concern based on their toxicological properties, exposure pathways, and health effects. Align water quality standards with established drinking water guidelines, public health benchmarks, and international best practices to ensure protection of human health. ➢ **Public Health Risk Assessment**: Conduct comprehensive public health risk assessments, exposure assessments, and hazard analyses to evaluate potential health risks associated with recycled water use, considering both acute and chronic exposure pathways, vulnerable populations, and sensitive receptors. Use epidemiological studies, quantitative microbial risk assessment (QMRA), and exposure modeling to quantify health risks, inform risk management decisions, and support regulatory decision-making.

Table 5 Barriers and measures for rainwater collection from ground surfaces

Rainwater collection from ground surfaces		
Barrier Category	**Barrier**	**Measures**
Financial	**Initial Infrastructure Costs**	➢ **Tax Incentives:** Offering tax credits or deductions for investments in rainwater harvesting infrastructure encourages private individuals and organizations to invest in these technologies. ➢ **Water Pricing Policies:** Implementing water pricing structures that reflect the true cost of water can create economic incentives for adopting rainwater collection technologies by highlighting potential cost savings. ➢ **Public-Private Partnerships (PPPs):** Encouraging collaboration between public and private entities through PPPs can attract private investment and expertise, supporting the implementation of rainwater collection projects. ➢ **Incentive Programs for Water Utilities:** Providing financial incentives for water utilities to integrate rainwater collection into their infrastructure can accelerate the adoption of these technologies in broader water management strategies
	Maintenance and Operation Expenses	➢ **Regular Inspection and Maintenance:** Establish a proactive maintenance schedule for rainwater collection systems, including regular inspection, cleaning, and servicing of components such as pumps, filters, pipes, and storage tanks. Conduct routine maintenance tasks, such as debris removal, sediment flushing, and equipment lubrication, to prevent clogs, blockages, and mechanical failures that can lead to costly repairs. ➢ **Preventive Maintenance Planning**: Develop a preventive maintenance plan that outlines scheduled maintenance tasks, frequency of inspections, and maintenance procedures for each component of the rainwater collection system. Prioritize preventive maintenance activities, such as lubrication, alignment checks, and corrosion protection, to prevent equipment deterioration and prolong asset life. ➢ **Vendor Partnerships and Service Contracts:** Establish partnerships with equipment suppliers, vendors, and service providers to access technical support, maintenance services, and spare parts for rainwater collection systems. Negotiate service contracts, maintenance agreements, or warranties that provide access to timely repairs, replacement parts, and technical assistance to minimize downtime and ensure system reliability.

Rainwater collection from ground surfaces		
Barrier Category	**Barrier**	**Measures**
Non-Financial	**Public Awareness and Perception**	➢ **Public Awareness Campaigns:** Implementing educational initiatives and awareness campaigns to inform the public about the benefits and safety of rainwater collection can promote acceptance and support. ➢ **Local Advocacy and Support Groups:** Forming local advocacy groups or support networks can create a sense of community around rainwater collection initiatives, fostering shared experiences and knowledge exchange. ➢ **Recognition Programs:** Implementing recognition programs or awards for individuals, businesses, or communities that successfully adopt rainwater collection can incentivize positive behaviour and set examples for others. ➢ **Partnerships with NGOs and Community Organizations:** Collaborating with NGOs and community-based organizations can provide additional resources, expertise, and support for the implementation of rainwater collection projects.
	Technical Complexity	➢ **Standardized Designs and Guidelines** ✓ Develop standardized designs, guidelines, and manuals for rainwater collection systems that provide clear, step-by-step instructions, specifications, and recommendations for system sizing, component selection, and installation procedures. ✓ Publish user-friendly resources, such as design manuals, technical guides, and online toolkits, that simplify the process of planning, designing, and implementing rainwater harvesting systems, making technical information more accessible and understandable to a wider audience. ➢ **Pre-Fabricated and Modular Systems** ✓ Promote the use of pre-fabricated, modular, and plug-and-play rainwater harvesting systems that come with standardized components, pre-assembled parts, and simple installation procedures, reducing the technical complexity and labour requirements associated with custom-built systems. ✓ Partner with manufacturers, suppliers, and vendors to develop and market pre-packaged rainwater harvesting kits, ready-to-install tanks, and modular components that simplify the installation process and make rainwater collection technology more user-friendly and accessible.

Table 6 Barriers and measures for Boreholes as Drought Intervention for Domestic Water Supply

Boreholes as Drought Intervention for Domestic Water Supply		
Barrier Category	**Barrier**	**Measures**
Financial	**High Initial Investment Costs**	➢ **Government Funding and Subsidies:** Providing financial support through government funding or subsidies can help offset the initial costs of borehole drilling, making it more financially viable for communities. ➢ **Public-Private Partnerships (PPPs):** Encouraging collaborations between public and private entities through PPPs can attract private investment and expertise, leveraging resources for borehole implementation. ➢ **Tax Incentives:** Offering tax incentives for individuals or businesses investing in boreholes encourages private sector participation and can reduce the overall financial burden.
	Operational and Maintenance Expenses	➢ **Preventive Maintenance Planning** ✓ Develop a preventive maintenance plan that outlines scheduled maintenance tasks, frequency of inspections, and maintenance procedures for each component of the rainwater collection system. ✓ Prioritize preventive maintenance activities, such as lubrication, alignment checks, and corrosion protection, to prevent equipment deterioration and prolong asset life. ➢ **Vendor Partnerships and Service Contracts** ✓ Establish partnerships with equipment suppliers, vendors, and service providers to access technical support, maintenance services, and spare parts for rainwater collection systems. ✓ Negotiate service contracts, maintenance agreements, or warranties that provide access to timely repairs, replacement parts, and technical assistance to minimize downtime and ensure system reliability.
Non-Financial	**Technical Challenges**	➢ **Hydrogeological Surveys:** Conduct detailed surveys to assess the feasibility of borehole installation, considering factors like groundwater availability, depth, and quality. ➢ **Proper Site Selection:** Choose optimal locations for borehole installation based on geological data and local hydrology to maximize water yield and minimize potential contamination risks. ➢ **Advanced Drilling Techniques:** Utilize advanced drilling technologies and techniques to penetrate different types of soil and rock formations efficiently. ➢ **Water Quality Testing:** Regularly test the water quality to ensure it meets safety standards for domestic use, addressing concerns about contamination and health risks.

Boreholes as Drought Intervention for Domestic Water Supply		
Barrier Category	**Barrier**	**Measures**
	Interference with existing water resources	➢ **Hydrogeological Studies and Impact Assessments** ✓ Conduct comprehensive hydrogeological studies and environmental impact assessments (EIAs) prior to borehole development to understand the hydrological dynamics, groundwater interactions, and potential impacts on existing water resources, including surface water bodies, streams, and aquifers. ✓ Evaluate the potential risks of borehole abstraction, such as groundwater drawdown, reduced streamflow, or ecological disturbance, on adjacent water resources and sensitive ecosystems, identifying mitigation measures to prevent or minimize adverse effects. ➢ **Buffer Zones and Setback Requirements** ✓ Establish buffer zones, setback distances, and protective measures around borehole sites to minimize interference with existing water resources, wetlands, riparian areas, and ecological habitats, ensuring that borehole development does not encroach upon sensitive hydrological features. ✓ Adhere to regulatory requirements, zoning regulations, and land use planning guidelines that specify minimum setback distances from water bodies, groundwater recharge areas, or protected natural areas to prevent contamination, habitat fragmentation, or hydraulic interference. ➢ **Water Resource Monitoring and Management** ✓ Implement water resource monitoring networks, stream gauges, and groundwater observation wells to track changes in water levels, flow patterns, and water quality parameters before, during, and after borehole development, providing early warning of potential impacts and informing adaptive management decisions. ✓ Establish groundwater management plans, flow monitoring programs, and adaptive management strategies that integrate borehole abstraction data with surface water hydrology to optimize water allocation, prevent over-extraction, and maintain ecological flows.

Boreholes as Drought Intervention for Domestic Water Supply		
Barrier Category	**Barrier**	**Measures**
	Technical Knowledge Transfer	➢ **Demonstration Sites and Field Visits** ✓ Establish demonstration sites or model borehole installations where community members and local technicians can observe best practices in borehole design, construction, and maintenance firsthand, gaining practical insights and hands-on experience. ✓ Organize field visits to existing borehole projects, water supply facilities, and technical installations within the region, allowing stakeholders to learn from successful examples, exchange knowledge, and benchmark performance against industry standards. ➢ **Technical Manuals and Guidelines** ✓ Develop technical manuals, operation guides, and instructional materials that provide step-by-step guidance on borehole drilling, pump installation, water quality testing, and troubleshooting procedures, serving as practical reference resources for borehole practitioners. ✓ Translate technical documents into local languages, adapt content to local contexts, and disseminate printed or digital copies to relevant stakeholders, ensuring accessibility and usability for diverse audiences with varying levels of technical expertise. ➢ **Partnerships with Technical Institutions** ✓ Collaborate with technical institutions, vocational training centres, and engineering schools to integrate borehole management and water supply curriculum into formal education programs, vocational training courses, and continuing professional development initiatives. ✓ Establish partnerships with universities, research institutions, and international organizations to facilitate knowledge sharing, research collaboration, and technology transfer in the field of groundwater development and management.

Table 7 Enabling framework for overcoming barriers in the water sector

Barrier	Enabling Framework	Responsible Entity
Policy and Regulatory Support	Develop and implement supportive policies, strategies, and regulatory frameworks that prioritize water sector adaptation to climate change and variability.	Water Commission
	Integrate adaptation considerations into national water policies, strategies, and plans, ensuring coherence with broader climate change adaptation and sustainable development agendas	
	Establish clear regulatory guidelines, standards, and incentives to promote the adoption of climate-resilient water management practices and technologies	
Stakeholder Engagement and Participation	Foster multi-stakeholder engagement and collaboration across government agencies, water utilities, civil society organizations, academia, private sector entities, and local communities	Integrated Catchment Management
	Involve stakeholders in the planning, decision-making, and implementation of water sector adaptation initiatives, ensuring their perspectives, needs, and knowledge are incorporated into adaptation strategies	Water Commission
Capacity Building and Knowledge Sharing	Enhance technical capacity, skills, and knowledge among water sector professionals, policymakers, and practitioners through training, capacity-building programs, and knowledge-sharing platforms.	Department of Water Affairs
	Promote research, innovation, and learning in climate-resilient water management practices, technologies, and adaptation strategies, facilitating the exchange of best practices and lessons learned.	Academia
Investment and Financing Mechanisms	Mobilize financial resources, investments, and funding mechanisms to support climate-resilient water infrastructure, projects, and initiatives.	Water Commission
	Develop innovative financing models, public-private partnerships, and risk-sharing mechanisms to attract private sector investment and leverage public funds for water sector adaptation.	Water Commission
Technology Transfer and Innovation	Facilitate technology transfer, diffusion, and adaptation of innovative water management technologies, tools, and practices suitable for local contexts and conditions.	Academia, DWA
	Promote research and development in climate-resilient water technologies, including drought-resistant irrigation systems, rainwater harvesting techniques, and water reuse technologies.	Academia
Risk Assessment and Management	Conduct comprehensive risk assessments to identify climate-related hazards, vulnerabilities, and impacts on water resources, infrastructure, and ecosystems	Academia, DWA
	Develop risk management strategies, early warning systems, and contingency plans to enhance resilience to climate risks and ensure adaptive capacity in the face of uncertainty.	LMS
Monitoring, Evaluation, and Learning	Establish monitoring and evaluation frameworks to track progress, measure performance, and assess the effectiveness of adaptation interventions in the water sector.	Water Commission

Barrier	Enabling Framework	Responsible Entity
	Foster a culture of learning, innovation, and continuous improvement through knowledge exchange, peer-to-peer learning, and participatory feedback mechanisms	Academia
Cross-sectoral Coordination	Promote cross-sectoral coordination and integration of water sector adaptation with other sectors, such as agriculture, energy, infrastructure, and urban planning, to address interconnected challenges and maximize co-benefits	Water Commission
	Foster collaboration between water-related sectors and stakeholders to promote integrated water resources management, climate resilience, and sustainable development.	Integrated Catchment Management, Water Commission

Chapter 1 Agriculture Sector

Climate-smart agricultural (CSA) development is imperative in the advent of climate change. In Lesotho, agriculture accounts for just six percent of Lesotho's Gross Domestic Product (GDP) but supports livelihoods of 80 percent of the country's population (World Bank, 2018). The cropping sub-sector is dominated by cereal (maize, sorghum, wheat) mono-cropping system with occasional rotation with legumes (field beans and peas). The livestock sub-sector, on the other hand, is dominated by large stock (dual purpose cattle) and small stock (goats and sheep for mohair and wool respectively). The state of agricultural land resource base is characterized by low soil fertility, high levels of land degradation and soil erosion; and high vulnerability to droughts which compounds already high import food price fluctuations and reliance to meet local food needs. CSA technologies and practices present opportunities for addressing climate change challenges.

However, the sector sustains livelihoods of 71% of Lesotho population residing in the rural areas and directly generates employment for 41% of this population, although primarily on an informal basis, with women making up the largest share of the labour force (World Bank, 2020). It is mostly dominated by subsistence agriculture, with few farmers producing at a commercial scale, yet the country holds potential to produce organic products for exports. Notwithstanding, the significance of the agricultural sector in terms of contribution to GDP, its annual trends in performance are erratic and reflect the effect of climatic variations on agricultural productivity (Nhemachena et al., 2017). The recent climate change projections for the agriculture sector indicate increase in temperature, changes in rainfall patterns and changes in wind and solar radiation patterns that will adversely affect crop productivity with a looming threat to the national food security gains.

One of the most important challenges to the growth of the sector is the slow rate of technological innovation due to limited adoption of progressive farming techniques. Hence, to cope with the severe impacts of climate change, the agriculture sector needs to adopt environmentally sound technologies to move towards a climate resilient development pathway. Keeping in view the above stated projected climate change impacts on the agriculture sector, the TNA project in its phase-I identified and prioritized the following three climate change adaptation technologies in the agriculture sector: a) Decentralized community-run early warning systems; b) Rainwater harvesting; and c) Conservation Agriculture.

These technologies are mainly prioritized as an adaptation measure to reduce the vulnerability of the population linked with or dependent on the agriculture sector to the impact of climate change. However, it is emphasized from the outset that all the above three technologies are available and used in the country at various levels, and the only issue is that these technologies are not being used and implemented widely and sustainably enough to bring sustainable benefits to the agriculture sector and within the context of climate change.

1.1 Preliminary targets for technology transfer and diffusion

The preliminary targets identified under the TNA project for the transfer and diffusion of the three technologies in agriculture sector are:

1.1.1 Decentralized community based early warning systems

The target is to establish decentralized community based early warning systems (DCEWS) in every district by 2030 starting with CBEWS in six pilot areas supported by up-graded and modernized climate monitoring and forecasting systems. Precise seasonal predictions and proper preparation for various climate hazards including droughts, floods and hail storms would reduce crop failure by 80% during droughts, reduce livestock mortality and morbidity by 100% during droughts and heavy snow and cold fronts during the winter. This technology belongs to the non-market goods and targets smallholder crop and livestock farmers in rural areas of Lesotho including emerging commercial blocking farmers, fruit producers including semi-commercial to commercial dairy, wool and mohair farmers and poultry farmers throughout Lesotho.

1.1.2 Rainwater harvesting

Rainwater harvesting is a method for inducing, collecting, storing and conserving local surface runoff for agriculture in arid and semi-arid regions (Boers and Ben-Asher, 1982). Both small and large-scale structures are used for rainwater harvesting collection and storage including water pans, tanks, reservoirs and dams. The catchment area is the area where the rainfall or water runoff is initially captured and is in most cases either the roof-top of a house or building, ground surface or rock surface. Rainwater harvesting technology is simple to install and operate and does not imply any specific institutional or organisational requirements. However, government and NGOs could play a key role in providing subsidies for equipment purchases by making the technology accessible to a larger number of farmers, particularly small-scale farmers, who may have problems raising capital investment funds.

According to the water supply and sanitation targets, by the year 2030, the idea is to avail sanitation to more than 80% of the rural population and adequate and sustainable supply of potable water and sanitation services to all the population of Lesotho. To reach these targets in the advent of climate change and projected droughts, every community council under the local government structure should have at least one major ground water harvesting infrastructure serving at least 25 percent of the population in the community council. These must be augmented by roof water harvesting structures for at 50 percent of the households with a corrugated iron sheet roofing. However, research and innovation must develop systems for water harvesting from grass thatched building.

1.1.3 Conservation agriculture

The long-term target of conservation agriculture is to transform the tillage system from one dominated almost 99 percent by conventional practices to at least 50 percent CA practices in Lesotho by 2045. However, in the short term, by 2030, the target is to growth the farmer participation by reducing conventional agricultural by at least 10 percent and to leverage the use of drought tolerant tillage systems to achieve resilient and diversified agricultural sector with improved and sustainable capacity to respond to climate variability and land degradation (Resilience). The Conservation Agriculture systems will be leveraged to scaling-up climate smart agriculture practices and actions to promote adaptation. and increased food security achieving zero hunger by 2050.

1.2 Barrier analysis and possible enabling measures for DCEWS

1.2.1 General Description of DCEWS

For the Lesotho context, a decentralized community-run early warning system (DCEWS) is "the provision of precise and effective information through identified institutions that allows the farming community, development agents and government officials to prepare for effective response to slow on set disasters including drought to avoid or reduce risks" (UNEP 2012). Due to the large economic loss and the magnitude of these disasters, the primary focus of

DCEWS is mitigating disaster risk from drought which is a slow onset hazard. However, rapid onset hazards such as floods, storms and others are also considered in the technology. Annual economic losses caused by weather-related natural disasters have increased in recent times in Lesotho. The tendency for increased frequency of climate extremes is expected to continue in the future. As a result, drought is highly likely to occur more frequently, bringing risks for cropping and livestock agriculture. In addition, there is clear evidence of drought intensification in Lesotho under global climate change hence DCEWS integrates four main components of risk knowledge, monitoring and predicting, and information dissemination. The barriers and measures identified for DCEWS are detailed in Appendices 1-1 and 1-2.

1.2.2 Identification of Barriers for DCEWS

The first step was gathering a list of all barriers to the diffusion of the DCEWS using expert opinion, experience and drawing lessons from the literature. The findings were compiled into a draft report and presented to a stakeholder meeting organized to analyse and validate the identified barriers. The identified barriers were organized in the order of cause-effect relations, with the main problem/barrier at the centre and the direct causes below it and direct effects above (Fig. 1). Overall, two categories of barriers were prioritized: economic and financial and non-financial barriers However, the two entail institutional and organizational capacities, and information awareness barriers.

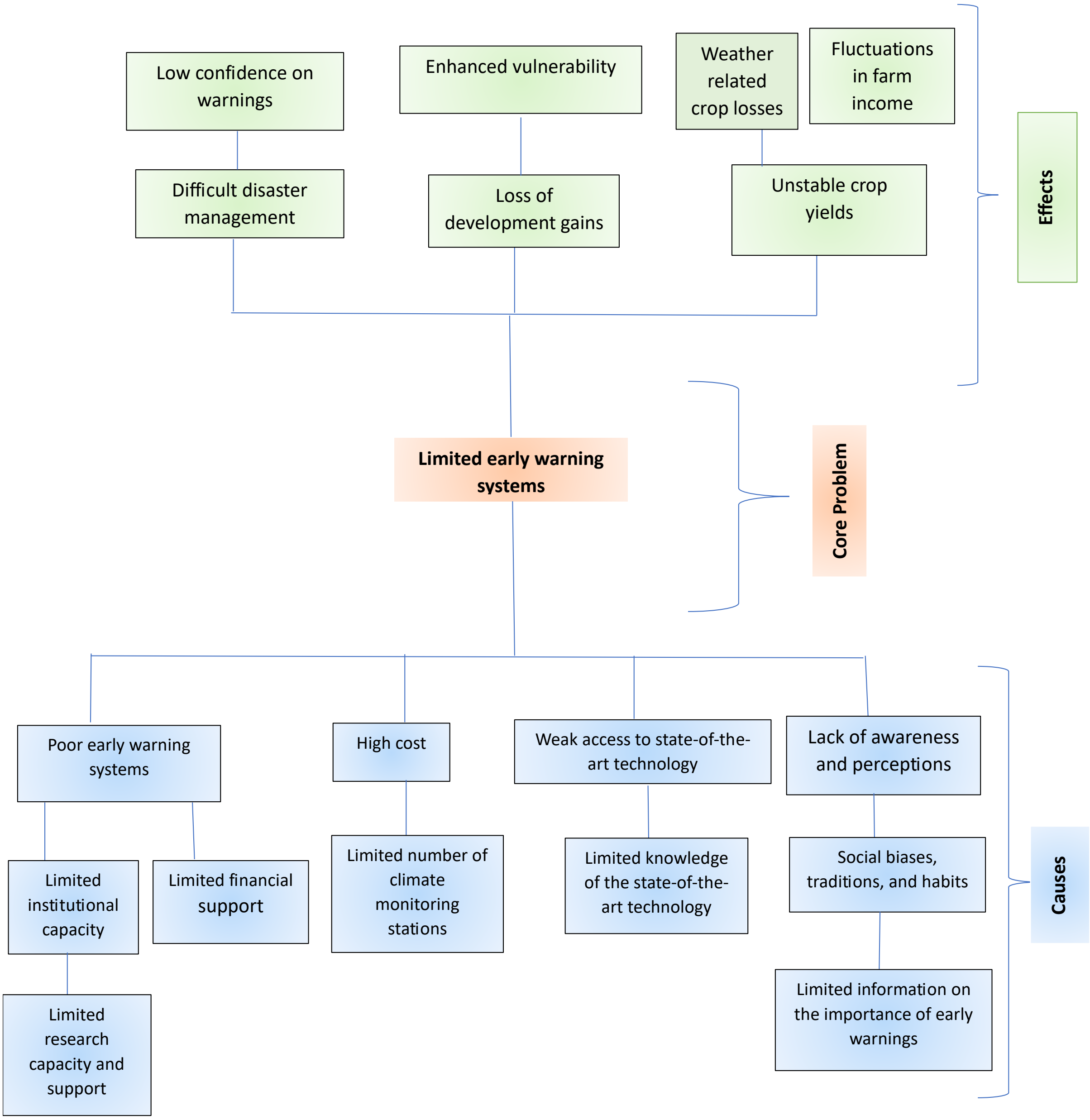

Fig. 1. Problem tree for the DCEWS technology indicating causes and effects.

1.2.2.1 Economic and financial barriers

High Initial Cost: Lesotho is a mountainous terrain with deep valleys requiring high grid density within a small geographic space. This makes the cost of setting up a meteorological, operation and management of station network and prohibitive within the government budget. The upfront expenses for acquiring and setting up advanced monitoring technologies, and sensor networks can be substantial, creating a barrier for Lesotho given its limited financial resources. The cost of an automatic weather station is approximately Euro 10,000.00 (climate) and Euro 15,000.00 according to estimates of the Early Warning Systems II Project (Personal Communication). Thus, costs of appropriate instrumentation are prohibitive given that there are many competing demands for national resources. .

Maintenance expenses: The operation and management costs include security and data retrieval costs and are compounded by a sparse electrical grid especially within the remote rural locations. Thus, sustaining and updating monitoring systems require continuous investments. Regular maintenance, software updates, and technology upgrades contribute to long-term costs that some regions may find challenging to bear. Lightning presents serious challenges in the mountains of Lesotho in particular and strikes can take a station out of functionality hence such electronic protection and maintenance may be high.

Data management expenses: Collecting, processing, and analysing large volumes of data generated by climate monitoring systems necessitate sophisticated infrastructure and data management capabilities. The associated costs can be a significant obstacle. This has a time lag for development of the requisite skills.

Training and capacity building: There is need for capacity building through staff training. Skilled personnel are essential for operating and interpreting data from these systems. Training a workforce capable of managing and utilizing advanced technologies adds to the overall expenses including the lag for development of requisite skills and retaining them.

Limited funding: The Government of Lesotho annually allocates limited budgets to environmental initiatives, and climate change monitoring competes with other pressing economic priorities. This limitation in funding creates a significant impediment to the establishment and maintenance of comprehensive monitoring systems.

Lack of financial incentives: The Lesotho Meteorological Services provides climate information services free of charge, hence there are no direct financial incentives for government and private sector organizations to invest in these systems, especially when the benefits are not immediately apparent or tangible.

Global economic disparities: Like all developing countries, Lesotho faces greater challenges in implementing advanced monitoring systems due to economic disparities. The financial capacity to invest in cutting-edge technologies is beyond its budgetary means.

1.2.2.2 Non-financial barriers

Technical Challenges: Implementing advanced monitoring systems in Lesotho is hindered by technical complexities, including interoperability issues, data integration challenges, and the need for albeit unaffordable specialized technical expertise at LMS and other government institutions where the direct use of climate information services is imperative.

Lack of Technical Capacity: Lesotho lacks the necessary technical know-how to effectively operate and maintain sophisticated climate monitoring technologies. This capacity gap impedes the successful implementation of these systems.

Data Sharing and Cooperation: The success of climate monitoring often depends on cross-border data sharing and international cooperation. Barriers related to data sovereignty, privacy concerns, and geopolitical tensions hinder collaborative efforts in implementing integrated systems.

Policy and Regulatory Hurdles: Inconsistent or inadequate policies and regulations related to climate monitoring and early warning systems can impede progress. Clear and supportive regulatory frameworks are crucial for the successful implementation of such technologies.

Public Awareness and Engagement: In Lesotho, there is a general lack of public awareness or understanding of the importance of climate monitoring which contributes to resistance or indifference. Thus, building public support and engagement is vital for the successful adoption of these technologies. This would also go a long way to mitigate theft and vandalism in some remote stations.

Cultural and Social Factors: In Lesotho, local communities mainly rely on "traditional indicators" for weather and seasonal forecasting hence the indifference and resistance to the new technology. However, scientific weather monitoring and short-term forecasts (a few days) are already being undertaken in Lesotho with appreciable success. In the advent of climate change, traditional indicators of weather (e.g., bird and animal movement, the date and quantity of the first rains, the special forecasting knowledge of diviners etc) become more and more unreliable and eventually obsolete. That notwithstanding, cultural beliefs, social norms, and historical factors influence the acceptance and integration of climate monitoring technologies. Thus, understanding and addressing these cultural aspects is essential for effective implementation.

1.2.3 Identified measures

Addressing these economic and financial barriers requires international collaboration, innovative funding mechanisms, and a recognition of the long-term benefits of effective climate change monitoring and early warning systems. Addressing technical challenges and non-financial barriers for decentralized community early warning systems requires a comprehensive approach that focuses on capacity building, technology innovation, collaboration, and community engagement. The solution tree for the aforementioned barriers was constructed (Fig. 2).

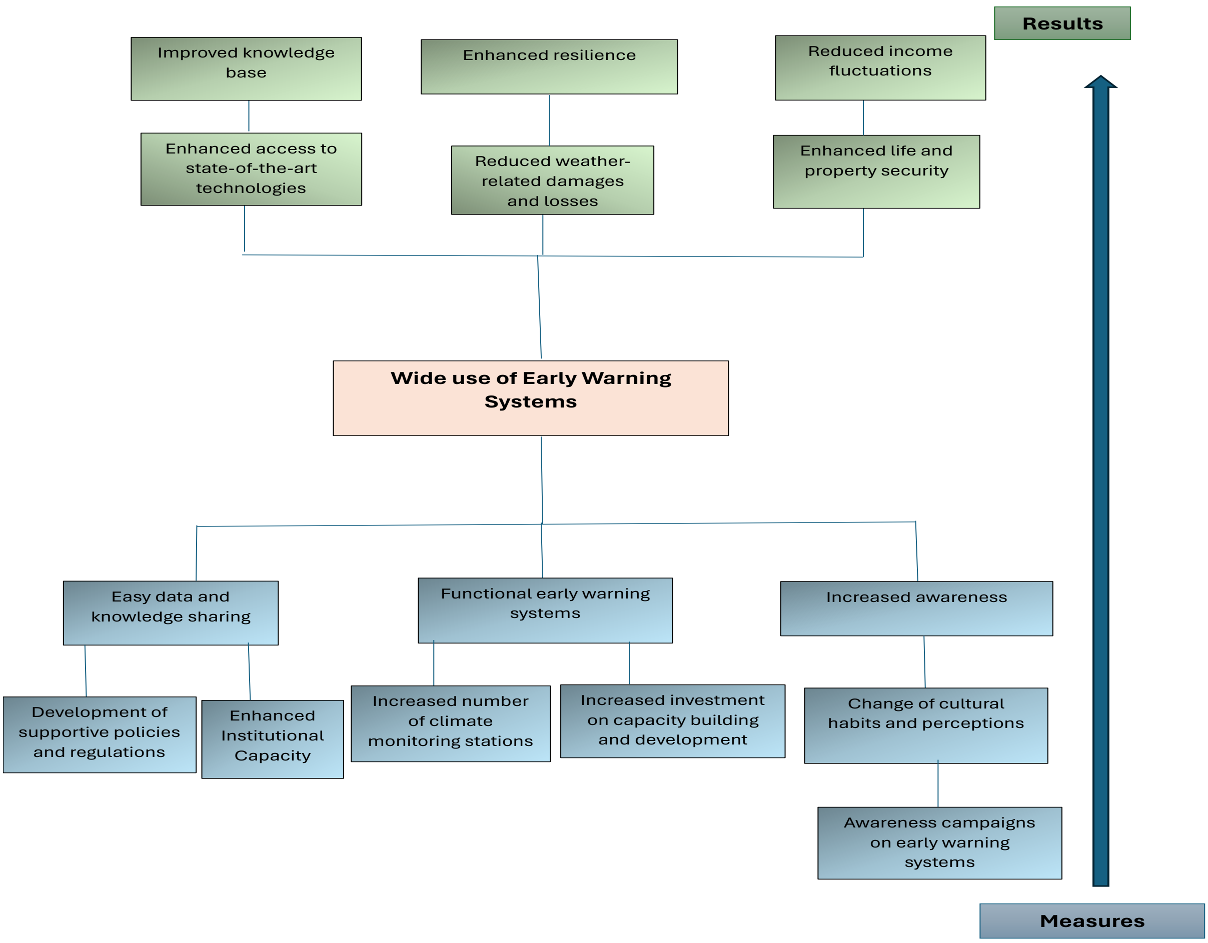

Fig. 2. Solution tree analysis for DCEWS.

1.2.3.1 Economic and financial measures

In order to establish an appropriate financing and fiscal policy to enable wide use of DCEWS there is need for government to:

- Allocate specific and reliable budgets for the establishment, maintenance, and upgrading of climate monitoring and early warning systems. This ensures a consistent financial commitment.
- Foster collaboration between governments, academia and private sector entities to share costs, leverage expertise, and enhance financial resources for implementing and sustaining these systems.
- Hone its capacity to leverage and seek international assistance through grants and aid from developed nations, climate funds and global organizations for support to acquire and maintain climate monitoring technologies.
- Create financial incentives, such as tax breaks or subsidies, for businesses and organizations that invest in or develop technologies related to climate change monitoring and early warning systems.

Technology Design for Sustainability: Design systems with durability and ease of maintenance in mind. Use robust, low-maintenance hardware and open-source software solutions that are accessible and adaptable to local contexts.

Regular Inspections and Maintenance Schedules: Establish a regular schedule for system inspections and maintenance activities. This includes checking sensors, cleaning equipment, and updating software to ensure optimal performance.

1.2.3.2 Non-economic measures

On-the-Job Training and Apprenticeships: Offer on-the-job training opportunities and apprenticeships for community members interested in gaining practical experience in early warning system operation and maintenance. Pair novices with experienced mentors to facilitate knowledge transfer and skill development.

Policy Coherence and Integration: Promote policy coherence and integration across sectors, including disaster risk reduction, climate change adaptation, sustainable development, and poverty alleviation. Align national policies, strategies, and investments to mainstream decentralized community early warning systems into broader development agendas, fostering synergies and maximizing impact on economic disparities and resilience-building efforts.

Community Engagement and Ownership: Foster community ownership by involving local residents in the maintenance process. This can include training community members to handle basic repairs, conducting regular community meetings to discuss system upkeep, and encouraging participation in system monitoring.

Training and Capacity Building: Provide training sessions for community members on system maintenance, troubleshooting, and data management. This empowers locals to address minor issues and reduces the need for external support.

Partnerships and Collaboration: Collaborate with local organizations, government agencies, or international NGOs to share resources, expertise, and funding for maintenance activities. Partnerships can help distribute the financial burden and ensure long-term sustainability.

Technical Internships and Exchanges: Facilitate technical internships, exchange programs, and knowledge sharing visits to expose community members to diverse technical environments, practices, and innovations related to early warning systems. Learning from peers and experts in different contexts can inspire new ideas and approaches.

1.3 Barrier analysis and possible enabling measures for rainwater harvesting

1.3.1 General Description of rainwater harvesting technology

Surface runoff water harvesting is the collection, accumulation, treatment or purification, and storing of storm water for its eventual reuse for various purposes such as domestic water supply, livestock watering and irrigation (Hatibu et al. 2006). The system consists of a catchment area (the surface on which runoff is generated), command area (the area where runoff is utilized), runoff transfer infrastructure (channels, gullies, hard surfaces), diversion and storage structures (Mzirai and Tumbo 2010). Rainwater harvesting is a method for inducing, collecting, storing and conserving local surface runoff for agriculture in arid and semi-arid regions (Boers and Ben-Asher, 1982). Both small and large-scale structures are used for rainwater harvesting collection and storage including water pans, tanks, reservoirs and dams. The catchment area is the area where the rainfall or water runoff is initially captured and is in most cases either the roof-top of a house or building, ground surface or rock surface. In the roof-top method water from rainfall is collected in vessels at the edge of the roof or channelled to a storage system via gutters and pipes.

Roofs can be constructed with a range of materials including galvanised corrugated iron, or thatch. Thatch roofs can provide a low-cost alternative but can be difficult to clean and can taint the runoff. Tiled roofs, or roofs sheeted with corrugated iron are preferable, since they are the easiest to construct and give the cleanest water. Roof-top collection is suitable for household level application and can provide freshwater for domestic purposes and small-scale farming. In the ground surface method water flowing along the ground during the rains is usually diverted toward a tank below the surface. Bedrock surfaces found within rocky top slopes or exposed rock outcrops in lowlands often have natural hollows or valleys which can be turned into water reservoirs by building dam walls.

Surface runoff water harvesting is done at micro and macro level. Micro-catchment rainwater harvesting systems are designed to guide runoff from a catchment area of 10–500 m^2 into an infiltration-enhancing structure for irrigating plants such as vegetables, coffee and bananas (Kiggundu et al. 2018). Common micro-catchment techniques include pitting, contouring, terracing, furrowing and micro-basins supplemented with mulching and reduced tillage (Biazin et al. 2012). The economic and financial barriers and measures identified are detailed in Appendix 2.

1.3.2 Identification of barriers for rainwater harvesting

Installation of macro-catchment surface runoff water harvesting is expensive (Mugerwa 2007; Kiggundu et al 2018). Capital cost items include purchase or renting of land for siting the reservoir, equipment such as bulldozers, scrapers and tractors for excavation, pipes for inlets and spillways, and rollers for soil compaction or clay lining to minimize permeability of the storage basin, above-ground brickwork to enhance storage capacity, fencing, a system for water abstraction with an energy source (Kiggundu et al 2018). Reservoir construction costs vary widely depending on soil type, the size of the tank and season of construction. Smaller tanks cost more per cubic meter. Elsewhere, per cubic meter cost is US$21.2 for excavation of ponds of 35 m^3 and US$ 99.6 for sub-surface tanks of 11 m^3 (Anyoni et al. 2015). Recurrent costs are repairs, desiltation and cleaning of reservoir, silt traps, gutters, etc. at least once a year, monthly maintenance of pumps abstraction energy bills, and water treatment from contamination (Kiggundu et al 2018). The identified barriers for the rain water harvesting were organized in the order of cause-effect relations, with the main problem/barrier at the centre, direct causes below it and direct effects above (Fig.3).

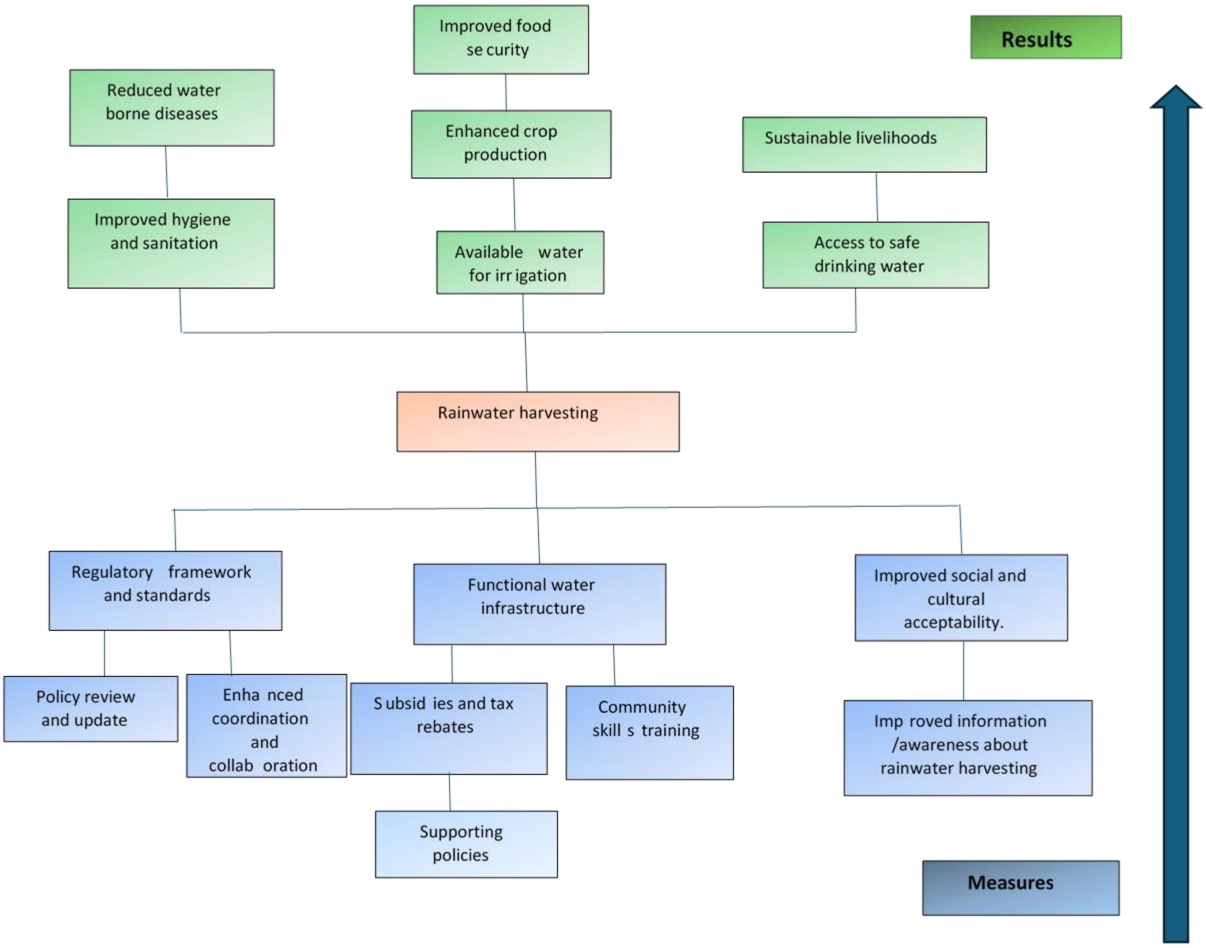

Fig. 3. Problem tree for rain water harvesting technology indicating causes and effects.

1.3.2.1 Economic and financial barriers

High Initial Costs: The upfront investment required for installing rainwater harvesting infrastructure, such as collection systems and storage facilities, can be a significant barrier for farmers, particularly those with limited financial resources.

Maintenance Expenses: Ongoing maintenance costs for rainwater harvesting systems, including repairs and cleaning of infrastructure, can pose a financial challenge for farmers, affecting the sustainability of the technology.

Limited Access to Capital: Farmers face difficulties in accessing affordable capital for financing technology adoption like rainwater harvesting projects. Despite some efforts of NGOs and Department of Soil and Water Conservation to catalyse adoption of technologies, limited access to loans or credit hinders their ability to invest in the necessary infrastructure.

Uncertain Returns on Investment: Many farmers are hesitant to invest in rainwater harvesting technologies due to uncertainties surrounding the returns on investment, especially when such benefits are neither immediately apparent nor guaranteed.

Lack of Financial Incentives: In Lesotho, given the limited to no financial incentives or subsidies for adopting rainwater harvesting, farmers are less motivated to invest in these technologies, especially when alternative water sources are available.

1.3.2.2 Non-financial barriers

Land Tenure and Ownership Concerns: In Lesotho the commons property regime prevails for the most part and issues related to land tenure and ownership hinder farmers from making long-term investments in rainwater harvesting infrastructure in the commons, given lack secure land rights and security against vandalism.

Lack of Technical Knowledge: Smallholder farmers face challenges in understanding the technical aspects of rainwater harvesting systems. Insufficient knowledge about the design, installation, and maintenance of these technologies is a significant barrier.

Perception and Awareness: Limited awareness of the benefits of rainwater harvesting and its potential impact on agricultural practices hinders adoption. Farmers are less likely to invest time and effort in a technology they do not fully understand or appreciate.

Water Rights and Regulations: Lesotho has existing water policy and legislation under the jurisdiction of the water sector. However, the water-food nexus in the context of farming is not well regulated in practice. This leaves complex or unclear water rights and regulations which can potentially impede the implementation of rainwater harvesting. Farmers may face legal uncertainties or restrictions on the collection and use of rainwater.

Perceived Risks: Farmers might perceive risks associated with rainwater harvesting, such as system failures, water contamination, or changes in crop yields. Thus, overcoming these perceptions and demonstrating the reliability of the technology is essential for widespread adoption.

Community Dynamics: In Lesotho, farmers operate within a community context, and the dynamics of these communities can influence technology adoption. Social pressures, norms, or collective decision-making processes may act as non-economic barriers.

Limited Extension Services: The extension service in Lesotho faces lack of capacity at individual, institutional and systemic levels. Lack of accessible and effective agricultural extension services can hinder the dissemination of information about rainwater harvesting. Farmers may miss out on valuable guidance and support for implementing these technologies.

1.3.3 Identified measures

The combination of economic and non-financial measures is crucial for the successful promotion and adoption of rainwater harvesting technologies in agriculture, contributing to sustainable water management practices. The solution tree for the aforementioned barriers was constructed (Fig. 4).

1.3.3.1 Economic and financial measures

Government Subsidies: Provide financial incentives and subsidies to farmers for the adoption of rainwater harvesting technologies, including the installation of rainwater collection systems and storage facilities.

Low-Interest Loans: Establish accessible and low-interest loan programs to support farmers in investing in rainwater harvesting infrastructure. This can ease the financial burden and promote widespread adoption.

Insurance Schemes: Introduce insurance schemes that protect farmers from potential losses due to climate-related uncertainties. This can encourage them to invest in rainwater harvesting as a risk mitigation strategy.

Public-Private Partnerships: Collaborate with private sector entities to fund and implement rainwater harvesting projects. This partnership can attract additional financial resources and technical expertise.

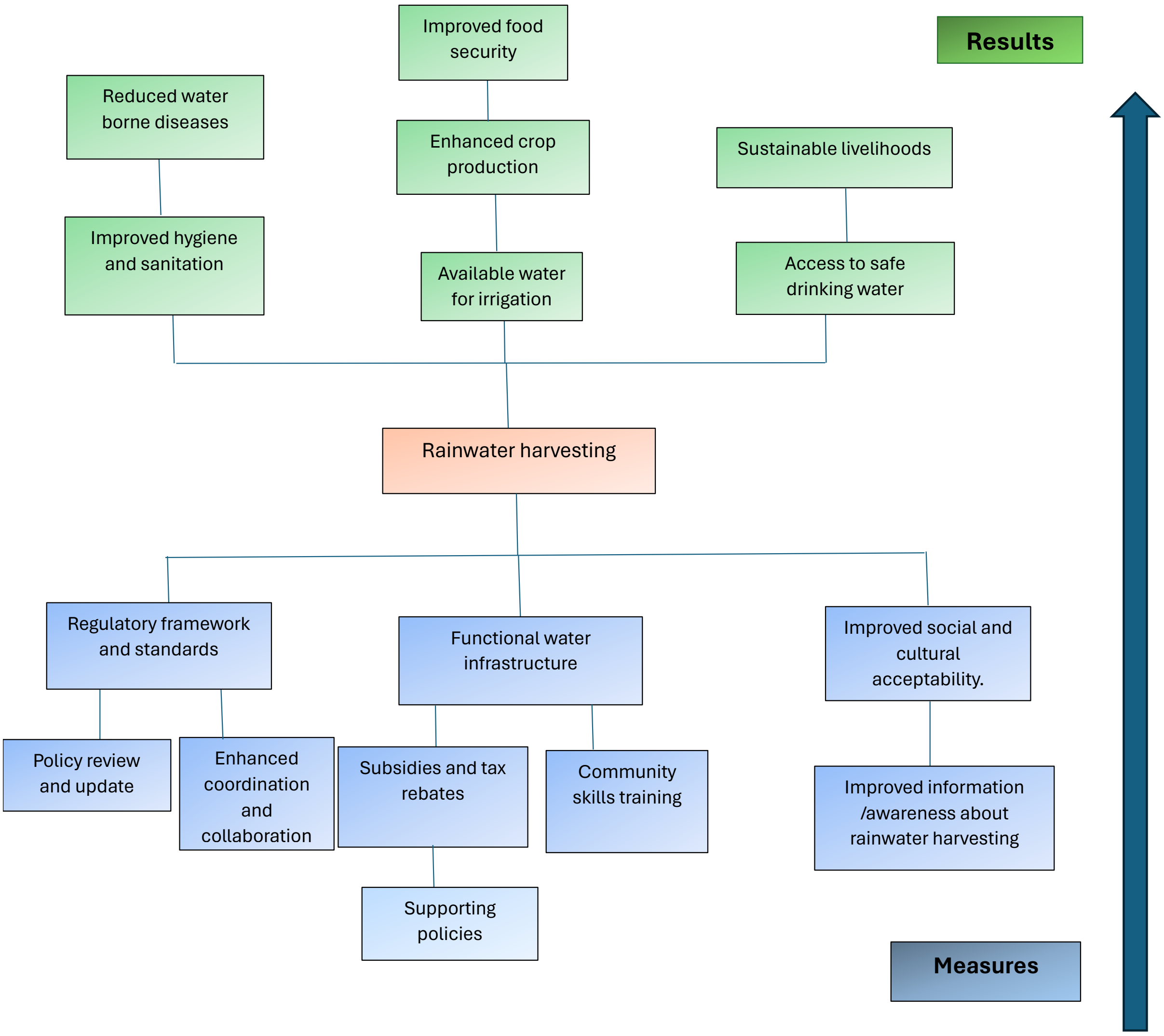

Fig. 4. Solution tree analysis for rainwater harvesting

1.3.3.2 Non-financial measures

Overcoming barriers through:

Education and Training: Conduct awareness programs and training sessions to educate farmers about the benefits of rainwater harvesting and provide guidance on the installation and maintenance of relevant technologies.

Technical Assistance: Offer technical support and guidance to farmers through agricultural extension services. This can include on-site visits, workshops, and access to experts who can assist with the implementation of rainwater harvesting systems.

Research and Development: Invest in research to develop and improve rainwater harvesting technologies, making them more efficient and cost-effective. This can be done in collaboration with agricultural research institutions and technology developers.

Policy Alignment: Develop and implement policies that promote rainwater harvesting in agriculture. This includes integrating rainwater harvesting considerations into agricultural development plans and water resource management policies.

Community Engagement: Foster community involvement and collaboration in the planning and implementation of rainwater harvesting projects. This ensures that solutions are tailored to local needs and conditions.

Demonstration Projects: Initiate demonstration projects to showcase the benefits of rainwater harvesting technologies. These projects serve as practical examples for farmers and communities, encouraging wider adoption.

Water Rights and Regulations: Establish clear and fair water rights and regulations that support rainwater harvesting practices. This includes addressing legal considerations related to ownership, use, and management of harvested rainwater.

Technical Assistance: Offer technical support and guidance to farmers through agricultural extension services. This can include on-site visits, workshops, and access to experts who can assist with the implementation of rainwater harvesting systems.

Research and Development: Invest in research to develop and improve rainwater harvesting technologies, making them more efficient and cost-effective. This can be done in collaboration with agricultural research institutions and technology developers.

Community Engagement: Foster community involvement and collaboration in the planning and implementation of rainwater harvesting projects. This ensures that solutions are tailored to local needs and conditions.

Demonstration Projects: Initiate demonstration projects to showcase the benefits of rainwater harvesting technologies. These projects serve as practical examples for farmers and communities, encouraging wider adoption.

1.4 Barrier analysis and possible enabling measures for conservation agriculture Technology

1.4.1 General description of Conservation Agriculture Technology

Conservation agriculture (CA) is generally defined as a set of management practices that minimize soil disturbance, incorporate legumes through rotations or intercropping, and maintain crop residues on the soil surface. These practices are promoted in order to reduce erosion, improve soil quality through the gradual build-up of soil carbon and in the long term, improve soil fertility and water infiltration. Other benefits of conservation agriculture can be decreased labour requirements, increased yields, earlier planting and greater drought tolerance due to improvements in soil physical properties.

1.4.2 Identified barriers for conservation agriculture technology

Conservation agriculture may require the application of herbicides in the case of heavy weed infestation, particularly in the transition phase, until the new balance of weed populations is established. Initial investment of time and money along with purchases of equipment and herbicides will be necessary for establishing the system. Higher levels of surface residue may result in higher plant disease and pest infestations, if not managed properly. There is a strong relationship between this technology and appropriate soil characteristics. For small scale and resource poor farmers, the labour intensiveness of CA is a serious disincentive. The identified barriers for CA were organized in the order of cause-effect relations, with the main problem/barrier at the centre, direct causes below it and direct effects above (Fig.5).

1.4.2.1 Economic and financial barriers

The economic and financial barriers for CA technology are detailed in appendix 3.1 and summarized as follows:

High Initial Costs: The adoption of conservation agriculture technology involves significant upfront investments in new and unconventional equipment, precision farming technologies, and training. The high initial costs can be a substantial economic barrier for farmers.

Access to Credit: Limited access to affordable credit or financing options can hinder farmers' ability to invest in conservation agriculture technology. Without financial support, most farmers struggle to make the necessary investments.

Operational Costs: Ongoing operational costs, including maintenance, fuel, and servicing of specialized equipment, can be a financial burden for farmers. The continuous expenses associated with conservation agriculture technology may impact its economic feasibility.

Market Access Challenges: Like other farmers, conservation agriculture innovators may face challenges in accessing markets for their produce. If there is insufficient demand or lower prices for crops produced using these techniques, the economic and environmental incentives for adoption diminish.

Insurance Availability: In Lesotho, the southern lowlands and Senqu river valley regions are prone to climate-related risks. The availability and affordability of insurance for crops using conservation agriculture practices may be limited. This lack of insurance coverage can deter farmers concerned about potential losses.

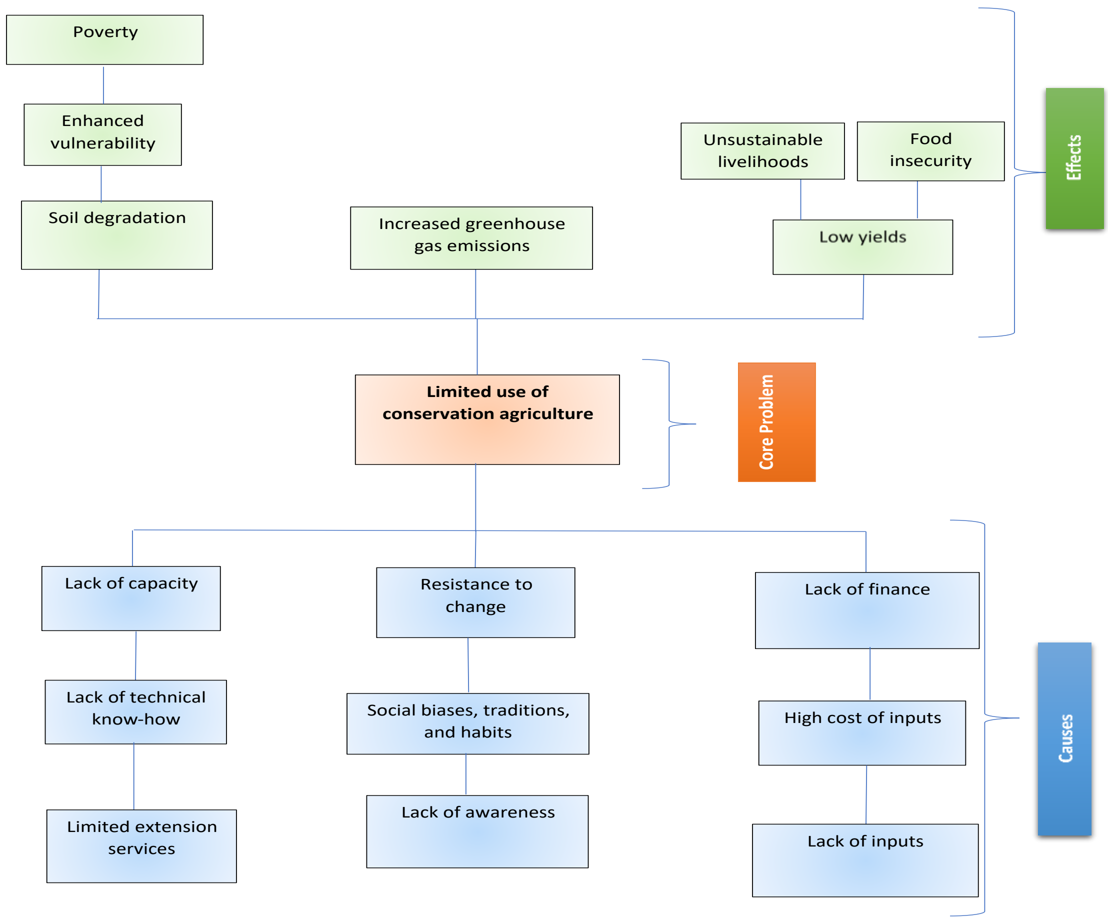

Fig. 5. Problem tree for Conservation Agriculture technology indicating causes and effects.

1.4.2.2 Non-financial barriers

The detailed analysis of non-financial barriers for CA technology are outline in appendix 3-2 and summarized as follows:

Land Tenure Issues: Uncertainties related to land tenure can act as an economic barrier. Farmers are reluctant to invest in long-term conservation practices if they do not have secure land rights, fearing potential land-use changes.

Knowledge and Awareness: Limited understanding and awareness of conservation agriculture practices act as a significant non-economic barrier. The lack of knowledge and awareness amongst extension agents exacerbates the farmers' lack of familiarity with the principles and benefits of conservation agriculture, hindering adoption.

Traditional Farming Practices: In Lesotho, deep-rooted reliance on conventional farming methods impedes the adoption of conservation agriculture. Resistance to change and scepticism about the effectiveness of new practices may pose a non-financial obstacle.

Access to Information and Extension Services: Conservation agriculture is a practice formally adopted by the Ministry of Agriculture, Food Security and Nutrition in Lesotho and is advocated for in strategic policy documents. Nevertheless, inadequate access to information and extension services hinders the dissemination of knowledge about conservation agriculture. Limited outreach and support for farmers can slow down the adoption process.

Technological Literacy: Many farmers, including extension officers lack the necessary technological literacy to implement conservation agriculture practices, particularly when it involves the use of advanced equipment or precision farming technologies.

Community Dynamics: Social dynamics within farming communities can impact the adoption of conservation agriculture. Resistance or support from peers, local leaders, and community norms can play a role in shaping individual farmers' decisions.

1.4.3 Identified Measures

The solution tree for the aforementioned barriers was constructed (Fig. 6).

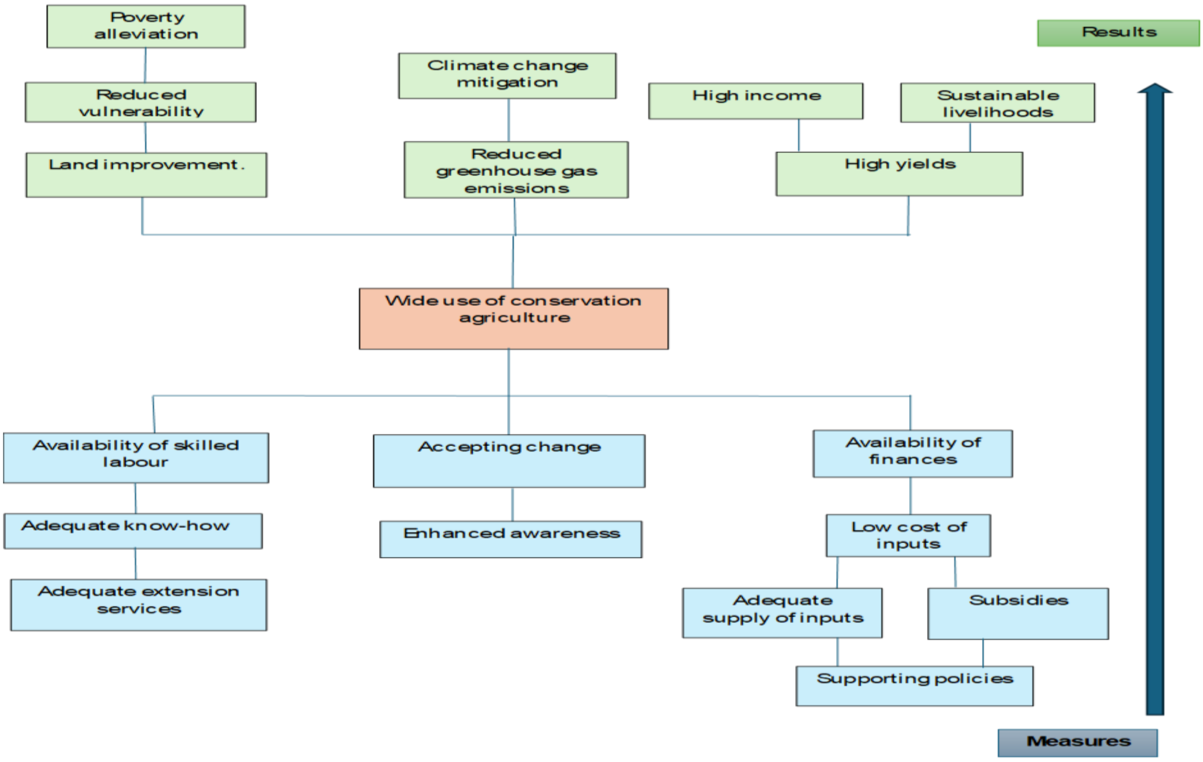

Fig. 6. Solution tree for Conservation Agriculture

1.4.3.1 Economic and financial measures

Insurance Subsidies and Incentives: Advocate for government subsidies, grants, or incentives to make insurance more affordable and accessible to farmers engaged in conservation agriculture. Provide premium subsidies, risk-sharing mechanisms, or tax incentives to encourage farmers to purchase insurance coverage.

Targeted Subsidies: Redirect existing agricultural subsidies towards supporting conservation agriculture practices. Design subsidy programs that prioritize investments in soil health, water conservation, biodiversity conservation, and climate resilience, thereby incentivizing farmers to adopt sustainable farming practices.

Index-Based Insurance: Promote the development and adoption of index-based insurance products that use weather, yield, or vegetation indices as triggers for payouts. Index insurance reduces administrative costs, eliminates the need for individual farm assessments, and provides timely compensation for weather-related losses.

Post-Harvest Handling and Storage: Improve post-harvest handling, storage, and transportation practices to maintain product quality, reduce losses, and meet market standards.

Invest in cold storage facilities, drying technologies, and packaging materials to extend shelf life and preserve product freshness.

Return on Investment: Farmers perceive a lack of certainty regarding the return on investment for conservation agriculture technology. This uncertainty can deter adoption, especially when compared to more conventional and familiar farming practices.

1.4.3.2 Non-financial measures

Education and Extension Services: Develop comprehensive educational programs and extension services to increase awareness and understanding of conservation agriculture practices among farmers. Strengthen extension services to provide ongoing support and guidance to farmers adopting conservation agriculture by ensuring that they have the necessary knowledge and resources for successful implementation.; helping them establish platforms for sharing experiences and networking.

Farmer Field Schools: Facilitate farmer field schools (FFS) or participatory learning groups where farmers collaborate, learn, and experiment together under the guidance of trained facilitators. Use FFS methodologies to promote experiential learning, problem-solving, and peer-to-peer knowledge sharing among farmers.

Training and Capacity Building: Offer training programs, workshops, and hands-on demonstrations to build farmers' capacity and confidence in using agricultural technologies relevant to conservation agriculture. Provide practical training on the use of farm machinery, precision agriculture tools, and digital platforms for data collection and analysis.

Legal Reform and Policy Support: Advocate for legal reforms and policy support that strengthen land tenure security and protect land rights for conservation agriculture practitioners. Lobby for legislation that recognizes and protects customary land tenure systems, promotes gender-equitable land rights, and safeguards land from encroachment or expropriation.

Land Tenure Formalization: Support efforts to formalize informal land tenure arrangements through land registration, certification, or documentation processes. Provide technical assistance, legal support, and financial incentives to help farmers formalize their land tenure rights and secure land titles or leases.

1.5 Linkages of the barriers identified

Three key technologies were identified in the agriculture sector. The linkages between barriers for conservation agriculture, rainwater harvesting, and decentralized community-run early warning systems in the agriculture sector are interconnected. The barriers and linkages can influence each other in multiple ways (Table 8).

Table 8 Linkages to Barriers Identified in the Agriculture Sector

Barrier	Linkage
Limited access to capital can hinder investments in conservation agriculture practices, rainwater harvesting infrastructure, and early warning systems.	Limited access to capital can hinder investments in all three technologies and without sufficient funding, farmers may struggle to adopt conservation agriculture techniques, implement rainwater harvesting systems, or establish early warning networks, limiting their ability to mitigate risks and enhance resilience to climate-related challenges.
Insufficient technical capacity can impede the adoption and effective implementation of conservation agriculture methods, rainwater harvesting techniques, and early warning systems.	Insufficient technical capacity can impede the adoption and effective implementation of these technologies because adequate technical knowledge and skills are essential for implementing conservation agriculture practices, designing and maintaining rainwater harvesting structures, and operating early warning systems effectively. Without technical capacity-building initiatives, adoption rates may remain low
Limited funding and financial incentives may deter investment in conservation agriculture, rainwater harvesting, and early warning systems, as there may be insufficient resources or economic incentives to support these initiatives.	Limited funding and financial incentives may deter investment in all three priorities because financial constraints can restrict implementation of conservation agriculture practices, construction of rainwater harvesting infrastructure, and establishment of early warning systems. Without adequate funding and incentives, farmers may be less motivated to adopt sustainable agricultural practices or invest in resilience-building measures.
Institutional and regulatory hurdles, such as lack of supportive policies or cumbersome permitting processes, can create barriers to the adoption and scaling up of conservation agriculture, rainwater harvesting, and early warning systems.	Policy and regulatory hurdles, such as lack of supportive policies or cumbersome permitting processes, can create barriers to the adoption and scaling up of these technologies. As a matter of fact, inadequate policy support or regulatory frameworks may hinder the expansion of conservation agriculture initiatives, deployment of rainwater harvesting technologies, and establishment of community-based early warning networks. Thus clear and supportive policies are necessary to create an enabling environment for these practices.
Limited extension services and technical support can hinder farmers' access to information, training, and assistance on conservation agriculture practices, rainwater harvesting techniques, and early warning systems.	Limited extension services and technical support can hinder farmers' access to information, training, and assistance on conservation agriculture practices, rainwater harvesting techniques, and early warning systems. Thus, access to extension services and technical support is crucial for promoting the adoption and successful implementation of the selected technologies and strengthening extension services can enhance farmers' capacity to adopt these practices.

Barrier	Linkage
Cultural beliefs, social norms, and traditional farming practices may influence farmers' willingness to adopt conservation agriculture techniques, embrace rainwater harvesting methods, and participate in early warning systems	Cultural beliefs, social norms, and traditional farming practices may influence farmers' willingness to adopt conservation agriculture techniques, embrace rainwater harvesting methods, and participate in early warning systems. Thus, addressing cultural and social factors is essential for promoting the adoption of conservation agriculture, rainwater harvesting, and early warning systems. Community engagement and awareness-raising efforts can help overcome cultural barriers and build social acceptance for these practices.
Water scarcity, inefficient water use, and competing water demands can pose challenges for rainwater harvesting initiatives and impact the effectiveness of early warning systems for water-related risks.	Water scarcity, inefficient water use, and competing water demands can pose challenges for rainwater harvesting initiatives and impact the effectiveness of early warning systems for water-related risks. In particular, rainwater harvesting relies on the availability of water for collection and storage, while early warning systems may be affected by water scarcity or variability. Integrated water management approaches are needed to address water challenges and support sustainable agriculture practices.
High operational costs and maintenance expenses can be barriers to the sustainability of rainwater harvesting systems and early warning networks, particularly for resource-constrained communities.	High operational costs and maintenance expenses can be barriers to the sustainability of rainwater harvesting systems and early warning networks, particularly for resource-constrained communities. Thus, adequate funding and financial incentives are essential for covering the operational costs and ongoing maintenance expenses of rainwater harvesting infrastructure and early warning systems. Without sustainable financing mechanisms, these systems may become neglected or non-functional over time

Addressing these interlinked barriers requires a holistic approach that considers the synergies and dependencies between conservation agriculture, rainwater harvesting, and decentralized early warning systems. Integrated strategies that address financial, technical, policy, social, and environmental factors can help overcome barriers and promote sustainable agriculture practices and resilience-building measures in the agriculture sector.

1.6 Enabling framework for overcoming the barriers in the agriculture sector

Creating an enabling framework for overcoming barriers to adaptation in the agriculture sector involves a comprehensive approach that integrates policy, institutional, financial, technological, and capacity-building measures (Table 9).

Table 9 Key components of an enabling framework for overcoming barriers in the agricultural sector

Barrier	Enabling Framework	Responsible Entity
Policy and Regulatory Support	Develop and implement supportive policies, strategies, and regulatory frameworks that prioritize climate change adaptation in agriculture.	
	The requisite framework must integrate adaptation considerations into national agricultural policies, plans,	

Barrier	Enabling Framework	Responsible Entity
	and programs, ensuring coherence with broader climate adaptation and sustainable development agendas.	Ministry of Agriculture and Food Security
	In addition, the framework needs to establish clear regulatory guidelines, standards, and incentives to promote the adoption of climate-resilient agricultural practices and technologies.	
Stakeholder Engagement and Participation	Foster multi-stakeholder engagement and collaboration across government agencies, agricultural extension services, research institutions, farmers' organizations, civil society groups, and private sector entities.	Integrated Catchment Management
	Involve stakeholders in the planning, decision-making, and implementation of agricultural adaptation initiatives, ensuring their perspectives, needs, and knowledge are incorporated into adaptation strategies	Ministry of Agriculture and Food Security
Capacity Building and Knowledge Sharing	Enhance technical capacity, skills, and knowledge among agricultural practitioners, policymakers, and extension workers through training, capacity-building programs, and knowledge-sharing platforms.	
	Promote research, innovation, and learning in climate-resilient agricultural practices, technologies, and adaptation strategies, facilitating the exchange of best practices and lessons learned	Department of Agricultural Research, Academia
Investment and Financing Mechanisms	Mobilize financial resources, investments, and funding mechanisms to support climate-resilient agriculture, including investments in agricultural infrastructure, research and development, extension services, and farmer support programs	Ministry of Agriculture and Food Security (MAFS)
	Develop innovative financing models, public-private partnerships, and risk-sharing mechanisms to attract private sector investment and leverage public funds for agricultural adaptation	Ministry of Finance and Development Planning
Technology Transfer and Innovation	Facilitate technology transfer, diffusion, and adaptation of climate-resilient agricultural technologies, tools, and practices suitable for local contexts and conditions.	Department of Agricultural Research, Academia
	Promote research and development in climate-smart agriculture, including drought-tolerant crops, climate-resilient livestock breeds, precision agriculture technologies, and sustainable soil and water management practices	
Risk Assessment and Management	Conduct comprehensive risk assessments to identify climate-related hazards, vulnerabilities, and impacts on agricultural systems, livelihoods, and food security.	Disaster Management Authority and Lesotho Meteorological Services
	Develop risk management strategies, early warning systems, and contingency plans to enhance resilience to climate risks and ensure adaptive capacity in the face of uncertainty	
Ecosystem-based Approaches	Promote ecosystem-based approaches to agricultural adaptation that integrate nature-based solutions, agroforestry, conservation agriculture, and biodiversity conservation into farming systems	Ministry of Agriculture Academia
	Protect and restore natural ecosystems, such as forests, wetlands, and watersheds, to enhance agricultural resilience, soil fertility, water availability, and ecosystem services	MAFS

Barrier	Enabling Framework	Responsible Entity
Market Access and Value Chains	Strengthen agricultural value chains, market access, and rural livelihoods by supporting climate-resilient farming practices, diversification of crops and income sources, and access to markets, credit, and insurance services.	
	Promote inclusive business models, farmer cooperatives, and agribusiness partnerships that enhance the economic viability and resilience of smallholder agriculture in the face of climate change.	
Monitoring, Evaluation, and Learning	Establish monitoring and evaluation frameworks to track progress, measure performance, and assess the effectiveness of agricultural adaptation interventions.	MAFS and Academia
	Foster a culture of learning, innovation, and continuous improvement through knowledge exchange, participatory research, and farmer-to-farmer learning networks.	
Cross-sectoral Coordination	Promote cross-sectoral coordination and integration of agricultural adaptation with other sectors, such as water management, land use planning, disaster risk reduction, and social protection, to address interconnected challenges and maximize co-benefits.	MAFS
	Foster collaboration between agriculture-related sectors and stakeholders to promote integrated land and water resources management, climate resilience, and sustainable rural development.	

By implementing these components within an enabling framework, policymakers, practitioners, and stakeholders can enhance the adaptive capacity of the agriculture sector, build resilience to climate change impacts, and ensure sustainable food production, livelihoods, and rural development for present and future generations.

Chapter 2 Water sector

Lesotho's Nationally Determined Contribution (LMS, 2017) has indicated that the water sector is highly vulnerable to the adverse impacts of climate change, and needs special adaptation interventions. Adaptation technologies prioritized in the Technology Needs Assessment include: water reuse, rainwater collection from ground water surfaces and boreholes as a drought intervention for domestic water supply.

This chapter presents the process followed and the results obtained in the identification and analysis of barriers hindering the acquisition, innovation, and diffusion of these technologies; the measures to overcome these barriers and the enabling framework for transfer and diffusion of these technologies. The respective targets of these technologies according to national aspirations are also presented.

2.1 Preliminary targets for technology transfer and diffusion

Lesotho has a population of approximately 2.2 million people with about 75% living in rural areas. Despite the ample water resources and revenues generated by the water sector, more than 40% of the population do not have adequate access to water and sanitation services, due to various challenges related to uneven distribution of water resources, population settlement patterns and sector planning and management. Water contributes to the Gross Domestic Product (GDP) of Lesotho's economy in terms of royalty payments for the transfer of water to South Africa, hydro-electric energy production, value of irrigated crops produced, domestic and commercial water, investment in water infrastructure and government expenditure in the water sector.

The 2016 Census revealed that whereas 97 % of the urban population has access to improved water services, this feature counts for only 80 % of the rural population. The Census report also estimated that only 44 % of Basotho are using improved sanitation facilities (around 50 % for urban and 34 % for rural).

The Lesotho Water and Sanitation Policy (2007) emphasises increasing service coverage and ensuring a sustainable water sector. The policy also underlines adequate and sustainable supply of potable water and sanitation services to all of the population of Lesotho as issues of importance.

The objectives of the policy are to promote:

a) The proper management of the country's water resources and its sustainable utilization.
b) Adequate and sustainable supply of potable water and sanitation services to all of the population of Lesotho.
c) Co-ordination and coherence in the management and development of water and other related natural resources, in order to maximise the resultant socio-economic benefits without compromising the sustainability of vital ecosystems; and
d) Harmonisation of processes and procedures followed by different development partners and other stakeholders in order to optimise available internal and external resources as well as ensure timely implementation of sector programmes.

Lesotho's targets in the water sector are aligned to the 2030 Sustainable Development Goals targets.

2.1.1 Water reclamation, treatment and reuse

Recent estimate on the total volume of wastewater generated by the domestic, municipal, and industrial sectors in Lesotho is 7.2 million cubic meters. Wastewater in Lesotho is mainly produced from pollution caused by human body's waste products, namely urine and faeces which are carried away by water to form sewerage from domestic and municipal sector as well as the effluent from the industrial sector. In Lesotho, primary treatment type is the dominant wastewater treatment. However, the rapid population increase in the urban areas together with increases of human and industrial activities have brought constraint to wastewater treatment. Water and Sewage Company (WASCO) is the only institution involved in wastewater collection, conveyance, and treatment in the country. After being treated to required standards wastewater is normally disposed into the Mohokare (Caledon) River System. Water reuse is minimal because in the country as it is only used in the industrial sector. However, initiatives are underway to extend use of wastewater to the agriculture sector especially for irrigation purposes.

2.1.2 Rainwater collection from ground surfaces

Rainwater collection from ground water surfaces may take the form of collecting rainwater from ground surfaces utilizing micro-catchments to divert or snow runoff so that it can be stored before it can evaporate to enter watercourses by constructing an earthen or other structure to dam the watercourse and form small reservoirs. Lesotho is investing heavily in water and sanitation through under frameworks of both the Lesotho Highlands Water Projects and the Lowlands Water Supply Schemes. However, the focus of these interventions is either on transfer of water to regional destinations e.g. currently South Africa and in the near future to Botswana. The rural communities only get a trickledown effect of these multinational water projects leaving a greater population of Lesotho in the rural areas exposed to water scarcity which is projected to increase both in the mid and distant periods. Thus, the target for this technology is that by the year 2030, water supply and sanitation services must reach at least 80 percent of the rural population (1.162 million people (and adequate and sustainable supply of potable water. According to the 2016 population census, this makes up approximately 1.162 million people in the rural areas. Furthermore, the target is provide sanitation services to all the population of Lesotho which is approximately 2.2 million people according to the 2016 population census.

2.1.3 Boreholes as a drought intervention for domestic water supply

Boreholes play a crucial role as a drought intervention for domestic water supply, particularly in regions prone to water scarcity. During droughts, surface water sources may become unreliable, making it necessary to tap into groundwater reservoirs through boreholes. As a drought intervention for domestic water supply, boreholes can take three major strategies: drilling new boreholes /deepening existing ones; repairing damage boreholes; and /or constructing relief boreholes with restricted used for drought periods only. The target is to drill three monitoring boreholes per each of three main hydrometric catchments of Lesotho especially in southern Lesotho and the Senqu River basin. In addition, take an inventory of all existing community boreholes in the local community councils of Lesotho and drill new ones in at least 80 percent of the electoral division in each community council.

2.2 Barrier analysis and possible enabling measures for water reclamation, treatment and reuse

2.2.1 General description of water reclamation, treatment and reuse

Water reuse is the use of treated wastewater (or reclaimed water) for a beneficial purpose. Water reuse provides a potential extra water resource to existing water consumption. Typical wastewater treatment schemes incorporate multiple levels of physical, biological, and chemical treatment in order to ensure that water discharged to the environment does not pose a significant risk of adverse environmental or health impacts. Treated wastewater is usually discharged to surface water and that surface water is often used by a water source for a water utility downstream.

Water reclamation and reuse approaches utilize the same treatment technologies as conventional wastewater treatment, including secondary clarifiers, filtration basins of various designs, membranes, and disinfection basins. Traditionally, it has even been uncommon for drinking water reservoirs to be augmented with reclaimed water. However, this practice, known as indirect potable reuse, has increased in popularity. However, for potable reuse, treatment requirements generally go beyond conventional tertiary treatment steps.

Since most urban wastewater treatment schemes and piped sewerage networks are centralized, integration of reclamation and reuse approaches require retrofitting of existing and construction of new infrastructure.

2.2.2 Identification of barriers for water reclamation, treatment and reuse

Water recycling technologies for the purposes of reusing water have a potential to protect the environment, result in less pollution, utilize resources in a more sustainable manner, and enable recycling of waste products as well as a more effective handling of residual wastes. However, a variety of barriers from costs to technical know-how and social issues create serious barriers for adoption and investment. Given the apparent abundance of water resources in Lesotho, the appetite for investment in such water saving projects may not be immediately obvious. However, the climate change projections for periods beyond 2070 are gloomy, with drought and high temperature extremes. Projects in this regard will need extensive costing and implementation plans identifying responsibilities and timelines. In addition, cost benefit analysis compared to the benefits to justify the interventions, or for seeking funding will be prerequisite.

2.2.2.1 Economic and financial barriers

The identified economic and financial barriers are detailed in Appendix 4-1. A brief summary is provided herein under.

Operational and Maintenance Costs: Ongoing operational and maintenance expenses can be substantial, impacting the economic feasibility of water reuse projects.

Limited Funding: Insufficient public and private funding for water reuse initiatives can impede the development and widespread adoption of these technologies.

Lack of Financial Incentives: The absence of financial incentives, such as tax breaks or subsidies, may discourage organizations from investing in water reuse technologies.

Uncertain Return on Investment: Uncertainties surrounding the economic benefits and long-term savings of water reuse projects may deter potential investors.

Inadequate Cost Recovery Mechanisms: Water pricing structures may not adequately reflect the actual cost of water, making it challenging for water reuse projects to recover their expenses.

Lack of Standardized Economic Valuation: The absence of universally accepted methods for economically valuing the benefits of water reuse makes it challenging to assess and compare the financial advantages of different projects.

2.2.2.2 Non-financial barriers

Regulatory Barriers: Complex or stringent regulations can increase compliance costs and create uncertainties, hindering the economic viability of water reuse technologies.

Public Perception and Acceptance: Concerns or resistance from the public regarding the safety and acceptance of recycled water for various uses can be a significant non-economic barrier.

Lack of Awareness and Education: Insufficient awareness and understanding of water reuse technologies among stakeholders, including policymakers, communities, and businesses, can hinder adoption.

Technical Challenges: The complexity and technical intricacies of certain water reuse technologies may pose barriers, especially for smaller water utilities or regions with limited technical expertise.

Institutional and Governance Issues: Poorly defined institutional frameworks, governance structures, or unclear responsibilities among stakeholders can create obstacles for implementing water reuse projects.

Water Quality Standards and Regulations: Ambiguous or restrictive water quality standards and regulations may create uncertainty for potential users and investors, impacting the adoption of water reuse technologies.

Risk Aversion: Perceived or real risks associated with water reuse, including concerns about liability, may discourage stakeholders from embracing these technologies.

Intersectoral Competition: Competition for water resources among different sectors, such as agriculture, industry, and urban development, can create challenges for reallocating treated water for reuse.

Cultural and Social Factors: Cultural beliefs and social attitudes towards water reuse, including the stigma associated with recycled water, can influence the acceptance and implementation of these technologies.

Resource Constraints: Limited human resources, expertise, and technical know-how within organizations or regions may hinder the successful implementation of water reuse initiatives.

2.2.3 Identified measures

The identified measures to the barrier identified are detailed in Appendices 4-2 and summarized here.

2.2.3.1 Economic and financial measures

Government Subsidies and Grants: Providing financial support through subsidies or grants can help offset the initial capital costs of implementing water reuse technologies, encouraging widespread adoption.

Tax Incentives: Offering tax credits or deductions for investments in water reuse infrastructure can stimulate private sector participation and attract capital to fund projects.

Low-Interest Loans: Establishing financial mechanisms that offer low-interest loans for water reuse projects can make funding more accessible and cost-effective for both public and private entities.

User Fees and Tariffs: Implementing fair and transparent user fees or tariffs for water services, including water reuse, ensures that the costs are appropriately distributed among users, supporting project sustainability.

Public-Private Partnerships (PPPs): Encouraging collaboration between public and private entities through PPPs can attract private investment and expertise, sharing both risks and rewards in water reuse projects.

Insurance Mechanisms: Developing insurance products or risk-sharing mechanisms can mitigate financial risks associated with water reuse projects, providing a safety net for investors and project developers.

2.2.3.2 Non-financial measures

Capacity Building: Investing in training programs and capacity building for local water utilities and industries can enhance their ability to manage and maintain water reuse technologies efficiently. In addition, it could also help with to enhance acceptance rates against expected reluctance to adopt the technology.

Tariff and Pricing Policies: Implement tariff structures, pricing mechanisms, and financial incentives that promote water reuse and reward water-saving behaviours among users. Introduce differential pricing for recycled water, offer discounts or rebates for recycled water customers, and adjust water tariffs to reflect the true cost of water services and incentivize conservation.

Regulatory Reform: Advocate for regulatory reform and policy incentives that promote water reuse, streamline permitting processes, and remove regulatory barriers to investment. Lobby policymakers to enact legislation, regulations, and standards that facilitate the development, financing, and operation of water reuse infrastructure and projects.

Knowledge Sharing and Best Practices: Share knowledge, lessons learned, and best practices from successful water reuse projects to build investor confidence, replicate successful models, and promote industry standards and benchmarks for financial performance. Foster collaboration, networking, and knowledge exchange among stakeholders to learn from each other's experiences and improve investment outcomes.

2.3 Barrier analysis and possible enabling measures for Rainwater collection from groundwater surfaces

2.3.1 General description of rainwater collection from groundwater surfaces

In regions of water scarcity small-scale collection infrastructure can contribute greatly to the volume of freshwater available for human use. This is especially true in such as the southern lowlands and Senqu river valley in Lesotho, where the little rainfall received is usually very intense and often seasonal. Because of this, runoff and river flows can be abundant for brief periods and non-existent throughout the rest of the year (Pacey and Cullis, 1986; Liebe et al., 2007). This technology entails two broad categories: i) Collecting rainfall from ground surfaces utilizing “micro-catchments” to divert or slow runoff so that it can be stored before it can evaporate or enter watercourses; and ii) Collecting flows from a river, stream or other natural watercourse i.e. floodwater harvesting by constructing an earthen or other structure to dam the watercourse and form “small reservoirs.” Micro-catchments are often used to “store” water as soil moisture for agriculture. Small reservoirs are typically used in areas with seasonal rainfall to ensure that adequate water is available during the dry season.

Collection and storage infrastructure can be natural or constructed and can take many forms including: i) Below ground tanks (i.e. cisterns) and excavations (either lined for waterproofing or unlined) into which rainwater is directed from the ground surface. Volumes of these are typically small (a few m^3 or less) and they are usually used by one household or institution (e.g. a school or health clinic; ii) Small reservoirs with earthen bunds or embankments to contain runoff or river flow. The earthen bunds or embankments are typically built from soil excavated from within the reservoir to increase storage capacity. A spillway or weir allows controlled overflow when storage capacity is exceeded; iii) Groundwater aquifers can be recharged by directing water down an unlined well. Groundwater recharge is also an added benefit of unlined reservoirs; stored water will infiltrate permeable soils during storage and eventually reach the groundwater table; iv) As soil moisture for agriculture, many runoff control methods for irrigation incorporate inundation or extended contact time with soils to increase topsoil moisture. Traditional methods were often developed in response to local conditions and have been practiced for centuries e.g. variations of contour farming to slow runoff flow, increase infiltration and decrease erosion.

Subsurface dams are another form of collection/storage infrastructure that can be used to address these same problems. Though they do not technically collect rain from the ground, they serve the same purpose as the above technologies. They have been used in Phamong (Mohale's Hoek) and Mapotu (Mafeteng) where riverbeds are often dry for a portion of the year. They consist of a low-permeability barrier (e.g. concrete) inserted into the ground across a riverbed, blocking the direction of flow. Though a seasonal riverbed may be dry at the surface, subsurface flow often continues throughout the year. Drilling a well on the upstream side of the subsurface dam enables access to water year-round. Subsurface dams cannot be applied everywhere and will only work when the stream is underlain by a shallow impermeable layer such as bedrock or clay. However, they have the advantages over conventional dams e.g. less evaporative loss, superior water quality, and less vector/parasite breeding (WHO, 2007; Foster and Tuinof, 2004).

Rainwater collected from the ground surface is typically used for non-potable purposes, including irrigation, general domestic use, and livestock. However, in some regions with seasonal rainfall small reservoirs are commonly used for drinking water supply during the dry season, despite the high turbidity and poor bacteriological quality of the water (Cobbina et al., 2010).

2.3.2 Identification of barriers for rainwater collection from groundwater surfaces

Addressing economic and financial barriers for rainwater collection technologies requires a combination of supportive policies, financial incentives, and public awareness to promote sustainable and cost-effective water management practices. A number of were identified along with associated measures to address them and these are the similar to those of rain water harvesting detailed in Appendices 3-1 and 3-2.

2.3.2.1 Economic and financial barriers

Initial Infrastructure Costs: The installation of rainwater collection systems involves significant upfront costs for equipment, storage tanks, and distribution infrastructure, which can be a financial barrier.

Maintenance and Operation Expenses: Ongoing maintenance and operation costs, including repairs and system upkeep, can strain budgets and hinder the economic viability of rainwater collection technologies.

Limited Funding Sources: Insufficient availability of funding, either through government grants, private investments, or community contributions, may impede the widespread adoption of rainwater collection systems.

Lack of Financial Incentives: The absence of financial incentives, such as tax breaks or subsidies, may discourage individuals, businesses, or municipalities from investing in rainwater collection infrastructure.

Uncertain Return on Investment: The unpredictability of the long-term economic benefits, such as reduced water bills or savings, may make potential investors hesitant to commit to rainwater collection projects.

Inadequate Pricing Models: Water pricing structures that do not account for the true cost of water may undermine the economic rationale for rainwater collection, as the financial benefits may not be fully realized.

Insurance and Liability Concerns: Lack of insurance options or concerns about liability in case of system failure or water quality issues may increase perceived risks and financial barriers.

High Payback Periods: The time it takes to recoup the initial investment through cost savings may be lengthy, making rainwater collection projects less attractive from a financial perspective.

2.3.2.2 Non-economic barriers

Regulatory Barriers: Complex or unclear regulations related to rainwater harvesting, including permitting processes and water rights, can create additional costs and uncertainties, acting as economic deterrents.

Land Ownership and Space Constraints: Issues related to land ownership and limited available space for rainwater collection infrastructure can pose economic challenges, particularly in densely populated urban areas.

Public Awareness and Perception: Lack of awareness or misconceptions about the safety and benefits of rainwater collection may create resistance among individuals or communities, acting as a non-economic barrier.

Cultural and Social Factors: Cultural beliefs and social norms regarding water sources may influence acceptance or reluctance to adopt rainwater collection technologies.

Technical Complexity: The technical intricacies of rainwater collection systems may pose challenges, especially for individuals or communities with limited technical expertise, acting as a non-economic barrier.

Regulatory and Permitting Challenges: Complex or unclear regulations, permitting processes, and zoning restrictions can create non-economic barriers, making it difficult to implement rainwater collection systems.

Water Quality Concerns: Perceived or actual concerns about water quality, contamination, or health risks associated with collected rainwater may hinder adoption.

Limited Space and Aesthetics: Constraints on available space, especially in urban environments, and concerns about the visual impact of rainwater collection infrastructure may be non-economic barriers.

Lack of Local Expertise: Insufficient local expertise in designing, installing, and maintaining rainwater collection systems may impede their successful implementation.

Community Engagement and Trust: Lack of community engagement or trust in the reliability and effectiveness of rainwater collection systems can be a non-economic barrier.

Resistance to Change: Resistance to change or inertia in adopting new water management practices, even if economically viable, can act as a significant non-economic barrier.

Perception of Alternatives: The perception that alternative water sources or traditional water supply systems are more reliable may discourage the adoption of rainwater collection technologies.

2.3.3 Identified measures

2.3.3.1 Economic and financial measures

Government Subsidies: Providing financial support through subsidies can help offset the initial costs of installing rainwater collection systems, making them more economically feasible for individuals and businesses.

Tax Incentives: Offering tax credits or deductions for investments in rainwater harvesting infrastructure encourages private individuals and organizations to invest in these technologies.

Low-Interest Loans: Establishing financial mechanisms that offer low-interest loans for rainwater collection projects can make funding more accessible and affordable, facilitating widespread adoption.

Performance-Based Financing: Introducing financing models tied to the performance and effectiveness of rainwater collection systems can align economic incentives with successful implementation.

Water Pricing Policies: Implementing water pricing structures that reflect the true cost of water can create economic incentives for adopting rainwater collection technologies by highlighting potential cost savings.

Insurance Mechanisms: Developing insurance products or risk-sharing mechanisms can mitigate financial risks associated with rainwater collection systems, providing a safety net for investors and users.

Public-Private Partnerships (PPPs): Encouraging collaboration between public and private entities through PPPs can attract private investment and expertise, supporting the implementation of rainwater collection projects.

Capacity Building and Training Incentives: Offering incentives for training programs and capacity building in rainwater harvesting technologies can enhance the skills and knowledge of individuals involved in implementation. In addition, it would go a long way to allay the fears of those who are not convinced with the use of water collected from tanks.

Research and Development Funding: Allocating funds for research and development in rainwater collection technologies can drive innovation, reduce costs, and improve overall economic viability.

Incentive Programs for Water Utilities: Providing financial incentives for water utilities to integrate rainwater collection into their infrastructure can accelerate the adoption of these technologies in broader water management strategies.

2.3.3.2 Non-economic measures

Shared and Community-Based Approaches: Implement shared, communal, or cooperative rainwater harvesting initiatives that pool resources, share costs, and leverage collective land assets among multiple stakeholders, property owners, or community members. Foster collaboration, partnerships, and joint ventures that enable shared access to land for rainwater collection, storage, and distribution purposes, maximizing efficiency and reducing individual land requirements.

Incentives for Landowners: Provide incentives, tax breaks, or financial incentives for landowners, property developers, and homeowners who allocate land for rainwater collection infrastructure, such as tax credits, rebates, or zoning incentives that encourage voluntary participation in rainwater harvesting programs. Work with local governments, regulatory authorities, and planning agencies to develop incentive programs that promote landowner participation and support rainwater harvesting initiatives.

Land Use Regulations and Zoning Policies: Advocate for land use regulations, zoning policies, and planning guidelines that recognize and accommodate rainwater harvesting installations as permissible land uses, land improvements, or accessory structures within residential, commercial, or industrial developments. Lobby for zoning code amendments, land use ordinances, or development standards that facilitate rainwater collection projects and streamline permitting processes for landowners.

Easements and Land Agreements: Negotiate easements, land leases, or land use agreements with landowners, property managers, or public agencies to secure access to land for rainwater collection purposes. Establish legal agreements that grant rights-of-way, access privileges, or land use permissions for installing, maintaining, and operating rainwater harvesting infrastructure on private or public lands, ensuring long-term land availability and security.

Urban Planning and Design Integration: Integrate rainwater harvesting considerations into urban planning, land use planning, and site design processes to incorporate rainwater collection features, green infrastructure, and water-sensitive design principles into built environments. Collaborate with urban planners, landscape architects, and design professionals to incorporate rainwater harvesting into land development projects, urban renewal initiatives, and infrastructure investments, enhancing both water resilience and liveability.

2.4 Barrier analysis and possible enabling measures for Boreholes as a drought intervention for domestic water supply

2.4.1 General description of boreholes as a drought intervention for domestic water supply

Increasing access to groundwater is a key strategy for household water supply (both potable and non-potable) during drought. Therefore, drought relief programs in rural areas typically incorporate drilling or deepening of boreholes. However, these activities are often inefficient and may be unnecessary (Moss, 2003). Boreholes are more specifically defined as tubewells penetrating bedrock, with casing not extending below the interface between unconsolidated soil and bedrock. They require a drilling method with an external power source. The choice of technology and drilling method depends on the cost, resources, groundwater table, desired yield and other factors.

Three major strategies are employed for increasing borehole water supply during drought: a) Drilling new boreholes/deepening existing boreholes: These strategies form the basis of conventional approaches to improving groundwater access in rural areas during drought. They are frequently appropriate for mitigating extreme symptoms of drought although they are often not the most efficient use of limited resources (Moss, 2003). Additionally, groundwater surveys and proper siting of boreholes are necessary for achieving maximum impact.

2.4.2 Identification of barriers for boreholes as a drought intervention for domestic water supply

Experience in many parts of Lesotho indicates high levels of breakdown and poor maintenance of boreholes. Thus, more often than not, it is not so much groundwater depletion or lowering of water tables during drought but failure of individual boreholes due mechanical failure. In other areas studies also revealed that most non-functional boreholes had failed because of problems with hardware (e.g. pump failure) or demand management (e.g. localized drawdown) (Moss, 2003). The failure of a water point (including traditional sources) increases pressure on boreholes, increasing demand, local drawdown and hardware failure. Thus, repairing damaged boreholes is a quick and inexpensive way to prevent this cascade of water point failure (Calow et al., 1997); Relief boreholes with use restricted to drought periods: Development of deep “relief boreholes” that remain capped when water supplies are adequate and are uncapped for use during drought is a strategic coping innovation (Burdon, 1985). Appendices 5-1 and 5-2 the barriers and measures identified.

2.4.2.1 Economic and financial barriers

High Initial Investment Costs: Drilling boreholes involves significant upfront expenses, including the cost of drilling equipment, labour, and materials, which can be a substantial economic barrier.

Operational and Maintenance Expenses: Ongoing operational and maintenance costs for borehole systems, including pump maintenance and water quality monitoring, can strain budgets and pose financial challenges.

Limited Funding Sources: Insufficient availability of funding, either through government allocations, donor support, or community contributions, may impede the implementation of boreholes for drought intervention.

Lack of Financial Incentives: The absence of financial incentives, such as subsidies or tax breaks, may discourage individuals, communities, or governments from investing in borehole projects.

Uncertain Return on Investment: The unpredictability of the long-term economic benefits, such as reduced dependence on alternative water sources or increased resilience to drought, may make potential investors hesitant.

Inadequate Cost Recovery Mechanisms: Challenges in establishing effective cost recovery mechanisms, such as user fees, can impact the sustainability of borehole projects and hinder their economic viability.

Regulatory Barriers: Complex or unclear regulations related to borehole drilling permits, water rights, and environmental compliance can create additional costs and uncertainties, acting as economic deterrents.

Insurance and Liability Concerns: Lack of insurance options or concerns about liability in case of borehole system failure or water quality issues may increase perceived risks and financial barriers.

2.4.2.2 Non-economic barriers

Land Ownership and Access Issues: Challenges related to land ownership, rights, and access for drilling boreholes may create economic barriers, particularly in areas with complex land tenure systems.

Technical Challenges: The technical complexity of borehole drilling and maintenance may act as a non-economic barrier, especially in areas with limited technical expertise or access to skilled personnel.

Environmental Impact and Compliance: Concerns about the environmental impact of borehole drilling, potential land degradation, and compliance with environmental regulations may pose non-economic barriers.

Community Perceptions and Acceptance: Lack of awareness, misinformation, or negative perceptions about boreholes and groundwater usage may create resistance among local communities, acting as a non-economic barrier.

Cultural and Social Factors: Cultural beliefs and social norms regarding water sources, rituals, or traditions may influence acceptance or reluctance to adopt borehole technology.

Competition for Groundwater Resources: Conflicts arising from competition for groundwater resources among various users, including agriculture, industry, and domestic users, may hinder borehole projects.

Public Awareness Campaigns: Implementing educational initiatives and awareness campaigns to inform the public about the benefits and safety of rainwater collection can promote acceptance and support.

Community Engagement: Actively involving local communities in the decision-making process, seeking their input, and addressing their concerns can contribute to the successful implementation of rainwater collection projects.

Technical Assistance and Training: Providing technical assistance, workshops, and training programs for individuals and communities can build the necessary skills and knowledge for the effective use of rainwater collection systems.

Demonstration Projects: Launching pilot or demonstration projects can showcase the practicality and advantages of rainwater collection, helping to build confidence and trust among stakeholders.

Clear and Simple Regulations: Establishing clear and straightforward regulations for rainwater harvesting, including simplified permitting processes, can reduce non-economic barriers related to regulatory complexity.

2.4.3 Identified measures

2.4.3.1 Economic and financial measures

Government Funding and Subsidies: Providing financial support through government funding or subsidies can help offset the initial costs of borehole drilling, making it more financially viable for communities.

Public-Private Partnerships (PPPs): Encouraging collaborations between public and private entities through PPPs can attract private investment and expertise, leveraging resources for borehole implementation.

Microfinance and Loan Programs: Establishing microfinance or loan programs for communities or individuals can offer financial assistance for borehole projects, with manageable repayment terms.

Tax Incentives: Offering tax incentives for individuals or businesses investing in boreholes encourages private sector participation and can reduce the overall financial burden.

User Fees and Tariffs: Implementing transparent user fees or tariffs for water usage from boreholes can create a sustainable revenue stream for maintenance and operational costs.

Community Contributions: Encouraging communities to contribute financially, either through direct contributions or community fundraising initiatives, promotes a sense of ownership and responsibility for borehole projects.

Water Pricing Policies: Establishing water pricing policies that reflect the true cost of water, including the expenses associated with borehole implementation and maintenance, can incentivize sustainable use.

Insurance Mechanisms: Developing insurance products or risk-sharing mechanisms can mitigate financial risks associated with borehole projects, providing a safety net for investors and communities.

Capacity Building Investments: Investing in training programs and capacity building for local communities enhances their ability to manage and maintain borehole systems efficiently, ensuring long-term financial sustainability.

Research and Development Funding: Allocating funds for research and development in borehole technologies can drive innovation, reduce costs, and improve the overall economic viability of these interventions.

2.4.3.2 Non-economic barriers

Community Engagement and User Education: Engage the community, system users, and stakeholders in system operation, maintenance, and sustainability efforts through education, outreach, and participation initiatives. Foster a sense of ownership, responsibility, and stewardship among system users by involving them in decision-making, training programs, and maintenance activities to promote long-term system viability and user satisfaction.

Policy Advocacy and Engagement: Advocate for the development of clear and supportive policies, regulations, and guidelines governing borehole construction, operation, and management, emphasizing the importance of water security, resilience, and sustainability in drought-prone regions. Engage with government agencies, regulatory authorities, and policymakers to raise awareness about the role of boreholes in drought mitigation, water supply augmentation, and community resilience, highlighting the need for flexible and enabling regulatory frameworks.

Capacity Building and Training: Build capacity within regulatory agencies, local governments, and relevant institutions to effectively implement and enforce regulatory frameworks governing borehole projects, providing training, technical assistance, and knowledge sharing on regulatory compliance, monitoring, and enforcement. Equip water resource management authorities with the tools, resources, and expertise needed to assess borehole applications, conduct hydrogeological assessments, and ensure compliance with environmental, health, and safety regulations.

Compliance Monitoring and Enforcement: Strengthen compliance monitoring and enforcement mechanisms to ensure that borehole projects adhere to regulatory requirements, permit conditions, and technical standards, conducting regular inspections, site visits, and audits to verify compliance with applicable regulations. Establish penalties, sanctions, and enforcement measures for non-compliance with regulatory obligations, including fines, license revocation, or legal action against violators, deterring unauthorized borehole drilling, groundwater abstraction, or environmental pollution.

Policy Harmonization and Coordination: Promote policy harmonization and coordination among relevant government agencies, ministries, and departments responsible for water resources management, land use planning, environmental protection, and public health, fostering integrated approaches to borehole regulation and governance. Establish inter-agency coordination mechanisms, task forces, or inter-ministerial committees to facilitate collaboration, information sharing, and joint decision-making on regulatory issues related to borehole development, ensuring coherence and alignment with broader development objectives.

2.5 Linkages of the barriers identified

The technologies for rainwater collection from ground surfaces, boreholes as drought interventions for domestic water supply, and water reuse are interconnected. Table 10 shows the linkages between these barriers.

Table 10. Linkages to barriers identified in the water sector

Barrier	Linkage
Limited funding sources can hinder investments in rainwater collection infrastructure, borehole drilling projects, and water reuse technologies due to insufficient financial resources.	Inadequate funding may impede the development and implementation of rainwater collection systems, borehole installations, and water reuse projects. Without sufficient financial support, these initiatives may struggle to overcome technical, regulatory, and operational challenges.
Lack of financial incentives may discourage investment in rainwater collection, borehole development, and water reuse initiatives, as there may be little economic motivation for stakeholders to adopt these technologies	Financial incentives play a crucial role in incentivizing the adoption the selected technologies. Without financial incentives, stakeholders may be less motivated to invest in these initiatives, even if they offer long-term benefits.

Barrier	Linkage
Uncertain return on investment can deter stakeholders from investing in rainwater collection, borehole drilling, and water reuse projects, particularly if the economic benefits are unclear or perceived as risky.	Uncertainty about the financial returns of rainwater collection systems, borehole interventions, and water reuse technologies can undermine investor confidence and hinder their adoption. Clarifying the potential economic benefits and risks is essential for attracting investment and promoting uptake.
Regulatory barriers, such as permitting requirements, water rights regulations, and environmental standards, can create obstacles for prioritized technology initiatives.	Regulatory hurdles can impede the development and deployment of rainwater collection systems, borehole projects, and water reuse technologies by imposing compliance burdens, administrative delays, and legal uncertainties. Streamlining regulations and permitting processes is essential for facilitating their adoption.
Community perceptions, attitudes, and acceptance of rainwater collection, borehole interventions, and water reuse technologies may influence their adoption and implementation.	Engaging communities, addressing concerns, and promoting awareness about the benefits of these initiatives are crucial for gaining local support and acceptance. Building trust and fostering community participation can enhance their success.
Technical complexity and knowledge gaps related to rainwater collection, borehole drilling, and water reuse technologies may present challenges for stakeholders, particularly in resource-constrained settings.	Thus, providing technical assistance, capacity building, and training on rainwater collection systems, borehole construction techniques, and water reuse technologies can help overcome barriers related to technical complexity. Enhancing stakeholders' technical skills and knowledge is essential for successful implementation
High operational costs and maintenance expenses can be challenges for sustaining rainwater collection infrastructure, borehole installations, and water reuse systems over the long term.	Ensuring sustainable financing mechanisms, cost-effective operation, and proactive maintenance are essential for addressing barriers related to operational costs and maintenance expenses. Developing innovative financing models and promoting community ownership can help ensure their sustainability

Addressing these interlinked barriers requires a comprehensive approach that considers the synergies and dependencies between rainwater collection, borehole interventions, and water reuse technologies in the water sector. Integrated strategies that address financial, regulatory, technical, social, and environmental factors can help overcome barriers and promote sustainable water management practices and resilience-building measures.

2.6 Enabling framework for overcoming the barriers in the Water Sector

Creating an enabling framework for overcoming barriers to adaptation in the water sector involves a combination of policy, regulatory, institutional, financial, and technological measures. Here are key components of an enabling framework. By implementing these components within an enabling framework, policymakers, practitioners, and stakeholders can enhance the adaptive capacity of the water sector, build resilience to climate change impacts, and ensure sustainable water management for present and future generations. Table 11 details the barriers against the enabling framework.

Table 11 Key components of an enabling framework for overcoming barriers in the water sector

Barrier	Enabling Framework	Responsible Entity
Policy and Regulatory Support	Develop and implement supportive policies, strategies, and regulatory frameworks that prioritize water sector adaptation to climate change and variability.	Water Commission
	Integrate adaptation considerations into national water policies, strategies, and plans, ensuring coherence with broader climate change adaptation and sustainable development agendas	
	Establish clear regulatory guidelines, standards, and incentives to promote the adoption of climate-resilient water management practices and technologies	
Stakeholder Engagement and Participation	Foster multi-stakeholder engagement and collaboration across government agencies, water utilities, civil society organizations, academia, private sector entities, and local communities	Integrated Catchment Management
	Involve stakeholders in the planning, decision-making, and implementation of water sector adaptation initiatives, ensuring their perspectives, needs, and knowledge are incorporated into adaptation strategies	Water Commission
Capacity Building and Knowledge Sharing	Enhance technical capacity, skills, and knowledge among water sector professionals, policymakers, and practitioners through training, capacity-building programs, and knowledge-sharing platforms.	Department of Water Affairs
	Promote research, innovation, and learning in climate-resilient water management practices, technologies, and adaptation strategies, facilitating the exchange of best practices and lessons learned.	Academia
Investment and Financing Mechanisms	Mobilize financial resources, investments, and funding mechanisms to support climate-resilient water infrastructure, projects, and initiatives.	Water Commission
	Develop innovative financing models, public-private partnerships, and risk-sharing mechanisms to attract private sector investment and leverage public funds for water sector adaptation.	Water Commission
Technology Transfer and Innovation	Facilitate technology transfer, diffusion, and adaptation of innovative water management technologies, tools, and practices suitable for local contexts and conditions.	Academia, DWA
	Promote research and development in climate-resilient water technologies, including drought-resistant irrigation systems, rainwater harvesting techniques, and water reuse technologies.	Academia
Risk Assessment and Management	Conduct comprehensive risk assessments to identify climate-related hazards, vulnerabilities, and impacts on water resources, infrastructure, and ecosystems	Academia, DWA

Barrier	Enabling Framework	Responsible Entity
	Develop risk management strategies, early warning systems, and contingency plans to enhance resilience to climate risks and ensure adaptive capacity in the face of uncertainty.	LMS
Monitoring, Evaluation, and Learning	Establish monitoring and evaluation frameworks to track progress, measure performance, and assess the effectiveness of adaptation interventions in the water sector.	Water Commission
	Foster a culture of learning, innovation, and continuous improvement through knowledge exchange, peer-to-peer learning, and participatory feedback mechanisms	Academia
Cross-sectoral Coordination	Promote cross-sectoral coordination and integration of water sector adaptation with other sectors, such as agriculture, energy, infrastructure, and urban planning, to address interconnected challenges and maximize co-benefits	Water Commission
	Foster collaboration between water-related sectors and stakeholders to promote integrated water resources management, climate resilience, and sustainable development.	Integrated Catchment Management, Water Commission

List of References

Anyoni, G. O., Alinda, V., Imalingat, M., Okello, R., & Otim, S. 2015. Conserving soils: An assessment of the cost effectiveness of soil and water conservation techniques in Otuke district, Uganda. International Water Management Institute (IWMI); CGIAR Research Program on Water, Land and Ecosystems (WLE); Global Water Initiative East Africa (GWI EA).

Biazin, B., Sterk, G., Temesgen, M., Abdulkedir, A., & Stroosnijder, L. 2012. Rainwater harvesting and management in rainfed agricultural systems in sub-Saharan Africa–a review. Physics and Chemistry of the Earth, Parts A/B/C, 47, 139-151.

Boers, T. M. and J. Ben-Asher. 1982. A review of rainwater harvesting. In Agriculture Water Management. 5:145-158.

Burdon, D.J. 1985. Groundwater against drought in Africa. In Hydrogeology in the Service of Man, Mémoires of the 18th Congress of the International Association of Hydrogeologists. Cambridge. http://iahs.info/redbooks/a154/iahs_154_02_0076.pdf.

Calow, R.C., Robins, N.S., Macdonald, A.M., Macdonald, D.M.J., Gibbs, B.R., Orpen, W.R.G., Mtembezeka, P., Andrews, A.J., and Appiah, S.O. 1997. Groundwater management in drought prone areas of Africa. Water Resources Development Vol. 13:241-261.

CIAT; World Bank. 2018. Climate-Smart Agriculture in Lesotho. CSA Country Profiles for Africa Series. International Center for Tropical Agriculture (CIAT); Washington, D.C. 28 p.

Cobbina, S.J., Anyidoho, L.Y., Nyame, F. And Hodgson, I.O.A. 2010. Water quality status of dugouts from five districts in Northern Ghana: implications for sustainable water resources management in a water stressed tropical savannah environment. Environ Monit Assess. Vol. 167:405-416.

Foster, S. and Tuinof, A. 2004. Brazil, Kenya: Subsurface Dams to Augment Groundwater Storage in Basement Terrain for Human Subsistence. The World Bank. GW-MATE Case Profile Collection. Washington, DC. https://www.un-igrac.org/sites/default/files/resources/files/GWMATE% 20case%20 profile%20-%20Brazil%20%26%20Kenya.pdf.

Government of Lesotho. 2007. Lesotho Water and Sanitation Policy. Lesotho. Available at: https://www.water.org.ls/download/lesotho-water-and-sanitation-policy-2007/

Hatibu, N., Mutabazi, K., Senkondo, E. M., & Msangi, A. S. K. 2006. Economics of rainwater harvesting for crop enterprises in semi-arid areas of East Africa. *Agricultural Water Management*, *80* (1-3), 74-86.

Kiggundu, N., Wanyama, J., Mfitumukiz, D., Twinomuhangi, R., Barasa, B., Katimbo, A., & Kyazze, F. 2018. Rainwater harvesting knowledge and practice for agricultural production in a changing climate: A review from Uganda's perspective. Agricultural Engineering International: CIGR Journal, 20 (2), 19-36.

Lambert D.M., E. Bisangwa, N.S. Eash, and M. V. Marake. 2016. Minimal tillage and crop residue retention adoption, input demand, and maize (Zea mays L.) production: A household survey analysis of smallholder producers in Lesotho. Journal of Soil and Water Conservation 71(2):118-128.

Liebe, J., Andreini, M., van de Giesen, N. and Steenhuis, T. 2007. The small reservoirs project: Research to improve water availability and economic development in rural semi-arid areas. IN: Kittisou, M., Ndulo, M., Nagel, M. and Grieco, M. (eds.). 2007. The hydropolitics of Africa: A contemporary challenge. Newcastle, United Kingdom: Cambridge Scholars Publishing. https://hdl.handle.net/10568/17130

Lesotho Meteorological Services. 2017. Lesotho's Nationally Determined Contribution under the United Nations Framework Convention on Climate Change. Ministry of Energy and Meteorology, Lesotho. Available at: https://unfccc.int/sites/default/files/NDC/2022-06/Lesotho%20First%20NDC.pdf

Moss, S. 2003. "Re-evaluating emergency water supply in complex droughts in Africa" Towards the Millennium Development Goals. 29th WEDC Conference Proceedings.

Mzirai O.B and S.D. Tumbo. 2010. Macro-catchment rainwater harvesting systems: challenges and opportunities to access runoff, Journal of Animal & Plant Sciences,. Vol. 7, Issue 2: 789-800.

Nhemachena, C.; Matchaya, G.; Nhlengethwa, S. 2017. Agricultural growth trends and outlook for Lesotho. ReSAKSS-SA Annual Trends and Outlook Report 2016. International Food Policy Research Institute (IFPRI); International Water Management Institute (IWMI)

Pacey, A. and Cullis, A. 1986. Rainwater Harvesting: The collection of rainfall and runoff in rural areas. Intermediate Technology Publications. London.

Terrain for Human Subsistence. The World Bank. GW-MATE Case Profile Collection. Washington, DC.
https://www.ungrac.org/sites/default/files/resources/files/GWMATE%20case%20profile%20-%20Brazil%20%26%20Kenya.pdf

UNEP. 2012. Early Warning Systems: A State of the Art Analysis and Future Directions. Division of Early Warning and Assessment (DEWA), United Nations Environment Programme (UNEP), Nairobi

UNEP-IETC. 1998. Sourcebook of Alternative Technologies for Freshwater Augmentation in Some Asian Countries. IETC Technical Publication Series 8b, UNEP IETC/UNEP-IETC/Danish Hydraulic Institute.

World Health Organization. 2007. The International Decade For Action Water For Life - 2005-2015. World Health Organization. Geneva.
http://www.who.int/water_sanitation_health/wwd7_water_scarcity_final_rev_1.pdf

Appendices

1-1. Financial Barriers and Measures Identified for DCEWS

<table>
<tr><th colspan="2">Economic and Financial Barriers and Measures for DCEWS</th></tr>
<tr><th>Barriers</th><th>Measures</th></tr>
<tr><td colspan="2">Addressing these economic and financial barriers requires international collaboration, innovative funding mechanisms, and a recognition of the long-term benefits of effective climate change monitoring and early warning systems.</td></tr>
<tr><td>1.0 High Initial Costs

Lesotho is a mountainous terrain with deep valleys requiring high grid density within a small geographic space. This makes the cost of setting up a meteorological, operation and management of station network and prohibitive within the government budget. The upfront expenses for acquiring and setting up advanced monitoring technologies, and sensor networks can be substantial, creating a barrier for Lesotho given its with limited financial resources. The cost of an automatic weather station is approximately Euro 10,000.00 (climate) and Euro 15,000.00 (Personal Communications). Thus, costs of proper instrumentation are prohibitive given that there are many competing demands for national resources and the possibility of providing information that the public cannot understand and make use of.</td><td>1.1 Dedicated Funding: Allocate specific and reliable budgets for the establishment, maintenance, and upgrading of climate change monitoring and early warning systems. This ensures a consistent financial commitment.

1.2 Public-Private Partnerships (PPPs): Foster collaboration between governments, academia and private sector entities to share costs, leverage expertise, and enhance financial resources for implementing and sustaining these systems.
1.3 International Aid and Grants: Lesotho must hone its capacity to leverage and seek international assistance through grants and aid from developed nations, climate funds and global organizations for support to acquire and maintain climate monitoring technologies.
1.4 Carbon Pricing: Establish or enhance carbon pricing mechanisms, such as carbon taxes or cap-and-trade systems. The revenue generated can be directed towards funding climate-related initiatives, including monitoring systems.
1.5 Green Finance Initiatives: Encourage financial institutions to invest in green finance and support projects related to climate change mitigation and adaptation, including the implementation of monitoring technologies.
1.6 Incentive Programs: Create financial incentives, such as tax breaks or subsidies, for</td></tr>
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Economic and Financial Barriers and Measures for DCEWS	
Barriers	**Measures**
	businesses and organizations that invest in or develop technologies related to climate change monitoring and early warning systems. **1.7 Climate Bonds**: Promote the issuance of climate bonds to raise funds for climate-related projects, including the implementation of monitoring technologies. These bonds attract investors interested in environmentally sustainable initiatives.
2.0 Ongoing Maintenance Expenses The operation and management costs include security and data retrieval costs and are compounded by a sparse electrical grid especially within the remote rural locations. Thus, sustaining and updating monitoring systems require continuous investments. Regular maintenance, software updates, and technology upgrades contribute to long-term costs that some regions may find challenging to bear. Lightening presents serious challenges in the mountains of Lesotho in particular and strikes can take a station out of functionality hence such electronic protection and maintenance may be high.	Maintaining decentralized community early warning systems can be challenging, but here are some potential solutions: **2.1 Community Engagement and Ownership:** Foster community ownership by involving residents in the maintenance process. This can include training community members to handle basic repairs, conducting regular community meetings to discuss system upkeep, and encouraging participation in system monitoring. **2.2 Training and Capacity Building:** Provide training sessions for community members on system maintenance, troubleshooting, and data management. This empowers locals to address minor issues and reduces the need for external support. **2.3 Partnerships and Collaboration:** Collaborate with local organizations, government agencies, or international NGOs to share resources, expertise, and funding for maintenance activities. Partnerships can help distribute the financial burden and ensure long-term sustainability. **2.4 Technology Design for Sustainability:** Design systems with durability and ease of

Economic and Financial Barriers and Measures for DCEWS	
Barriers	**Measures**
	maintenance in mind. Use robust, low-maintenance hardware and open-source software solutions that are accessible and adaptable to local contexts. **2.5** **Regular Inspections and Maintenance Schedules:** Establish a regular schedule for system inspections and maintenance activities. This includes checking sensors, cleaning equipment, and updating software to ensure optimal performance. **2.6** **Community Funding Mechanisms**: Explore community-driven funding mechanisms such as crowdfunding, micro-financing, or community savings groups to finance ongoing maintenance costs. **Encourage residents to contribute financially based on their ability to pay.** **2.7** **Incentives and Recognition:** Provide incentives or recognition to individuals or groups within the community who actively participate in maintenance efforts. This can include certificates of appreciation, public recognition, or small rewards to motivate continued engagement. **2.8** **Data Monitoring and Remote Diagnostics:** Implement remote monitoring and diagnostic tools to identify maintenance needs quickly. This allows for timely interventions and reduces downtime of the early warning system. **2.9** **Training of Trainers:** Train a select group of individuals within the community to become "trainers of trainers" who can further disseminate maintenance knowledge and skills to others. This cascading model

Economic and Financial Barriers and Measures for DCEWS	
Barriers	**Measures**
	expands the pool of capable maintenance personnel. **2.10 Contingency Planning**: Develop contingency plans for unexpected events or disruptions that may impact the functioning of the early warning system. This includes backup power sources, spare parts inventory, and alternative communication channels. By implementing these solutions, decentralized community early warning systems can be effectively maintained, ensuring their reliability and sustainability in safeguarding communities against potential risks and disasters.
3.0 Data Management Costs Collecting, processing, and analysing large volumes of data generated by climate monitoring systems necessitate sophisticated infrastructure and data management capabilities. The associated costs can be a significant obstacle. In particular, there is need for capacity building through staff training. This has a time lag for development of the requisite skills.	Managing data effectively in decentralized community early warning systems can be critical for their success. Here are some solutions to address data management costs: **3.1 Data Prioritization**: Prioritize essential data collection and storage to minimize costs. Focus on capturing key parameters relevant to early warning objectives while avoiding unnecessary data collection that may inflate storage and processing expenses. **3.2 Open-Source Technologies**: Utilize open-source software solutions for data management to reduce licensing fees and dependence on proprietary platforms. Open-source options often offer robust functionality and community support without the associated costs. **3.3 Cloud Services and Infrastructure**: Leverage cloud computing services to store, process, and analyse data. Cloud platforms

Economic and Financial Barriers and Measures for DCEWS	
Barriers	**Measures**
	offer scalable and cost-effective solutions, allowing communities to pay only for the resources they use, without the need for significant upfront investment in hardware infrastructure. **3.4** **Data Compression and Optimization**: Implement data compression techniques and optimization algorithms to reduce storage requirements and processing overhead. This can help minimize data management costs while maintaining data quality and integrity. **3.5** Data Sharing and Collaboration: Foster data sharing and collaboration among multiple stakeholders, including government agencies, NGOs, research institutions, and other communities. Sharing resources and expertise can help distribute data management costs and improve the effectiveness of early warning systems. **3.6** Capacity Building: Invest in capacity building initiatives to enhance local expertise in data management practices. Provide training and technical assistance to community members on data collection, processing, analysis, and interpretation, empowering them to take ownership of data management tasks. **3.7** Standardization and Interoperability: Adopt standardized data formats and protocols to ensure interoperability across different systems and stakeholders. This facilitates seamless data exchange and integration, reducing the complexity and cost of managing heterogeneous data sources. **3.8** Data Quality Assurance: Implement robust data quality assurance measures to ensure

Economic and Financial Barriers and Measures for DCEWS	
Barriers	**Measures**
	the accuracy, completeness, and reliability of collected data. By minimizing errors and inconsistencies, communities can avoid costly data cleanup and remediation efforts. **3.9** Lifecycle Management: Develop a comprehensive data lifecycle management strategy encompassing data acquisition, storage, processing, analysis, archival, and disposal. This ensures efficient utilization of resources and minimizes unnecessary data retention costs. **3.10** Partnerships and Funding: Forge partnerships with government agencies, development organizations, and private sector entities to secure funding support for data management activities. Grants, sponsorships, and collaborative initiatives can help alleviate the financial burden on communities. By implementing these solutions, decentralized community early warning systems can effectively manage data while controlling costs, enabling communities to make informed decisions and respond proactively to potential hazards and emergencies.
4.0 Training and Capacity Building Skilled personnel are essential for operating and interpreting data from these systems. Training a workforce capable of managing and utilizing advanced technologies adds to the overall expenses including the lag for development of requisite skills and retaining them.	Training and capacity building are essential for the successful implementation and sustainability of decentralized community early warning systems. Here are some solutions to enhance training and capacity building efforts: **4.1 Community Workshops and Training Sessions:** Organize regular workshops and training sessions within the community to educate residents on the importance of early warning systems, their components, and

Economic and Financial Barriers and Measures for DCEWS	
Barriers	**Measures**
	how to use them effectively. These sessions can cover topics such as system operation, maintenance, data interpretation, and emergency response procedures. **4.2** **Train-the-Trainer Programs:** Implement train-the-trainer programs to build a cadre of local leaders and experts who can then train others within the community. This cascading model maximizes the reach and sustainability of training initiatives while empowering community members to take ownership of the process. **4.3** **Interactive Learning Materials**: Develop interactive learning materials such as videos, manuals, and online tutorials tailored to the local context and language. These resources can supplement traditional training methods and accommodate different learning styles, making training more accessible and engaging. **4.4** **Hands-on Practical Exercises:** Provide hands-on practical exercises that allow participants to apply their knowledge and skills in real-world scenarios. This could involve conducting mock drills, simulating emergency situations, or using training equipment to reinforce learning outcomes. **4.5** **Cross-Cultural Training:** Recognize and respect cultural differences within the community by integrating cross-cultural training components into capacity building initiatives. This ensures that training materials and methods are culturally appropriate and resonate with diverse audiences.

Economic and Financial Barriers and Measures for DCEWS	
Barriers	**Measures**
	4.6 **Peer Learning Networks:** Facilitate peer learning networks where community members can exchange experiences, best practices, and lessons learned related to early warning systems. These networks foster collaboration, mutual support, and continuous improvement within the community. **4.7** **Partnerships with Educational Institutions:** Collaborate with local schools, colleges, and universities to integrate early warning system training into formal education curricula. This not only enhances the knowledge and skills of students but also promotes long-term sustainability by embedding awareness from an early age. **4.8** **On-the-Job Training and Apprenticeships**: Offer on-the-job training opportunities and apprenticeships for community members interested in gaining practical experience in early warning system operation and maintenance. Pair novices with experienced mentors to facilitate knowledge transfer and skill development. **4.9** **Mobile Learning Platforms**: Utilize mobile learning platforms and applications to deliver training content directly to community members' smartphones or tablets. Mobile technology enables convenient access to training materials anytime, anywhere, particularly in remote or hard-to-reach areas. **4.10** **Continuous Monitoring and Evaluation:** Establish mechanisms for continuous monitoring and evaluation of training

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	programs to assess their effectiveness and identify areas for improvement. Solicit feedback from participants and stakeholders to tailor future training activities accordingly. By implementing these solutions, decentralized community early warning systems can build the necessary human capacity to effectively utilize and maintain the technology, ensuring its long-term sustainability and resilience in the face of potential hazards and disasters.
5.0 Limited Funding The Government of Lesotho annually allocates limited budgets to environmental initiatives, and climate change monitoring competes with other pressing economic priorities. This limitation in funding creates a significant impediment to the establishment and maintenance of comprehensive monitoring systems.	Limited funding can pose a significant challenge to decentralized community early warning systems, but there are several solutions to address this issue: **5.1 Grant Funding:** Seek grants from government agencies, international organizations, philanthropic foundations, and corporate social responsibility programs dedicated to disaster risk reduction and community resilience. Grant funding can provide essential resources to establish and maintain early warning systems. **5.2 Public-Private Partnerships:** Collaborate with private sector partners, including telecommunications companies, technology providers, and insurance companies, to co-finance early warning system initiatives. Private sector involvement can bring additional funding, expertise, and resources to the table. **5.3 Community Contributions:** Encourage community members to contribute financially or in-kind to support the implementation and maintenance of early warning systems. This could include

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	fundraising events, community dues, volunteer labour, or donations of equipment and materials. **5.4 Cost-sharing Agreements:** Explore cost-sharing agreements with neighbouring communities, local governments, or regional organizations to distribute funding responsibilities and leverage collective resources. Pooling funds and sharing infrastructure can reduce the financial burden on individual communities. **5.5 Crowdfunding Campaigns**: Launch crowdfunding campaigns through online platforms to raise funds from a broader audience, including individuals, businesses, and organizations passionate about disaster preparedness and community resilience. Engage supporters through compelling storytelling and transparent reporting on project progress. **5.6 Resource Mobilization Strategies:** Develop resource mobilization strategies to identify and tap into diverse funding sources, including government grants, international development assistance, community savings groups, microfinance institutions, and social impact investors. Diversifying funding streams reduces dependency on a single source and increases financial resilience. **5.7 In-kind Donations and Pro Bono Services:** Solicit in-kind donations of equipment, software licenses, technical expertise, and pro bono services from corporate partners, technology vendors, academic institutions, and professional

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	associations. Leveraging non-monetary contributions stretches limited funds and extends the reach of early warning initiatives. **5.8 Cost-effective Technologies:** Prioritize the use of cost-effective and scalable technologies for early warning systems, such as low-cost sensors, open-source software, and community-based monitoring approaches. Opting for affordable solutions minimizes upfront investment and ongoing maintenance costs while maximizing the impact of limited funding. **5.9 Advocacy and Awareness Campaigns:** Advocate for increased government funding and policy support for decentralized community early warning systems through public awareness campaigns, advocacy initiatives, and stakeholder engagement activities. Highlighting the social, economic, and environmental benefits of early warning systems can mobilize political will and financial support. **5.10 Long-term Sustainability Planning:** Develop long-term sustainability plans that outline strategies for generating revenue, securing funding, and maintaining operations beyond initial project funding cycles. Sustainable financing models, user fees, revenue-generating activities, and cost recovery mechanisms can help ensure the continuity of early warning system services. By implementing these solutions and adopting a multifaceted approach to funding, decentralized community early warning systems can overcome financial constraints and achieve their goals of

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	enhancing disaster preparedness, reducing risk, and protecting vulnerable communities.
6.0 Lack of Financial Incentives The Lesotho Meteorological Services provides climate information services free of charge hence there is no direct financial incentives for government and private sector organizations to invest in these systems, especially when the benefits are not immediately apparent or tangible.	Addressing the lack of financial incentives for decentralized community early warning systems requires creative approaches to incentivize participation and investment. Here are some measures: **6.1 Insurance Premium Reduction**: Work with insurance companies to offer reduced premiums to communities that implement effective early warning systems. Insurance discounts can serve as a financial incentive for communities to invest in risk reduction measures, including early warning technology. **6.2 Disaster Risk Reduction Funds:** Advocate for the establishment of dedicated funds at the local, national, and international levels to support decentralized community early warning systems. These funds can provide financial incentives in the form of grants, subsidies, or low-interest loans to encourage investment in risk reduction infrastructure. **6.3 Tax Incentives:** Lobby for tax incentives or credits for individuals, businesses, and organizations that contribute financially to the development, maintenance, or improvement of early warning systems. Tax breaks can incentivize private sector involvement and community support for disaster preparedness initiatives. **6.4 Reward Mechanisms:** Introduce reward mechanisms or recognition programs for communities that demonstrate exemplary performance in implementing and maintaining early warning systems. This

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	could include cash prizes, awards, or public recognition to incentivize proactive risk management practices. **6.5 Performance-Based Financing:** Implement performance-based financing mechanisms that tie financial incentives to the achievement of specific targets or outcomes related to early warning system effectiveness, such as timely dissemination of warnings, reduced disaster losses, or increased community resilience. **6.6 Community Revenue Generation:** Explore revenue-generating opportunities associated with early warning systems, such as offering data services, training workshops, or consultancy services to neighbouring communities, businesses, or government agencies. Community-owned enterprises can generate income to sustain the operation and maintenance of early warning infrastructure. **6.7 Public-Private Partnerships:** Foster public-private partnerships to leverage private sector resources, expertise, and technologies for early warning system implementation. Incentivize private sector participation through revenue-sharing arrangements, co-branding opportunities, or access to new markets. **6.8 Community Benefits Sharing:** Ensure that communities directly benefit from the implementation of early warning systems by linking them to broader development objectives, such as improved access to markets, increased agricultural productivity, or enhanced ecosystem services. Tangible

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	benefits can incentivize community buy-in and long-term commitment to early warning initiatives. **6.9** **Community Savings Groups:** Facilitate the formation of community savings groups or revolving funds to pool resources and finance early warning system activities collectively. These groups can provide financial incentives, access to credit, and emergency assistance to members affected by disasters. **6.10** **Capacity Building Grants:** Provide grants or financial support for capacity building activities, such as training workshops, technical assistance, or equipment procurement, to strengthen community resilience and institutionalize early warning practices. Investing in human capital development can yield long-term dividends in disaster risk reduction. By implementing these solutions, stakeholders can address the lack of financial incentives for decentralized community early warning systems, incentivizing investment, participation, and ownership at the local level.
7.0 Global Economic Disparities Like all developing countries, Lesotho faces greater challenges in implementing advanced monitoring systems due to economic disparities. The financial capacity to invest in cutting-edge technologies is beyond its budgetary means.	Addressing the global economic disparities in decentralized community early warning systems requires a combination of targeted interventions and systemic changes. Here are some solutions: **7.1** **International Aid and Funding**: Increase international aid and funding for disaster risk reduction initiatives, including decentralized community early warning systems, particularly in low- and middle-income countries that are most vulnerable to

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Barriers	**Measures**
	natural hazards. Donor countries and international organizations can allocate more resources to support capacity building, technology transfer, and infrastructure development in at-risk communities. **7.2** **Technology Transfer and Adaptation:** Facilitate technology transfer and adaptation by providing assistance to developing countries in accessing and adopting cost-effective early warning technologies. This may involve sharing knowledge, best practices, and innovative solutions from more advanced economies, as well as providing financial and technical support for technology procurement and implementation. **7.3** **South-South Cooperation:** Promote South-South cooperation and collaboration among developing countries to share experiences, expertise, and resources in decentralized community early warning systems. Peer-to-peer learning and exchange can empower countries facing similar challenges to find context-specific solutions and build resilience collectively. **7.4** **Capacity Building and Training:** Invest in capacity building and training programs to strengthen the technical and institutional capabilities of local communities, governments, and civil society organizations in disaster risk management and early warning system operation. Tailored training initiatives can empower communities to take proactive measures to mitigate risks and respond effectively to emergencies.

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	7.5 Inclusive Policy Formulation: Advocate for inclusive policy formulation processes that prioritize the needs and perspectives of marginalized and vulnerable populations, including women, children, elderly, and persons with disabilities. Ensure that decentralized community early warning systems are designed and implemented in a manner that addresses the specific vulnerabilities and capacities of diverse social groups. **7.6 Social Protection Programs:** Integrate decentralized community early warning systems into social protection programs aimed at reducing poverty, inequality, and vulnerability to disasters. Linking early warning with social safety nets, livelihood support, and access to basic services can enhance resilience and promote sustainable development outcomes for disadvantaged communities. **7.7 Public-Private Partnerships:** Foster public-private partnerships to leverage private sector expertise, resources, and innovation in decentralized community early warning systems. Encourage corporate social responsibility initiatives, technology companies, and telecommunications providers to contribute proactively to disaster risk reduction efforts through technology transfer, financial support, and strategic collaborations. **7.8 Climate Finance Mechanisms:** Mobilize climate finance mechanisms, such as the Green Climate Fund, to support the implementation of decentralized community

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	early warning systems as part of broader climate adaptation and resilience-building initiatives. Ensure that financing mechanisms prioritize investments in the most vulnerable regions and communities disproportionately affected by climate change. **7.9 Local Resource Mobilization:** Strengthen local resource mobilization efforts through community-driven fundraising, innovative financing mechanisms, and revenue-generating activities. Empower communities to mobilize their own resources and contribute financially to the development, operation, and maintenance of early warning systems, thereby enhancing local ownership and sustainability. **7.10 Policy Coherence and Integration:** Promote policy coherence and integration across sectors, including disaster risk reduction, climate change adaptation, sustainable development, and poverty alleviation. Align national policies, strategies, and investments to mainstream decentralized community early warning systems into broader development agendas, fostering synergies and maximizing impact on economic disparities and resilience-building efforts. By implementing these solutions in a coordinated and inclusive manner, stakeholders can address the global economic disparities in decentralized community early warning systems, advancing sustainable development, reducing vulnerability, and building resilience for all.

1-2. Non- Financial Barriers and Measures Identified for DCEWS

Non-Financial Barriers and Measures for DCEWS	
Barriers	**Measures**
1.0 Technical Challenges Implementing advanced monitoring systems in Lesotho is hindered by technical complexities, including interoperability issues, data integration challenges, and the need for albeit unaffordable specialized technical expertise at LMS and other government institutions where the direct use of climate information services is imperative.	Addressing technical challenges and non-financial barriers for decentralized community early warning systems requires a comprehensive approach that focuses on capacity building, technology innovation, collaboration, and community engagement. Here are some ways to tackle these challenges: **1.1 Technical Training and Capacity Building:** Provide technical training and capacity building programs for community members, local authorities, and relevant stakeholders on the operation, maintenance, and troubleshooting of early warning system components. This includes training on sensor installation, data analysis, communication protocols, and emergency response procedures. **1.2 Local Technology Adaptation:** Adapt and customize early warning technologies to suit the local context, environmental conditions, and cultural preferences of the community. Engage local stakeholders in the design and development process to ensure that technology solutions are user-friendly, affordable, and culturally appropriate. **1.3 Open-Source Solutions:** Embrace open-source software and hardware solutions for early warning systems, which offer flexibility, transparency, and cost-effectiveness. Open-source platforms enable communities to customize and adapt technology tools according to their specific needs and requirements without being locked into proprietary systems. **1.4 Interoperability Standards:** Promote interoperability standards and protocols to ensure seamless integration and compatibility between different early warning system components, data sources, and communication networks. Standardization facilitates data exchange, collaboration, and information sharing among stakeholders.

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Barriers	**Measures**
	1.5 Mobile and Internet Technologies: Harness the power of mobile and internet technologies to enhance early warning system effectiveness. Develop mobile applications, SMS alerts, and online platforms for disseminating warnings, collecting real-time data, and engaging with community members in risk communication and preparedness activities. **1.6 Community-Based Monitoring:** Empower communities to participate in decentralized monitoring and data collection efforts through citizen science initiatives, community-based sensors, and participatory mapping. By involving local residents as active contributors to the early warning system, communities can improve data accuracy, timeliness, and relevance. **1.7 Infrastructure Resilience:** Strengthen the resilience of critical infrastructure, such as communication networks, power supply, and sensor networks, to withstand natural hazards and man-made disruptions. Invest in robust infrastructure design, redundancy measures, and backup systems to minimize downtime and ensure system continuity during emergencies. **1.8 Partnerships and Collaboration:** Foster partnerships and collaboration among government agencies, research institutions, technology providers, civil society organizations, and the private sector to leverage expertise, resources, and networks for addressing technical challenges. Collaborative initiatives can accelerate innovation, scale-up solutions, and promote knowledge exchange. **1.9 Risk Communication Strategies:** Develop risk communication strategies that effectively convey hazard information, warning messages, and preparedness actions to diverse audiences, including vulnerable groups and marginalized communities. Use accessible and culturally sensitive communication channels, languages, and formats to reach all segments of the population.

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Barriers	**Measures**
	1.10 Continuous Monitoring and Evaluation: Establish mechanisms for continuous monitoring, evaluation, and feedback to assess the performance, usability, and impact of decentralized community early warning systems. Gather feedback from end-users, conduct system audits, and incorporate lessons learned into iterative improvements and upgrades. By addressing technical challenges and non-financial barriers through a combination of capacity building, innovation, collaboration, and community engagement, decentralized community early warning systems can become more effective, resilient, and sustainable in protecting lives and livelihoods against disaster risks.
2.0 Lack of Technical Capacity Lesotho lacks the necessary technical know-how to effectively operate and maintain sophisticated climate monitoring technologies. This capacity gap impedes the successful implementation of these systems.	Addressing the lack of technical capacity in decentralized community early warning systems requires targeted interventions to build skills, knowledge, and capabilities among community members and relevant stakeholders. Here are some ways to tackle this challenge: **2.1 Technical Training Programs:** Develop and implement technical training programs tailored to the specific needs and contexts of decentralized community early warning systems. These programs should cover a range of topics, including system operation, maintenance, troubleshooting, data analysis, and emergency response protocols. **2.2 Hands-on Workshops and Simulations:** Organize hands-on workshops, practical exercises, and simulation drills to provide participants with opportunities to apply their technical knowledge and skills in real-world scenarios. Hands-on learning experiences help reinforce learning outcomes and build confidence in system operation and maintenance. **2.3 Train-the-Trainer Initiatives:** Implement train-the-trainer initiatives to build a cadre of local experts and champions who can then cascade their knowledge and

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Barriers	**Measures**
	skills to other community members. Train-the-trainer programs help multiply the impact of capacity building efforts and promote sustainability. **2.4 Peer Learning Networks:** Facilitate peer learning networks and communities of practice where individuals and groups can share experiences, best practices, and lessons learned related to decentralized community early warning systems. Peer learning fosters collaboration, mutual support, and continuous improvement among participants. **2.5 Technical Assistance and Mentoring:** Provide ongoing technical assistance, mentoring, and coaching to community members and local authorities responsible for operating and maintaining early warning systems. Expert guidance and support can help troubleshoot technical issues, address challenges, and enhance system performance. **2.6 Partnerships with Technical Institutions:** Forge partnerships with technical institutions, universities, research centers, and professional associations to access specialized expertise, resources, and training facilities for decentralized community early warning systems. Collaborative initiatives can enrich training programs and provide access to state-of-the-art technologies and methodologies. **2.7 Online Learning Platforms**: Develop online learning platforms, e-learning courses, and digital resources to complement traditional training methods and reach a wider audience. Online learning offers flexibility, scalability, and accessibility, allowing community members to access training materials anytime, anywhere. **2.8 Technical Internships and Exchanges:** Facilitate technical internships, exchange programs, and knowledge sharing visits to expose community members to diverse technical environments, practices, and innovations related to early warning systems. Learning

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Barriers	**Measures**
	from peers and experts in different contexts can inspire new ideas and approaches. **2.9 Community Engagement and Ownership:** Foster community engagement and ownership by involving local residents in the design, implementation, and evaluation of technical capacity building initiatives. Empower community members to identify their own training needs, prioritize actions, and take ownership of capacity building activities. **2.10 Continuous Learning and Improvement:** Establish mechanisms for continuous learning, feedback, and evaluation to assess the effectiveness and impact of technical capacity building efforts. Regularly review and update training programs based on lessons learned, emerging trends, and changing community needs. By implementing these strategies, decentralized community early warning systems can strengthen their technical capacity, enhance system resilience, and empower communities to effectively manage disaster risks and protect lives and livelihoods.
3.0 Data Sharing and Cooperation The success of climate monitoring often depends on cross-border data sharing and international cooperation. Barriers related to data sovereignty, privacy concerns, and geopolitical tensions hinder collaborative efforts in implementing integrated systems.	Promoting data sharing and cooperation in decentralized community early warning systems is crucial for enhancing effectiveness, responsiveness, and resilience. Here are several ways to address this: **3.1 Establish Data Sharing Protocols:** Develop clear data sharing protocols and agreements that outline the terms, conditions, and responsibilities for sharing information among stakeholders in decentralized early warning systems. Ensure that these protocols comply with relevant privacy, security, and legal regulations. **3.2 Standardize Data Formats and Metadata:** Adopt standardized data formats, metadata schemas, and interoperability standards to facilitate seamless data exchange and integration across different early warning system components, platforms, and organizations.

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Barriers	**Measures**
	Common standards enhance compatibility and interoperability among diverse data sources. **3.3** **Open Data Policies:** Embrace open data policies that promote transparency, accessibility, and reuse of early warning system data by making it freely available to the public, researchers, policymakers, and other stakeholders. Open data initiatives foster collaboration, innovation, and knowledge sharing while increasing trust and accountability. **3.4** **Data Ownership and Control:** Clarify data ownership rights and control mechanisms to ensure that communities, governments, and other stakeholders have appropriate ownership, access, and control over their data. Establish mechanisms for transparent governance, consent, and accountability in data sharing arrangements. **3.5** Data Management Platforms: Invest in data management platforms and information systems that support secure, centralized repositories for storing, managing, and sharing early warning system data. These platforms should feature robust data governance, access controls, and audit trails to protect sensitive information. **3.6** **Collaborative Data Collection:** Encourage collaborative data collection efforts involving community members, local authorities, scientific institutions, and civil society organizations. Foster partnerships and citizen science initiatives that empower communities to collect, validate, and contribute data to the early warning system. **3.7** **Real-time Data Sharing**: Implement mechanisms for real-time data sharing and communication during emergencies to facilitate timely decision-making and coordinated response actions. Utilize communication channels such as mobile apps, SMS alerts, social media, and community radio to disseminate warnings and updates.

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Barriers	**Measures**
	3.8 Cross-sectoral Collaboration: Foster cross-sectoral collaboration and information sharing among government agencies, humanitarian organizations, academia, private sector entities, and community-based groups involved in disaster risk reduction and early warning efforts. Promote joint planning, data exchange, and resource sharing to address complex challenges collectively. **3.9 Capacity Building and Training:** Provide training and capacity building programs to enhance stakeholders' skills and knowledge in data sharing, collaboration, and information management. Equip individuals and organizations with the necessary tools, methodologies, and best practices for effective data-driven decision-making and cooperation. **3.10 Community Engagement:** Engage communities in the data sharing process by raising awareness, building trust, and soliciting feedback on data collection, use, and dissemination practices. Empower community members to participate in decision-making processes and contribute local knowledge to enrich early warning system datasets. By implementing these strategies, decentralized community early warning systems can foster a culture of collaboration, cooperation, and data sharing among stakeholders, leading to more effective risk management, improved response coordination, and enhanced resilience to disasters.
4.0 Policy and Regulatory Hurdles Inconsistent or inadequate policies and regulations related to climate monitoring and early warning systems can impede progress. Clear and supportive regulatory frameworks are crucial for the successful implementation of such technologies.	Addressing policy and regulatory hurdles for decentralized community early warning systems requires advocacy, collaboration, and engagement with relevant stakeholders. Here are some ways to tackle these challenges: **4.1 Policy Advocacy:** Advocate for policy reforms and regulatory changes at the local, national, and international levels to create an enabling environment for decentralized community early warning systems. Engage

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	policymakers, legislators, and government agencies to raise awareness about the importance of early warning, highlight gaps in existing policies, and advocate for supportive regulations. **4.2** **Policy Dialogue and Consultations:** Facilitate policy dialogues, stakeholder consultations, and multi-stakeholder forums to bring together government officials, community leaders, civil society organizations, academia, and industry representatives to discuss policy and regulatory issues related to early warning systems. Foster dialogue, consensus-building, and knowledge exchange to inform policy development processes. **4.3** **Policy Analysis and Research**: Conduct policy analysis, research, and evidence-based advocacy to identify barriers, gaps, and opportunities in existing regulatory frameworks for decentralized community early warning systems. Generate empirical evidence, case studies, and best practices to support policy recommendations and decision-making processes. **4.4** **Capacity Building for Policymakers:** Provide capacity building and training programs for policymakers, regulators, and government officials on the technical, social, and economic aspects of decentralized community early warning systems. Enhance policymakers' understanding of the benefits, challenges, and implications of early warning initiatives to inform policy formulation and implementation. **4.5** **Policy Harmonization and Integration:** Promote policy harmonization and integration across different sectors, including disaster risk reduction, climate change adaptation, urban planning, and infrastructure development. Ensure coherence and alignment between policies, regulations, and strategies to mainstream early warning considerations into broader development agendas.

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Barriers	**Measures**
	4.6 Legal and Institutional Frameworks: Develop or strengthen legal and institutional frameworks that support the establishment, operation, and maintenance of decentralized community early warning systems. Clarify roles, responsibilities, and mandates of relevant government agencies, local authorities, and community organizations to enhance coordination and collaboration. **4.7 Leverage Existing Policies and Programs:** Identify and leverage existing policies, programs, and funding mechanisms that can support decentralized community early warning systems. Align early warning initiatives with national disaster management plans, climate resilience strategies, and development agendas to access resources and institutional support. **4.8 Public-Private Partnerships:** Foster public-private partnerships and collaboration with industry stakeholders, technology providers, and telecommunications companies to address policy and regulatory hurdles. Engage the private sector in policy dialogues, regulatory advocacy, and capacity building efforts to promote innovation and investment in early warning technologies. **4.9 Community Participation and Empowerment:** Empower communities to participate in policy advocacy and decision-making processes related to decentralized community early warning systems. Strengthen community-based organizations, networks, and platforms to amplify local voices, advocate for policy reforms, and hold policymakers accountable. **4.10 Monitoring and Evaluation:** Establish mechanisms for monitoring, evaluation, and review of policy implementation and regulatory compliance related to decentralized community early warning systems. Track progress, assess impacts, and identify areas for improvement to inform policy adjustments and adaptive management approaches.

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	By implementing these strategies, stakeholders can overcome policy and regulatory hurdles and create an enabling environment for decentralized community early warning systems to thrive, ultimately enhancing disaster resilience and protecting vulnerable communities.
5.0 Public Awareness and Engagement In Lesotho, there is a general lack of public awareness or understanding of the importance of climate monitoring which contributes to resistance or indifference. Thus, building public support and engagement is vital for the successful adoption of these technologies. This would also go a long way to mitigate theft and vandalism in some remote stations.	Addressing public awareness and engagement for decentralized community early warning systems is crucial for their effectiveness and sustainability. Here are some ways to tackle this: **5.1 Community Outreach Programs:** Organize community outreach programs, awareness campaigns, and public events to educate residents about the importance of early warning systems, potential hazards, and disaster preparedness measures. Use interactive workshops, demonstrations, and storytelling to engage audiences and raise awareness. **5.2 Multi-media Campaigns:** Develop multi-media campaigns using a variety of communication channels, including radio broadcasts, television programs, social media platforms, and community notice boards. Use compelling visuals, stories, and infographics to convey key messages and reach diverse audiences. **5.3 Local Language and Culture:** Tailor communication materials and messages to the local language, culture, and context of the community. Use culturally relevant metaphors, symbols, and narratives to enhance understanding and resonance with target audiences. **5.4 School and Youth Engagement:** Engage schools, youth groups, and educational institutions in awareness-raising activities and curriculum integration. Incorporate early warning system education into school curricula, extracurricular activities, and student-led initiatives to empower young people as change agents and advocates for disaster resilience.

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	5.5 Community Leaders and Influencers: Mobilize community leaders, religious figures, influencers, and opinion makers to serve as advocates and champions for decentralized community early warning systems. Leverage their credibility, authority, and social networks to disseminate messages, promote participation, and mobilize community action. **5.6 Door-to-Door Campaigns:** Conduct door-to-door campaigns and neighbourhood meetings to directly engage with residents, answer questions, and address concerns about early warning systems. Use this opportunity to collect feedback, gather input, and build trust with community members. **5.7 Participatory Communication**: Adopt participatory communication approaches that involve community members in co-creating, sharing, and disseminating information about early warning systems. Encourage two-way communication, feedback loops, and dialogue to foster active engagement and ownership. **5.8 Demonstrations and Simulations:** Organize demonstrations, simulations, and mock drills to showcase the functioning of early warning systems, simulate emergency scenarios, and practice response procedures with community members. Hands-on experiences help reinforce learning and build confidence in the effectiveness of early warning measures. **5.9 Peer-to-Peer Learning:** Facilitate peer-to-peer learning networks, support groups, and community-based organizations where residents can share knowledge, experiences, and best practices related to early warning systems. Encourage mutual support, collaboration, and solidarity among peers in disaster-prone areas. **5.10 Continuous Engagement:** Maintain ongoing communication and engagement with the public before, during, and after disasters to sustain awareness and preparedness efforts. Provide regular updates, warnings,

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	and advisories through multiple channels to keep communities informed and empowered to take proactive measures. By implementing these strategies, stakeholders can enhance public awareness, understanding, and engagement with decentralized community early warning systems, ultimately strengthening disaster resilience and saving lives.
6.0 Cultural and Social Factors In Lesotho, local communities mainly rely on “traditional indicators” for weather and seasonal forecasting hence the indifference and resistance to the new technology. However, scientific weather monitoring and short-term forecasts (a few days) are already being undertaken in Lesotho with appreciable success. Thus, as “traditional indicators” of weather (e.g., bird and animal movement, the date and quantity of the first rains, the special forecasting knowledge of diviners etc) become more unreliable, due largely to climate change, local communities previously relying on such indicators will gradually embrace the scientific systems. That notwithstanding, cultural beliefs, social norms, and historical factors influence the acceptance and integration of climate monitoring technologies. Thus, understanding and addressing these cultural aspects is essential for effective implementation.	Addressing cultural and social factors in decentralized community early warning systems is essential for ensuring that these systems are effective, inclusive, and culturally appropriate. Here are some ways to tackle this: **6.1 Cultural Sensitivity Training:** Provide cultural sensitivity training for stakeholders involved in the design, implementation, and operation of early warning systems. Foster an understanding of local cultural norms, beliefs, practices, and communication preferences to ensure that early warning messages are culturally sensitive and respectful. **6.2 Community Participation and Consultation:** Involve community members in the planning, decision-making, and implementation of early warning systems. Consult with local leaders, elders, and community groups to understand cultural perspectives, traditional knowledge, and social dynamics that may influence disaster risk perception and response behaviours. **6.3 Cultural Integration of Early Warning Systems:** Integrate cultural elements, symbols, and rituals into early warning systems to make them more culturally relevant and acceptable to the community. Incorporate indigenous knowledge, storytelling, and traditional warning methods into modern early warning technologies and communication strategies. **6.4 Local Language Communication:** Communicate early warning messages in the local language or dialect spoken

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	by the community to ensure maximum comprehension and effectiveness. Translate written materials, audio messages, and visual aids into local languages and use culturally appropriate terminology and expressions. **6.5 Respect for Gender and Social Dynamics:** Recognize and respect gender roles, social hierarchies, and power dynamics within the community when designing and implementing early warning systems. Ensure that women, children, elderly, and marginalized groups have equal access to information, resources, and decision-making processes. **6.6 Community-Based Risk Mapping:** Engage communities in participatory risk mapping exercises to identify and prioritize local hazards, vulnerabilities, and capacities. Incorporate local knowledge, perceptions, and experiences into risk assessments to ensure that early warning systems address the specific needs and concerns of the community. **6.7 Traditional Communication Channels:** Leverage traditional communication channels and social networks, such as community gatherings, religious institutions, storytelling circles, and local media, to disseminate early warning messages and mobilize community action. Harness the power of trusted messengers and opinion leaders to enhance message credibility and reach. **6.8 Cultural Events and Festivals:** Use cultural events, festivals, and ceremonies as opportunities to raise awareness about early warning systems and disaster preparedness. Integrate risk reduction messages into cultural activities, performances, and rituals to capture community attention and engagement. **6.9 Capacity Building and Empowerment:** Build the capacity of local leaders, volunteers, and community organizations to serve as advocates, educators, and responders in decentralized early warning systems. Provide training, resources, and support to empower

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	communities to take ownership of their safety and resilience. **6.10 Continuous Learning and Adaptation:** Foster a culture of continuous learning, adaptation, and feedback within decentralized early warning systems to respond to changing cultural and social dynamics. Regularly assess the effectiveness of communication strategies, monitor community feedback, and adjust approaches based on lessons learned. By addressing cultural and social factors in decentralized community early warning systems, stakeholders can enhance community engagement, trust, and resilience, ultimately saving lives and reducing the impact of disasters on vulnerable populations.
7.0 Institutional Barriers Existing institutional structures and bureaucracies pose challenges. For example, in Lesotho, data storage, retrieval and sharing protocols are convoluted at best. Thus, integrating new technologies requires changes in institutional structures, to mitigate resistance or bureaucratic hurdles.	Addressing institutional barriers in decentralized community early warning systems requires collaboration, coordination, and institutional reform. Here are some ways to tackle these challenges: **7.1 Multi-level Coordination Mechanisms:** Establish multi-level coordination mechanisms involving national, regional, and local authorities, as well as relevant stakeholders from civil society, academia, and the private sector. Facilitate dialogue, information sharing, and joint decision-making to overcome institutional silos and promote integrated approaches to early warning. **7.2 Clear Mandates and Responsibilities:** Clarify mandates, roles, and responsibilities of different institutions and stakeholders involved in decentralized community early warning systems. Ensure that responsibilities for data collection, analysis, dissemination, and response are clearly defined and coordinated to avoid duplication and gaps in service delivery. **7.3 Interagency Collaboration:** Foster interagency collaboration and partnerships among government

Non-Financial Barriers and Measures for DCEWS	
Barriers	**Measures**
	agencies responsible for disaster risk management, meteorological services, environmental monitoring, health services, telecommunications, and infrastructure development. Promote joint planning, resource sharing, and capacity building initiatives to strengthen early warning capabilities. **7.4** **Legal and Policy Reforms:** Advocate for legal and policy reforms to address institutional barriers and facilitate the implementation of decentralized community early warning systems. Lobby for the enactment of legislation, regulations, and guidelines that support decentralized decision-making, community participation, and information sharing. **7.5** **Capacity Building and Training**: Provide capacity building and training programs for institutional staff, policymakers, and decision-makers on the technical, organizational, and governance aspects of decentralized community early warning systems. Equip institutions with the knowledge, skills, and tools needed to support effective implementation and management of early warning initiatives. **7.6** **Resource Allocation and Funding:** Allocate adequate resources and funding to support decentralized community early warning systems, including investment in infrastructure, equipment, technology, human resources, and capacity building activities. Advocate for dedicated budget lines, grants, and donor support for early warning initiatives at all levels of government. **7.7** **Performance Monitoring and Evaluation:** Establish mechanisms for monitoring, evaluation, and accountability to assess the performance and impact of decentralized community early warning systems. Develop indicators, benchmarks, and performance targets to track progress, identify bottlenecks, and guide institutional improvements over time.

Non-Financial Barriers and Measures for DCEWS	
Barriers	**Measures**
	7.8 Data Sharing and Information Management: Improve data sharing, information management, and interoperability among institutions involved in decentralized early warning systems. Develop standardized protocols, data formats, and information exchange platforms to facilitate seamless communication and collaboration across sectors and agencies. **7.9** **Community Engagement and Participation:** Promote community engagement, participation, and ownership in institutional decision-making processes related to early warning systems. Establish mechanisms for meaningful consultation, feedback, and collaboration with local communities to ensure that institutional responses meet their needs and priorities. **7.10** **Learning Networks and Knowledge Sharing:** Facilitate learning networks, communities of practice, and knowledge sharing platforms to exchange experiences, lessons learned, and best practices among institutions involved in decentralized community early warning systems. Promote peer-to-peer learning, mentorship, and South-South cooperation to foster institutional innovation and adaptation. By implementing these strategies, stakeholders can overcome institutional barriers and create an enabling environment for decentralized community early warning systems to thrive, ultimately enhancing disaster resilience and protecting vulnerable communities.
8.0 Risk Aversion Decision-makers are currently hesitant to invest in new technologies due to uncertainties and risks associated with their implementation. Overcoming this risk aversion is crucial for fostering innovation in climate monitoring.	Addressing risk aversion in decentralized community early warning systems requires proactive measures to build trust, confidence, and resilience among stakeholders. Here are some ways to tackle this challenge: **8.1** **Risk Communication Strategies:** Develop targeted risk communication strategies that emphasize the importance of early warning systems in enhancing community safety and resilience. Use clear, accessible language and visual

Non-Financial Barriers and Measures for DCEWS	
Barriers	**Measures**
	aids to convey risk information, debunk myths, and address misconceptions about hazards and early warning measures. **8.2 Evidence-based Risk Assessment:** Conduct evidence-based risk assessments and hazard mapping exercises to provide communities with accurate, science-based information about local hazards, vulnerabilities, and potential impacts. Use participatory approaches to engage community members in the risk assessment process and build consensus around risk reduction priorities. **8.3 Community Engagement and Participation:** Foster community engagement and participation in decentralized early warning systems by involving residents in decision-making, planning, and implementation processes. Empower communities to take ownership of their safety and resilience through participatory mechanisms, such as community-based organizations, risk reduction committees, and neighbourhood watch groups. **8.4 Transparent Decision-making Processes:** Ensure transparency and accountability in decision-making processes related to decentralized early warning systems. Provide opportunities for stakeholders to access information, ask questions, and provide input on decision-making processes. Transparency builds trust and confidence in institutional responses to risk. **8.5 Demonstrate Success Stories:** Highlight success stories and case studies of early warning systems that have effectively reduced disaster risk and saved lives in similar communities. Showcase tangible examples of how early warning measures have helped communities prepare for, respond to, and recover from disasters, overcoming initial skepticism and risk aversion. **8.6 Build Institutional Capacity:** Strengthen the capacity of local institutions, government agencies, and

Non-Financial Barriers and Measures for DCEWS	
Barriers	**Measures**
	community organizations to effectively implement decentralized early warning systems. Provide training, technical assistance, and resources to build institutional resilience and confidence in managing disaster risks and emergencies. **8.7** **Promote Adaptive Management:** Promote adaptive management approaches that allow for flexibility, learning, and adjustment in decentralized early warning systems. Encourage stakeholders to experiment with innovative solutions, pilot projects, and small-scale interventions to build confidence and demonstrate the effectiveness of risk reduction measures. **8.8** **Address Socio-economic Factors**: Recognize and address underlying socio-economic factors that contribute to risk aversion, such as poverty, inequality, and lack of access to resources and services. Implement poverty reduction strategies, livelihood support programs, and social protection measures to strengthen community resilience and reduce vulnerability to disasters. **8.9** **Partnerships and Collaboration:** Foster partnerships and collaboration among government agencies, civil society organizations, academic institutions, and the private sector to address risk aversion collectively. Pool resources, expertise, and networks to overcome barriers, leverage opportunities, and build a culture of risk-informed decision-making. **8.10** **Promote Positive Messaging:** Frame risk communication messages in a positive and empowering manner that focuses on resilience-building, community strengths, and collective action. Highlight the role of early warning systems in empowering communities to proactively manage risks, protect lives, and safeguard livelihoods.

Non-Financial Barriers and Measures for DCEWS	
Barriers	**Measures**
	By implementing these strategies, stakeholders can address risk aversion in decentralized community early warning systems and foster a culture of risk awareness, preparedness, and resilience, ultimately saving lives and reducing the impact of disasters on vulnerable communities.

2-1. Financial Barriers and Measures Identified for Rain Water Harvesting

Identified Economic and Financial Barriers and Measures for Rain Water Harvesting.	
Barriers	**Measures**
Addressing these economic and financial barriers involves the development of targeted financial mechanisms, government policies that incentivize adoption, and support systems that assist farmers in overcoming the initial hurdles associated with investing in rainwater harvesting technologies	
1.0 High Initial Costs The upfront investment required for installing rainwater harvesting infrastructure, such as collection systems and storage facilities, can be a significant barrier for farmers, particularly those with limited financial resources.	1.1 Government Subsidies: Provide financial incentives and subsidies to farmers for the adoption of rainwater harvesting technologies, including the installation of rainwater collection systems and storage facilities. 1.2 Low-Interest Loans: Establish accessible and low-interest loan programs to support farmers in investing in rainwater harvesting infrastructure. This can ease the financial burden and promote widespread adoption. 1.3 Insurance Schemes: Introduce insurance schemes that protect farmers from potential losses due to climate-related uncertainties. This can encourage them to invest in rainwater harvesting as a risk mitigation strategy. 1.4 Public-Private Partnerships: Collaborate with private sector entities to fund and implement rainwater harvesting projects. This partnership can attract additional financial resources and technical expertise. 1.5 Tax Incentives: Offer tax breaks or exemptions and /or subsidies to farmers and businesses engaged in rainwater harvesting activities, encouraging investment by reducing the overall cost of implementation. **1.0** .
2.0 Maintenance Expenses Ongoing maintenance costs for rainwater harvesting systems, including repairs and cleaning of infrastructure, can pose a financial challenge for farmers, affecting the sustainability of the technology.	Addressing maintenance expenses for rainwater harvesting systems involves proactive planning, regular maintenance, and efficient use of resources. Here are some ways to tackle this challenge: **2.1 Proper Design and Installation:** Ensure that rainwater harvesting systems are designed and installed correctly by qualified professionals to minimize maintenance requirements. Properly designed systems are more efficient and less prone to breakdowns or malfunctions.

Identified Economic and Financial Barriers and Measures for Rain Water Harvesting.	
Barriers	**Measures**
	2.2 Regular Inspection and Cleaning: Schedule regular inspections and cleaning of rainwater harvesting components, such as gutters, downspouts, filters, and storage tanks, to prevent blockages, contamination, and degradation of water quality. Routine maintenance helps prolong the lifespan of the system and ensures optimal performance. **2.3 Training and Capacity Building:** Provide training and capacity building programs for homeowners, facility managers, and maintenance staff on proper operation and maintenance of rainwater harvesting systems. Equip them with the knowledge and skills needed to identify potential issues, perform routine tasks, and troubleshoot common problems. **2.4 Invest in Quality Materials**: Invest in high-quality materials, components, and equipment for rainwater harvesting systems that are durable, corrosion-resistant, and low-maintenance. Choose products with warranties and certifications to ensure reliability and performance over time. **2.5 Implement Preventive Maintenance:** Adopt a preventive maintenance approach by implementing regular maintenance schedules, checklists, and procedures to identify and address potential issues before they escalate into costly repairs. Proactive maintenance helps minimize downtime and repair costs. **2.6 Monitor Water Quality:** Monitor the quality of harvested rainwater regularly to detect any signs of contamination, sediment buildup, or microbial growth. Conduct water quality testing and analysis to ensure compliance with health and safety standards and take corrective actions as needed. **2.7 Efficient Water Use Practices**: Promote efficient water use practices, such as using water-saving fixtures, appliances, and landscaping techniques, to reduce the demand on rainwater harvesting systems. Implement measures to

Identified Economic and Financial Barriers and Measures for Rain Water Harvesting.	
Barriers	**Measures**
	minimize wastage, leakage, and overuse of harvested water to optimize system performance and reduce maintenance needs. **2.8** **Community Participation:** Engage community members in the maintenance and management of shared rainwater harvesting systems through collective ownership, volunteer programs, or maintenance agreements. Foster a sense of responsibility and stewardship among users to ensure the long-term sustainability of the system. **2.9** **Budgeting and Financial Planning:** Allocate sufficient funds in the budget for ongoing maintenance expenses associated with rainwater harvesting systems. Incorporate maintenance costs into long-term financial planning and reserve funds for unexpected repairs or upgrades to avoid financial strain. **2.10** **Continuous Improvement:** Continuously evaluate the performance and efficiency of rainwater harvesting systems, solicit feedback from users, and implement improvements based on lessons learned and best practices. Stay informed about technological advancements, innovations, and cost-effective solutions for optimizing system maintenance and operation. By implementing these strategies, stakeholders can address maintenance expenses for rainwater harvesting systems effectively, ensuring their reliable operation, longevity, and contribution to sustainable water management.
3.0 Limited Access to Capital Farmers face difficulties in accessing affordable capital for financing technology adoption like rainwater harvesting projects. Despite some efforts of NGOs and Department of Soil and Water Conservation to catalyse adoption of technologies, limited access	Limited access to capital for rainwater harvesting projects can be addressed through various strategies aimed at increasing funding sources, reducing costs, and enhancing financial inclusivity. Here are some ways to tackle this challenge: **3.1** **Government Subsidies and Grants:*** Advocate for government subsidies, grants, or financial incentives to support rainwater harvesting initiatives, particularly for low-income households, rural communities, and marginalized populations. Lobby policymakers to allocate funds from

Identified Economic and Financial Barriers and Measures for Rain Water Harvesting.	
Barriers	**Measures**
to loans or credit hinders their ability to invest in the necessary infrastructure.	national budgets or development programs for rainwater harvesting projects. **3.2 Microfinance and Community Financing:** Facilitate access to microfinance schemes, community-based financing models, and revolving funds that provide affordable loans or credit for rainwater harvesting installations. Promote the establishment of community savings groups, credit unions, or cooperative networks to mobilize local resources for water infrastructure projects. **3.3 Public-Private Partnerships (PPPs)**: Foster public-private partnerships to leverage private sector investment, expertise, and innovation in rainwater harvesting technologies and services. Encourage collaboration between governments, financial institutions, technology providers, and community organizations to develop sustainable financing mechanisms for water infrastructure. **3.4 Crowdfunding and Peer-to-Peer Lending:** Explore crowdfunding platforms and peer-to-peer lending networks as alternative sources of capital for rainwater harvesting projects. Launch online fundraising campaigns to mobilize support from individuals, businesses, and philanthropic organizations interested in supporting water conservation initiatives. **3.5 Social Impact Investing:** Attract social impact investors, impact funds, and socially responsible enterprises that prioritize investments in environmental sustainability and community development. Seek partnerships with impact investors who are willing to finance rainwater harvesting projects in exchange for social and environmental returns on investment. **3.6 Carbon Finance and Climate Funds:** Tap into carbon finance mechanisms, climate funds, and green finance initiatives that provide financial incentives for climate mitigation and adaptation activities, including rainwater harvesting. Access funding opportunities available through

Identified Economic and Financial Barriers and Measures for Rain Water Harvesting.	
Barriers	**Measures**
	international climate finance mechanisms, such as the Green Climate Fund or the Global Environment Facility. **3.7 Result-Based Financing:** Explore result-based financing approaches, such as pay-for-performance contracts or outcome-based payments, where funding is linked to the achievement of specific water-related outcomes, such as increased water availability or improved water quality from rainwater harvesting systems. **3.8 Technology Innovation and Cost Reduction:** Promote technology innovation and cost reduction measures to make rainwater harvesting systems more affordable and accessible to a wider range of users. Invest in research and development of low-cost, scalable technologies, and decentralized solutions that minimize upfront investment and maintenance costs. **3.9 Capacity Building and Technical Assistance:** Provide capacity building and technical assistance to communities, local governments, and stakeholders to develop project proposals, access funding opportunities, and manage rainwater harvesting projects effectively. Build local expertise and institutional capacity to navigate the complexities of project financing and implementation. **3.10 Policy and Regulatory Support:** Advocate for supportive policy and regulatory frameworks that incentivize investment in rainwater harvesting infrastructure and facilitate access to capital. Lobby for policy reforms that streamline permitting processes, reduce bureaucratic barriers, and create an enabling environment for private sector participation in water conservation initiatives. By implementing these strategies in a coordinated and integrated manner, stakeholders can overcome the challenge of limited access to capital for rainwater harvesting projects, unlock new financing opportunities, and accelerate the adoption of sustainable water management practices.

Identified Economic and Financial Barriers and Measures for Rain Water Harvesting.	
Barriers	**Measures**
4.0 Uncertain Returns on Investment Many farmers are hesitant to invest in rainwater harvesting technologies due to uncertainties surrounding the returns on investment, especially when such benefits are neither immediately apparent nor guaranteed.	Addressing uncertain returns on investments for rainwater harvesting involves implementing strategies to mitigate risks, improve financial viability, and demonstrate the value proposition of such investments. Here are some ways to tackle this challenge: **4.1** **Cost-Benefit Analysis:** Conduct a comprehensive cost-benefit analysis to evaluate the financial viability and potential returns on investment (ROI) of rainwater harvesting projects. Consider both direct financial benefits, such as reduced water bills and irrigation savings, as well as indirect benefits, such as increased property value and environmental conservation. **4.2** **Demonstrate Economic Value:** Quantify the economic value of rainwater harvesting by assessing the long-term cost savings, revenue generation opportunities, and social benefits associated with improved water availability, reduced flooding, and enhanced resilience to droughts. Use economic valuation methods, such as net present value (NPV) analysis or cost-effectiveness analysis, to demonstrate the financial attractiveness of rainwater harvesting investments. **4.3** **Performance Guarantees:** Offer performance guarantees or warranties for rainwater harvesting systems to provide assurance to investors and end-users about system reliability, durability, and performance. Stand behind the quality of installations and components, and commit to addressing any issues or defects that may arise during the warranty period. **4.4** **Insurance and Risk Management:** Purchase insurance coverage or engage in risk management strategies to protect against potential losses or damages associated with rainwater harvesting systems, such as equipment failures, property damage, or water contamination incidents. Seek insurance products tailored to the specific risks and needs of water infrastructure projects. **4.5** **Long-Term Financing Options:** Explore long-term financing options, such as low-interest loans, lease-to-own agreements, or public-private partnerships, that offer flexible repayment terms and lower the financial burden on upfront

Identified Economic and Financial Barriers and Measures for Rain Water Harvesting.	
Barriers	**Measures**
	investment costs for rainwater harvesting installations. Structure financing arrangements to align with project cash flows and expected returns. **4.6 Subsidies and Incentives:** Advocate for government subsidies, tax incentives, or rebates to offset the initial costs of rainwater harvesting systems and incentivize investment in water conservation technologies. Lobby policymakers to implement financial incentives that reward water savings, stormwater management, or environmental stewardship practices. **4.7 Diversification of Revenue Streams:** Diversify revenue streams associated with rainwater harvesting projects by exploring additional income-generating opportunities, such as selling excess harvested water to neighbouring properties or municipalities, offering water-related services (e.g., irrigation, landscaping), or leveraging carbon credits or ecosystem service payments. **4.8 Community Engagement and Ownership:** Foster community engagement and ownership of rainwater harvesting projects by involving residents, businesses, and local stakeholders in the planning, financing, and management of water infrastructure initiatives. Build consensus around the importance of water conservation and resilience-building measures to gain community support and commitment. **4.9 Performance Monitoring and Maintenance:** Implement robust performance monitoring and maintenance programs to ensure the ongoing functionality and effectiveness of rainwater harvesting systems. Regularly track system performance indicators, such as water quality, quantity, and reliability, and invest in preventive maintenance to minimize downtime and optimize returns on investment. **4.10 Education and Awareness:** Raise awareness and educate stakeholders about the benefits and value proposition of rainwater harvesting through targeted outreach campaigns, demonstration projects, and community workshops.

Identified Economic and Financial Barriers and Measures for Rain Water Harvesting.	
Barriers	**Measures**
	Empower decision-makers, investors, and end-users with knowledge about water conservation practices, sustainable water management, and the potential returns on investment associated with rainwater harvesting. By implementing these strategies, stakeholders can address uncertain returns on investments for rainwater harvesting projects, enhance financial resilience, and unlock the full potential of rainwater as a sustainable water resource.
5.0 Lack of Financial Incentives In Lesotho, given the limited to no financial incentives or subsidies for adopting rainwater harvesting, farmers are less motivated to invest in these technologies, especially when alternative water sources are available	Addressing uncertain returns on investments for rainwater harvesting involves implementing strategies to mitigate risks, improve financial viability, and demonstrate the value proposition of such investments. Here are some ways to tackle this challenge: **5.1** **Cost-Benefit Analysis:** Conduct a comprehensive cost-benefit analysis to evaluate the financial viability and potential returns on investment (ROI) of rainwater harvesting projects. Consider both direct financial benefits, such as reduced water bills and irrigation savings, as well as indirect benefits, such as increased property value and environmental conservation. **5.2** **Demonstrate Economic Value:** Quantify the economic value of rainwater harvesting by assessing the long-term cost savings, revenue generation opportunities, and social benefits associated with improved water availability, reduced flooding, and enhanced resilience to droughts. Use economic valuation methods, such as net present value (NPV) analysis or cost-effectiveness analysis, to demonstrate the financial attractiveness of rainwater harvesting investments. **5.3** **Performance Guarantees:** Offer performance guarantees or warranties for rainwater harvesting systems to provide assurance to investors and end-users about system reliability, durability, and performance. Stand behind the quality of installations and components, and commit to addressing any issues or defects that may arise during the warranty period. **5.4** **Insurance and Risk Management:** Purchase insurance coverage or engage in risk management strategies to protect

Identified Economic and Financial Barriers and Measures for Rain Water Harvesting.	
Barriers	**Measures**
	against potential losses or damages associated with rainwater harvesting systems, such as equipment failures, property damage, or water contamination incidents. Seek insurance products tailored to the specific risks and needs of water infrastructure projects. **5.5 Long-Term Financing Options:** Explore long-term financing options, such as low-interest loans, lease-to-own agreements, or public-private partnerships, that offer flexible repayment terms and lower the financial burden on upfront investment costs for rainwater harvesting installations. Structure financing arrangements to align with project cash flows and expected returns. **5.6 Subsidies and Incentives:** Advocate for government subsidies, tax incentives, or rebates to offset the initial costs of rainwater harvesting systems and incentivize investment in water conservation technologies. Lobby policymakers to implement financial incentives that reward water savings, stormwater management, or environmental stewardship practices. **5.7 Diversification of Revenue Streams:** Diversify revenue streams associated with rainwater harvesting projects by exploring additional income-generating opportunities, such as selling excess harvested water to neighbouring properties or municipalities, offering water-related services (e.g., irrigation, landscaping), or leveraging carbon credits or ecosystem service payments. **5.8 Community Engagement and Ownership:** Foster community engagement and ownership of rainwater harvesting projects by involving residents, businesses, and local stakeholders in the planning, financing, and management of water infrastructure initiatives. Build consensus around the importance of water conservation and resilience-building measures to gain community support and commitment. **5.9 Performance Monitoring and Maintenance:** Implement robust performance monitoring and maintenance programs to

Identified Economic and Financial Barriers and Measures for Rain Water Harvesting.	
Barriers	**Measures**
	ensure the ongoing functionality and effectiveness of rainwater harvesting systems. Regularly track system performance indicators, such as water quality, quantity, and reliability, and invest in preventive maintenance to minimize downtime and optimize returns on investment. **5.10 Education and Awareness:** Raise awareness and educate stakeholders about the benefits and value proposition of rainwater harvesting through targeted outreach campaigns, demonstration projects, and community workshops. Empower decision-makers, investors, and end-users with knowledge about water conservation practices, sustainable water management, and the potential returns on investment associated with rainwater harvesting. By implementing these strategies, stakeholders can address uncertain returns on investments for rainwater harvesting projects, enhance financial resilience, and unlock the full potential of rainwater as a sustainable water resource.
6.0 Market Access and Pricing Issues Challenges related to market access and pricing of agricultural products can impact the economic feasibility of rainwater harvesting. In Lesotho, farmers already struggle to sell their produce at fair prices, and this affects their ability to recoup investment costs.	Addressing market access and pricing issues for rainwater harvesting involves implementing strategies to improve product availability, distribution channels, and affordability, while ensuring that pricing reflects the value proposition of rainwater harvesting. Here are some ways to tackle this challenge: **6.1 Market Development Initiatives:** Invest in market development initiatives to increase awareness, demand, and adoption of rainwater harvesting technologies and services. Conduct targeted marketing campaigns, demonstrations, and promotional events to showcase the benefits and applications of rainwater harvesting to potential customers. **6.2 Product Innovation and Diversification:** Encourage product innovation and diversification to meet the diverse needs and preferences of customers in different market segments. Develop a range of rainwater harvesting products, systems, and solutions that cater to varying scales, budgets, and use cases, from simple rain barrels to complex integrated systems.

Identified Economic and Financial Barriers and Measures for Rain Water Harvesting.	
Barriers	**Measures**
	6.3 Partnerships with Manufacturers and Suppliers: Collaborate with manufacturers, suppliers, and distributors to expand the availability and accessibility of rainwater harvesting products in the market. Establish partnerships to streamline supply chains, reduce costs, and improve product quality, reliability, and availability. **6.4 Certification and Quality Standards:** Promote the adoption of certification and quality standards for rainwater harvesting products and systems to build consumer trust and confidence. Advocate for industry-wide standards, certifications, or labeling schemes that certify product performance, durability, and compliance with regulatory requirements. **6.5 Bulk Procurement and Group Purchasing:** Facilitate bulk procurement and group purchasing arrangements to negotiate favourable pricing and terms for rainwater harvesting products and installations. Aggregate demand from multiple buyers, such as community groups, homeowners' associations, or government agencies, to achieve economies of scale and lower costs. **6.6 Subsidies and Financial Assistance:** Provide subsidies, grants, or financial assistance programs to offset the upfront costs of rainwater harvesting installations for low-income households, rural communities, and vulnerable populations. Offer financial incentives or rebates to encourage investment in water conservation technologies and infrastructure. **6.7 Flexible Financing Options:** Offer flexible financing options, such as installment payment plans, leasing arrangements, or microfinance schemes, to make rainwater harvesting more affordable and accessible to customers with limited financial resources. Partner with financial institutions to develop tailored financing solutions that suit the needs of different customer segments. **6.8 Capacity Building and Training:** Provide capacity building and training programs for contractors, installers, and maintenance technicians to ensure quality installation and servicing of rainwater harvesting systems. Build a skilled

Identified Economic and Financial Barriers and Measures for Rain Water Harvesting.	
Barriers	**Measures**
	workforce capable of meeting market demand and delivering reliable, professional services to customers. **6.9** **Consumer Education and Outreach:** Conduct consumer education and outreach campaigns to raise awareness about the benefits, cost savings, and environmental impact of rainwater harvesting. Empower consumers with information about available products, financing options, and local incentives to make informed decisions about rainwater harvesting investments. **6.10** **Policy Support and Regulatory Reform:** Advocate for supportive policies, regulations, and incentives that promote market access and pricing fairness for rainwater harvesting products and services. Lobby policymakers to remove barriers, streamline permitting processes, and provide tax incentives or rebates to encourage adoption and investment in rainwater harvesting infrastructure. By implementing these strategies, stakeholders can address market access and pricing issues for rainwater harvesting, expand the adoption of sustainable water management practices, and contribute to water security and resilience.
7.0 Land Tenure and Ownership Concerns In Lesotho the commons property regime prevails for the most part and issues related to land tenure and ownership hinder farmers from making long-term investments in rainwater harvesting infrastructure in the commons, given lack secure land rights and security against vandalism.	Addressing land tenure and ownership concerns for rainwater harvesting involves implementing strategies to clarify property rights, facilitate access to land, and promote community engagement and collaboration. Here are some ways to tackle this challenge: **7.1** **Community Participation and Consultation:** Engage local communities in the planning, design, and implementation of rainwater harvesting projects to ensure their needs, preferences, and concerns are taken into account. Foster participatory decision-making processes that involve stakeholders from diverse backgrounds, including landowners, tenants, and indigenous communities. **7.2** **Secure Land Tenure Rights:** Advocate for secure land tenure rights and property ownership for individuals and communities, particularly in informal settlements or areas with unclear land tenure arrangements. Work with

Identified Economic and Financial Barriers and Measures for Rain Water Harvesting.	
Barriers	**Measures**
	government authorities to formalize land titles, issue land certificates, or establish community land trusts to protect land rights and prevent disputes. **7.3** Legal and Regulatory Reform: Lobby for legal and regulatory reforms that clarify the rights and responsibilities of landowners, tenants, and users regarding rainwater harvesting activities. Advocate for supportive policies, zoning regulations, and land use planning frameworks that recognize and facilitate rainwater harvesting as a sustainable land use practice. **7.4** **Land Use Agreements:** Negotiate land use agreements or lease arrangements between landowners and rainwater harvesting practitioners to secure access to land for water infrastructure projects. Establish clear terms, conditions, and duration of agreements to prevent conflicts and ensure mutual benefit for all parties involved. **7.5** **Community Land Management:** Promote community-based land management approaches that empower local communities to collectively manage and steward land resources, including rainwater harvesting infrastructure. Establish community land management committees, user groups, or cooperatives to oversee the planning, maintenance, and operation of water infrastructure projects. **7.6** **Inclusive Decision-Making Processes:** Ensure that decision-making processes related to rainwater harvesting projects are inclusive, transparent, and participatory, with opportunities for all stakeholders to contribute, voice concerns, and provide input. Foster dialogue, consensus-building, and conflict resolution mechanisms to address land tenure issues and resolve disputes amicably. **7.7** **Capacity Building and Legal Awareness:** Provide capacity building and legal awareness training for landowners, tenants, and community members on land tenure rights, property laws, and regulations related to rainwater harvesting. Empower stakeholders with knowledge and skills to navigate legal

Identified Economic and Financial Barriers and Measures for Rain Water Harvesting.	
Barriers	**Measures**
	frameworks, negotiate agreements, and advocate for their rights. **7.8 Mediation and Dispute Resolution:** Establish mechanisms for mediation and dispute resolution to address conflicts or disagreements that may arise over land tenure and ownership issues for rainwater harvesting projects. Facilitate dialogue, mediation, or arbitration processes to resolve disputes in a fair, transparent, and equitable manner. **7.9 Stakeholder Collaboration**: Foster collaboration and partnerships among stakeholders, including government agencies, civil society organizations, private sector actors, and community groups, to address land tenure concerns collectively. Pool resources, expertise, and networks to develop inclusive solutions that benefit all stakeholders and promote sustainable land management practices. **7.10 Policy Advocacy and Legal Reform:** Advocate for policy changes, legal reforms, and institutional mechanisms that strengthen land tenure security, protect property rights, and promote inclusive access to land for rainwater harvesting initiatives. Lobby policymakers to adopt supportive policies and regulations that facilitate land access and tenure for water infrastructure projects. By implementing these strategies, stakeholders can address land tenure and ownership concerns for rainwater harvesting projects, promote inclusive access to land resources, and foster sustainable land management practices that contribute to water security and resilience.

2-2. Non- Financial Barriers and Measures Identified for Rain Water Harvesting

Identified Non-Financial Barriers and Measures for Rain Water Harvesting	
Barriers	**Measures**
Addressing these non-economic barriers involves targeted education and awareness campaigns, community engagement, providing technical support, and aligning rainwater harvesting initiatives with local cultural practices and regulations. Successfully navigating these non-financial challenges is crucial for the sustainable implementation of rainwater harvesting technologies in agriculture.	
1.0 Lack of Technical Knowledge Smallholder farmers face challenges in understanding the technical aspects of rainwater harvesting systems. Insufficient knowledge about the design, installation, and maintenance of these technologies is a significant barrier.	**1.1 Education and Training:** Conduct awareness programs and training sessions to educate farmers about the benefits of rainwater harvesting and provide guidance on the installation and maintenance of relevant technologies. **1.2 Technical Assistance:** Offer technical support and guidance to farmers through agricultural extension services. This can include on-site visits, workshops, and access to experts who can assist with the implementation of rainwater harvesting systems. **1.3 Research and Development:** Invest in research to develop and improve rainwater harvesting technologies, making them more efficient and cost-effective. This can be done in collaboration with agricultural research institutions and technology developers. **1.4 Policy Alignment:** Develop and implement policies that promote rainwater harvesting in agriculture. This includes integrating rainwater harvesting considerations into agricultural development plans and water resource management policies. **1.5 Community Engagement:** Foster community involvement and collaboration in the planning and implementation of rainwater harvesting projects. This ensures that solutions are tailored to local needs and conditions. **1.6 Demonstration Projects:** Initiate demonstration projects to showcase the benefits of rainwater harvesting technologies. These projects serve as

Identified Non-Financial Barriers and Measures for Rain Water Harvesting	
Barriers	**Measures**
	practical examples for farmers and communities, encouraging wider adoption. **1.7 Water Rights and Regulations:** Establish clear and fair water rights and regulations that support rainwater harvesting practices. This includes addressing legal considerations related to ownership, use, and management of harvested rainwater. The combination of economic and non-financial measures is crucial for the successful promotion and adoption of rainwater harvesting technologies in agriculture, contributing to sustainable water management practices.
2.0 Perception and Awareness Limited awareness of the benefits of rainwater harvesting and its potential impact on agricultural practices hinders adoption. Farmers ae less likely to invest time and effort in a technology they do not fully understand or appreciate.	Addressing perception and awareness for rainwater harvesting involves educating and engaging stakeholders to increase understanding, acceptance, and adoption of rainwater harvesting practices. Here are some ways to tackle this challenge: **2.1 Education Campaigns:** Launch targeted education campaigns to raise awareness about the benefits, feasibility, and importance of rainwater harvesting. Use a variety of communication channels, such as community workshops, school programs, social media, and informational materials, to reach diverse audiences and disseminate key messages. **2.2 Demonstration Projects**: Implement demonstration projects to showcase the effectiveness and practicality of rainwater harvesting systems in real-world settings. Construct demonstration sites in public spaces, schools, or community centers where people can see, touch, and learn about different rainwater harvesting technologies and applications. **2.3 Storytelling and Case Studies**: Share success stories, case studies, and testimonials from individuals, communities, and businesses that have implemented rainwater harvesting projects.

Identified Non-Financial Barriers and Measures for Rain Water Harvesting	
Barriers	**Measures**
	Highlight the tangible benefits, cost savings, and environmental impact of rainwater harvesting to illustrate its relevance and potential. **2.4** **Participatory Workshops:** Organize participatory workshops, focus groups, or community meetings to engage stakeholders in discussions about rainwater harvesting. Create opportunities for dialogue, questions, and sharing of experiences to address concerns, dispel myths, and build trust in rainwater harvesting as a viable water management solution. **2.5** **Incorporate Rainwater Harvesting into Curricula:** Integrate rainwater harvesting education into school curricula, vocational training programs, and continuing education courses to instill knowledge and skills among students and professionals. Empower future generations with the awareness and technical know-how to implement rainwater harvesting practices. **2.6** **Community Engagement:** Engage local communities in the planning, design, and implementation of rainwater harvesting projects to build ownership and foster a sense of collective responsibility. Involve community members in decision-making processes, site selection, and maintenance activities to ensure project sustainability and success. **2.7** **Tailored Messaging:** Tailor messaging and communication materials to resonate with the cultural, social, and economic context of the target audience. Use language, imagery, and examples that are relevant and relatable to different demographic groups and community preferences. **2.8** **Peer-to-Peer Learning:** Facilitate peer-to-peer learning networks, knowledge sharing platforms, or study tours where individuals and groups can learn

Identified Non-Financial Barriers and Measures for Rain Water Harvesting	
Barriers	**Measures**
	from each other's experiences with rainwater harvesting. Encourage sharing of best practices, challenges, and lessons learned to build a supportive learning community. **2.9 Engage Local Leaders and Influencers:** Mobilize local leaders, influencers, and opinion makers to champion rainwater harvesting initiatives and promote awareness within their networks. Leverage their credibility, authority, and social influence to amplify messages, generate interest, and inspire action among community members. **2.10 Continuous Monitoring and Evaluation:** Regularly monitor and evaluate awareness levels, perceptions, and behaviour change related to rainwater harvesting through surveys, interviews, or focus groups. Use feedback and data to refine communication strategies, target interventions, and measure the impact of awareness-building efforts over time. By implementing these strategies, stakeholders can address perception and awareness gaps for rainwater harvesting, empower communities with knowledge and skills, and catalyse positive behaviour change towards sustainable water management practices.
3.0 Water Rights and Regulations Lesotho has existing water policy and legislation under the jurisdiction of the water sector. However, the water-food nexus in the context of farming is not well regulated in practice. This leaves complex or unclear water rights and regulations which can potentially impede the implementation of rainwater harvesting. Farmers may face legal uncertainties or restrictions on the collection and use of rainwater.	Addressing water rights and regulations for rainwater harvesting involves advocating for supportive policies, clarifying legal frameworks, and promoting inclusive access to water resources. Here are some ways to tackle this challenge: **3.1 Legal Recognition of Rainwater Harvesting:** Advocate for the legal recognition of rainwater harvesting as a legitimate water management practice within existing water rights and regulations. Lobby policymakers to amend laws, regulations, and water governance frameworks to

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Barriers	**Measures**
	explicitly include provisions for rainwater harvesting. **3.2** **Water Allocation and Permitting:** Streamline water allocation and permitting processes to facilitate rainwater harvesting projects. Develop simplified procedures, expedited review timelines, and standardized permit applications for rainwater harvesting installations to reduce administrative barriers and regulatory uncertainty. **3.3** **Prioritize Non-Potable Uses:** Prioritize non-potable uses of harvested rainwater, such as irrigation, landscaping, toilet flushing, and industrial processes, in water allocation and permitting decisions. Advocate for regulatory exemptions or waivers for non-potable water uses to encourage rainwater harvesting without compromising public health or safety. **3.4** **Interpretive Guidance and Advisory Services:** Provide interpretive guidance, technical assistance, and advisory services to stakeholders on navigating water rights and regulations for rainwater harvesting. Develop clear guidelines, fact sheets, and informational materials to help users understand their rights and obligations under existing laws and regulations. **3.5** Community-Based Water Management: Promote community-based water management approaches that empower local communities to collectively manage and regulate rainwater harvesting activities. Establish community water management committees, user groups, or cooperatives to oversee the allocation, distribution, and use of harvested rainwater resources. **3.6** **Water Use Efficiency Standards:** Advocate for the adoption of water use efficiency standards and performance metrics that incentivize rainwater

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Barriers	**Measures**
	harvesting and other sustainable water management practices. Encourage regulators to establish benchmarks and targets for water conservation, reuse, and efficiency in various sectors. **3.7** **Leverage Water Conservation Policies:** Leverage existing water conservation policies, strategies, and programs to promote rainwater harvesting as a means of reducing water demand and minimizing reliance on traditional water sources. Align rainwater harvesting initiatives with broader water conservation goals and objectives at the regional or national level. **3.8** **Inclusive Stakeholder Engagement:** Foster inclusive stakeholder engagement processes that involve a wide range of actors, including government agencies, water utilities, community organizations, indigenous groups, and private sector entities, in decision-making related to water rights and regulations for rainwater harvesting. **3.9** **Policy Research and Advocacy:** Conduct policy research and analysis to identify gaps, barriers, and opportunities for reforming water rights and regulations to support rainwater harvesting. Advocate for policy changes, legislative amendments, or regulatory updates based on evidence-based research and best practices. **3.10** **International Collaboration and Knowledge Sharing:** Engage in international collaboration and knowledge sharing initiatives to learn from experiences in other countries or regions that have successfully integrated rainwater harvesting into their water management policies and regulations. Participate in forums, conferences, and exchange programs to exchange lessons learned and best practices with global peers.

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Barriers	**Measures**
	By implementing these strategies, stakeholders can address water rights and regulations for rainwater harvesting, create an enabling policy environment, and promote the sustainable use of rainwater as a valuable water resource.
4.0 Perceived Risks Farmers might perceive risks associated with rainwater harvesting, such as system failures, water contamination, or changes in crop yields. Thus, overcoming these perceptions and demonstrating the reliability of the technology is essential for widespread adoption.	Addressing perceived risks associated with rainwater harvesting involves providing accurate information, implementing risk mitigation measures, and building trust among stakeholders. Here are some ways to tackle this challenge: **4.1 Education and Awareness Campaigns:** Launch educational campaigns to provide information about the benefits, safety, and reliability of rainwater harvesting. Address common misconceptions and concerns through targeted messaging, workshops, and informational materials. **4.2 Water Quality Testing and Monitoring:** Conduct regular water quality testing and monitoring to ensure that harvested rainwater meets safety standards. Provide access to testing facilities or mobile testing services to reassure users about the quality of the water. **4.3 Treatment and Filtration Systems:** Install appropriate treatment and filtration systems to remove contaminants and pathogens from harvested rainwater. Educate users about the importance of proper maintenance and operation of these systems to ensure water safety. **4.4 Regulatory Compliance:** Ensure compliance with local regulations and standards for rainwater harvesting installations. Work with regulatory authorities to develop guidelines and best practices that address safety concerns and minimize risks associated with rainwater harvesting.

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Barriers	**Measures**
	4.5 Professional Installation and Maintenance: Encourage professional installation and regular maintenance of rainwater harvesting systems to ensure proper functionality and safety. Provide training and certification programs for installers and maintenance technicians to uphold quality standards. **4.6 Community Engagement and Participation:** Involve community members in the planning, design, and monitoring of rainwater harvesting projects. Foster a sense of ownership and responsibility among users to actively participate in ensuring the safety and success of the system. **4.7 Risk Communication and Transparency:** Establish clear channels for communication and transparency regarding the risks and benefits of rainwater harvesting. Encourage open dialogue, feedback, and reporting of any issues or concerns to address them promptly. **4.8 Insurance and Liability Coverage:** Consider obtaining insurance or liability coverage for rainwater harvesting systems to protect against unforeseen risks or damages. Work with insurance providers to develop tailored policies that address the specific needs and risks associated with rainwater harvesting. **4.9 Demonstration Projects and Case Studies:** Showcase successful demonstration projects and case studies that highlight the safety and effectiveness of rainwater harvesting. Provide real-life examples and testimonials to build confidence and trust in the technology. **4.10 Continuous Improvement and Adaptation**: Monitor feedback, evaluate performance, and continuously improve rainwater harvesting systems based on user experiences and evolving best

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Barriers	**Measures**
	practices. Stay informed about advancements in technology and innovation to address emerging risks and opportunities. By implementing these strategies, stakeholders can address perceived risks associated with rainwater harvesting, promote confidence and acceptance of the technology, and encourage its widespread adoption as a sustainable water management solution.
5.0 Community Dynamics In Lesotho, farmers operate within a community context, and the dynamics of these communities can influence technology adoption. Social pressures, norms, or collective decision-making processes may act as non-economic barriers.	Addressing community dynamics for rainwater harvesting involves fostering inclusive participation, building trust, and promoting collaboration among community members. Here are some ways to tackle this challenge: **5.1 Community Engagement and Consultation**: Involve community members in the planning, design, and decision-making processes for rainwater harvesting projects. Hold community meetings, focus groups, or workshops to solicit input, gather feedback, and address concerns. **5.2 Stakeholder Mapping and Analysis:** Conduct a stakeholder analysis to identify key actors, interests, and dynamics within the community related to rainwater harvesting. Understand the social, cultural, and economic factors that may influence community dynamics and project outcomes. **5.3 Capacity Building and Training:** Provide capacity building and training programs to empower community members with the knowledge, skills, and resources to participate effectively in rainwater harvesting initiatives. Offer technical training, leadership development, and entrepreneurship support tailored to local needs. **5.4 Community-Based Organizations (CBOs):** Collaborate with existing community-based organizations, cooperatives, or associations to

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Barriers	**Measures**
	mobilize support and resources for rainwater harvesting projects. Leverage their networks, expertise, and grassroots connections to engage community members and drive collective action. **5.5 Local Leadership and Champions:** Identify and empower local leaders, influencers, and champions who can advocate for rainwater harvesting and mobilize community support. Build alliances with respected individuals and institutions to amplify messages and build trust among community members. **5.6 Social Norms and Cultural Practices:** Consider the social norms, cultural practices, and traditions that may influence community perceptions and behaviours related to water management. Respect local customs and traditions while promoting the adoption of rainwater harvesting as a sustainable practice. **5.7 Conflict Resolution Mechanisms:** Establish conflict resolution mechanisms and grievance redressal procedures to address disagreements, disputes, or tensions within the community. Provide a neutral platform for dialogue, mediation, and consensus-building to resolve conflicts amicably. **5.8 Equitable Access and Benefit Sharing:** Ensure equitable access to rainwater harvesting benefits and resources within the community, particularly for marginalized or vulnerable groups. Promote inclusive participation and distribution of benefits to minimize social disparities and enhance social cohesion. **5.9 Partnerships and Collaboration:** Forge partnerships and collaborations with diverse stakeholders, including government agencies, NGOs, academia, and private sector entities, to

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Barriers	**Measures**
	leverage resources and expertise for rainwater harvesting projects. Pool collective knowledge, networks, and resources to achieve shared goals and objectives. **5.10 Continuous Communication and Engagement:** Maintain ongoing communication and engagement with the community throughout the project lifecycle. Provide regular updates, share progress reports, and seek feedback to keep community members informed and involved in decision-making processes. By implementing these strategies, stakeholders can address community dynamics for rainwater harvesting, foster inclusive participation, and build social capital to support the successful implementation and sustainability of projects.
6.0 Limited Extension Services: The extension service in Lesotho faces lack of capacity at individual, institutional and systemic levels. Lack of accessible and effective agricultural extension services can hinder the dissemination of information about rainwater harvesting. Farmers may miss out on valuable guidance and support for implementing these technologies.	Addressing limited extension services for rainwater harvesting involves expanding outreach efforts, enhancing technical assistance, and building local capacity to support the implementation and maintenance of rainwater harvesting systems. Here are some ways to tackle this challenge: **6.1 Establish Extension Programs:** Develop extension programs specifically focused on rainwater harvesting, aimed at providing education, technical support, and guidance to communities, homeowners, and businesses interested in implementing rainwater harvesting systems. **6.2 Training Workshops and Seminars:** Organize training workshops, seminars, and capacity-building sessions to educate extension agents, community leaders, and practitioners on rainwater harvesting principles, design considerations, installation techniques, and maintenance practices.

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Barriers	**Measures**
	6.3 **Demonstration Sites:** Create demonstration sites or model rainwater harvesting installations that showcase different technologies, designs, and applications. These sites can serve as hands-on learning opportunities for extension agents and community members to observe and understand how rainwater harvesting works in practice. **6.4** **Mobile Extension Units:** Establish mobile extension units equipped with demonstration kits, educational materials, and technical tools to bring extension services directly to rural and underserved areas. These units can travel to remote communities to provide on-site training, consultations, and technical assistance. **6.5** **Online Resources and Webinars:** Develop online resources, webinars, and digital platforms to disseminate information and resources on rainwater harvesting. Create interactive modules, videos, and guides that are accessible to extension agents and stakeholders, regardless of their location. **6.6** **Peer-to-Peer Learning Networks:** Facilitate peer-to-peer learning networks and knowledge exchange platforms where extension agents, practitioners, and community members can share experiences, best practices, and lessons learned related to rainwater harvesting. **6.7** **Partnerships with NGOs and Civil Society:** Collaborate with non-governmental organizations (NGOs), civil society groups, and community-based organizations (CBOs) that have expertise in water management and rural development. Leverage their networks, resources, and grassroots connections to extend outreach and support for rainwater harvesting initiatives. **6.8** **Integration into Existing Extension Programs:** Integrate rainwater harvesting into existing

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Barriers	**Measures**
	agricultural extension programs, water conservation initiatives, and community development projects. Leverage existing extension networks and infrastructure to reach a wider audience and mainstream rainwater harvesting practices. **6.9 Capacity Building for Local Service Providers:** Build the capacity of local service providers, such as plumbers, contractors, and maintenance technicians, to offer rainwater harvesting services to clients. Provide training, certification programs, and business development support to enhance their skills and expand their service offerings. **6.10 Incentives for Extension Agents:** Provide incentives, recognition, and professional development opportunities for extension agents and service providers who promote and support rainwater harvesting initiatives. Encourage their engagement and commitment to delivering high-quality extension services to communities. By implementing these strategies, stakeholders can address limited extension services for rainwater harvesting, build local capacity, and empower communities to adopt sustainable water management practices that enhance resilience and water security.

3-1. Financial Barriers and Measures Identified for Conservation Agriculture Technology

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Barriers	**Measures**
1.0 High Initial Costs: The adoption of conservation agriculture technology involves significant upfront investments in new and unconventional equipment, precision farming technologies, and training. The high initial costs can be a substantial economic barrier for farmers.	**1.1 Government Subsidies:** Provide targeted subsidies for the adoption of conservation agriculture practices, reducing the financial burden on farmers and incentivizing investment in new technologies. **1.2 Low-Interest Loans:** Establish accessible and low-interest loan programs to support farmers in financing the adoption of conservation agriculture technology, facilitating affordability and reducing financial barriers. **1.3 Insurance Incentives:** Develop insurance schemes specifically tailored to farmers using conservation agriculture practices, offering affordable coverage against climate-related risks and potential yield losses. **1.4 Market Incentives:** Create market incentives such as premium prices or preferential access for crops produced through conservation agriculture, encouraging farmers by improving the economic returns on their investments. **1.5 Public-Private Partnerships:** Foster collaboration between government agencies and private sector entities to co-finance and implement conservation agriculture projects. Private sector involvement can bring additional financial resources and expertise. **1.6 Tax Incentives:** Offer tax breaks or exemptions for contractors investing in conservation agriculture equipment or farmers adopting conservation agriculture practices, providing additional financial relief and encouraging widespread adoption. **1.7 Research and Development Funding:** Allocate funds for research and development to improve and adapt conservation agriculture technologies, ensuring that farmers have access to advanced and cost-effective solutions.

2.0 Access to Credit Limited access to affordable credit or financing options can hinder farmers' ability to invest in conservation agriculture technology. Without financial support, most farmers struggle to make the necessary investments.	Addressing access to credit in conservation agriculture involves implementing strategies to improve financial inclusion, mitigate risks, and promote investment in sustainable agricultural practices. Here are some ways to tackle this challenge: **2.1 Financial Literacy and Education:** Provide financial literacy training and education to farmers to enhance their understanding of credit products, terms, and management practices. Empower farmers with the knowledge and skills to make informed decisions about borrowing, saving, and investing in conservation agriculture. **2.2 Credit Guarantee Schemes:** Establish credit guarantee schemes or risk-sharing mechanisms to encourage financial institutions to lend to farmers engaged in conservation agriculture. Provide guarantees or collateral support to reduce the perceived risk of lending to agricultural borrowers. **2.3 Value Chain Financing:** Develop value chain financing models that integrate credit provision with input supply, production, marketing, and off-take arrangements. Facilitate partnerships between farmers, input suppliers, agribusinesses, and financial institutions to provide access to credit along the entire value chain. **2.4 Microfinance Institutions (MFIs):** Partner with microfinance institutions (MFIs) and community-based organizations to provide smallholder farmers with access to microcredit and savings products tailored to their needs. Offer flexible repayment terms, group lending mechanisms, and agricultural credit lines to support conservation agriculture practices. **2.5 Digital Financial Services:** Promote the use of digital financial services, such as mobile banking, digital payments, and mobile credit, to overcome barriers to accessing credit in remote and underserved rural areas. Facilitate partnerships between financial technology providers, mobile network operators, and agricultural stakeholders to expand financial inclusion. **2.6 Warehouse Receipt Systems:** Implement warehouse receipt systems (WRS) that allow farmers to use stored

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Barriers	**Measures**
	produce as collateral to access credit from financial institutions. Provide farmers with access to certified storage facilities and transparent trading platforms to leverage their agricultural assets for financing. **2.7** **Contract Farming Arrangements:** Facilitate contract farming arrangements between farmers and agribusinesses that provide access to credit, inputs, technical assistance, and market linkages. Enable farmers to access production credit based on pre-agreed purchase agreements or forward contracts with off-takers. **2.8** **Government Subsidies and Support Programs:** Advocate for government subsidies, grants, or support programs that incentivize financial institutions to lend to farmers engaged in conservation agriculture. Provide matching grants, interest rate subsidies, or loan guarantees to reduce the cost of credit and encourage investment in sustainable farming practices. **2.9** **Credit Scoring and Risk Assessment Tools:** Develop credit scoring models and risk assessment tools specifically tailored to the needs and realities of smallholder farmers practicing conservation agriculture. Incorporate non-traditional indicators of creditworthiness, such as farm management practices, environmental sustainability, and resilience to climate change. **2.10** Policy Advocacy and Regulatory Reform: Advocate for policy reforms that promote an enabling environment for agricultural finance and conservation agriculture. Lobby policymakers to enact supportive regulations, streamline administrative procedures, and remove barriers to accessing credit for sustainable farming practices.

3.0 Operational Costs: Ongoing operational costs, including maintenance, fuel, and servicing of specialized equipment, can be a financial burden for farmers. The continuous expenses associated with conservation agriculture technology may impact its economic feasibility.	Addressing operational costs in conservation agriculture involves implementing strategies to improve efficiency, optimize resource use, and reduce input expenditures while maintaining or increasing yields. Here are some ways to tackle this challenge: **3.1 Precision Farming Technologies:** Invest in precision farming technologies, such as GPS-guided equipment, drones, and sensors, to optimize input application, reduce waste, and enhance resource efficiency. Use data-driven decision-making tools to tailor inputs, such as seeds, fertilizers, and pesticides, to specific soil and crop conditions. **3.2 Conservation Tillage Practices:** Adopt conservation tillage practices, such as no-till or reduced tillage, to minimize soil disturbance, erosion, and fuel consumption associated with conventional plowing. Preserve soil moisture, structure, and fertility while reducing labor, machinery, and fuel costs over time. **3.3 Cover Crops and Crop Rotation:** Integrate cover crops and crop rotation into the farming system to improve soil health, suppress weeds, and reduce the need for synthetic inputs. Select cover crops that provide multiple benefits, such as nitrogen fixation, erosion control, and pest management, while minimizing operational costs. **3.4 Integrated Pest Management (IPM):** Implement integrated pest management (IPM) strategies to control pests, diseases, and weeds using a combination of biological, cultural, and chemical control methods. Reduce reliance on synthetic pesticides and herbicides by promoting natural predators, crop diversification, and sanitation practices. **3.5 Soil Health Management:** Prioritize soil health management practices, such as soil testing, nutrient management planning, and organic matter enhancement, to optimize nutrient availability, crop uptake, and yield potential. Maintain soil fertility through balanced nutrient applications and organic amendments to minimize input costs.

	3.6 Water Management Techniques: Implement water management techniques, such as drip irrigation, mulching, and rainwater harvesting, to improve water-use efficiency and reduce irrigation costs. Optimize irrigation scheduling based on crop water requirements, soil moisture levels, and weather forecasts to avoid water waste. **3.7 Energy-Efficient Equipment:** Upgrade to energy-efficient equipment, such as fuel-efficient tractors, irrigation pumps, and machinery, to reduce fuel consumption and operating costs. Adopt renewable energy technologies, such as solar-powered irrigation systems or biomass heaters, to offset energy expenses and reduce reliance on fossil fuels. **3.8 Economic Thresholds and Decision Tools:** Use economic thresholds and decision support tools to guide input investments and pest management decisions based on cost-benefit analyses. Monitor pest populations, crop performance, and market conditions to make informed choices that optimize returns while minimizing operational costs. **3.9 Collaborative Resource Sharing:** Explore collaborative resource-sharing arrangements, such as equipment sharing agreements, cooperative purchasing, or labor exchanges, with neighbouring farmers or agricultural cooperatives. Pool resources, equipment, and labor to reduce individual operational costs and increase efficiency. **3.10 Training and Capacity Building:** Provide training and capacity-building programs for farmers on conservation agriculture principles, techniques, and best practices. Equip farmers with the knowledge and skills to implement cost-effective strategies, troubleshoot challenges, and adapt to changing environmental conditions. By implementing these strategies, farmers can address operational costs in conservation agriculture, improve profitability, and promote sustainable farming practices that

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Barriers	**Measures**
	enhance productivity, resilience, and environmental stewardship.

4.0 Market Access Challenges Like other farmers, conservation agriculture innovators may face challenges in accessing markets for their produce. If there is insufficient demand or lower prices for crops produced using these techniques, the economic and environmental incentives for adoption diminish	Addressing market access challenges in conservation agriculture involves implementing strategies to improve market linkages, enhance value chain integration, and promote market-oriented farming practices. Here are some ways to tackle this challenge: **4.1 Market Information Systems:** Establish market information systems to provide farmers with timely and accurate information on prices, demand trends, and market opportunities for conservation agriculture products. Utilize mobile apps, SMS alerts, or online platforms to disseminate market information to farmers in remote and rural areas. **4.2 Market Intelligence and Analysis:** Conduct market intelligence and analysis to identify market gaps, niche opportunities, and value-added products that align with conservation agriculture principles. Analyze consumer preferences, market dynamics, and competitive landscapes to inform production and marketing decisions. **4.3 Market Linkage Platforms:** Facilitate market linkage platforms that connect farmers with buyers, traders, processors, and retailers interested in sourcing sustainably produced agricultural products. Organize farmer-producer groups, cooperatives, or associations to negotiate bulk sales, access higher-value markets, and share marketing costs. **4.4 Contract Farming Arrangements:** Promote contract farming arrangements between farmers and agribusinesses that provide market access, technical assistance, and input supply support for conservation agriculture practices. Establish transparent contracts, quality standards, and pricing mechanisms to ensure fair and equitable partnerships. **4.5 Value-Added Processing and Certification**: Encourage value-added processing and certification of conservation agriculture products to differentiate them in the marketplace and capture premium prices. Invest in processing facilities, packaging, and branding to enhance product quality, safety, and marketability.

	4.6 Market Diversification Strategies: Diversify market channels and distribution channels to reduce dependence on traditional markets and mitigate market access risks. Explore opportunities to sell directly to consumers through farmers' markets, community-supported agriculture (CSA) schemes, or online platforms. **4.7 Market-Oriented Production Planning:** Adopt market-oriented production planning approaches that align cropping decisions with market demand and price expectations. Select crop varieties, planting schedules, and production practices based on market preferences, product specifications, and price signals. **4.8 Post-Harvest Handling and Storage:** Improve post-harvest handling, storage, and transportation practices to maintain product quality, reduce losses, and meet market standards. Invest in cold storage facilities, drying technologies, and packaging materials to extend shelf life and preserve product freshness. **4.9 Market Access Infrastructure:** Invest in market access infrastructure, such as roads, bridges, storage facilities, and market centres, to reduce transportation costs and improve market connectivity for rural farmers. Advocate for government investment in infrastructure projects that enhance market access for agricultural producers. **4.10 Market Development Partnerships:** Collaborate with market development partners, including government agencies, NGOs, research institutions, and private sector actors, to strengthen market access for conservation agriculture products. Pool resources, expertise, and networks to address market access challenges collectively and sustainably. By implementing these strategies, stakeholders can address market access challenges in conservation agriculture, improve farmers' access to markets, and unlock economic opportunities for sustainable agricultural production.
5.0 Insurance Availability In Lesotho, the southern lowlands and Senqu river valley regions are	Addressing insurance availability in conservation agriculture involves implementing strategies to mitigate production risks, enhance resilience, and improve access to insurance products tailored to the needs of farmers practicing sustainable

prone to climate-related risks, the availability and affordability of insurance for crops using conservation agriculture practices may be limited. This lack of insurance coverage can deter farmers concerned about potential losses.	agricultural practices. Here are some ways to tackle this challenge: **5.1 Index-Based Insurance:** Promote the development and adoption of index-based insurance products that use weather, yield, or vegetation indices as triggers for payouts. Index insurance reduces administrative costs, eliminates the need for individual farm assessments, and provides timely compensation for weather-related losses. **5.2 Parametric Insurance:** Encourage the use of parametric insurance schemes that provide predetermined payouts based on specific, measurable parameters, such as rainfall levels, temperature thresholds, or crop growth stages. Parametric insurance offers quick and transparent claims processing, reducing the time and administrative burden associated with traditional indemnity-based insurance. **5.3 Customized Insurance Products:** Work with insurers to develop customized insurance products tailored to the unique risk profiles and needs of conservation agriculture practitioners. Design insurance packages that cover specific risks, such as soil erosion, drought, or crop rotation failure, to provide comprehensive protection for farmers. **5.4 Risk Assessment and Modeling:** Conduct risk assessment and modeling exercises to identify and quantify the key production risks faced by farmers practicing conservation agriculture. Use data analytics, remote sensing, and geospatial technologies to assess vulnerability, predict potential losses, and design insurance solutions. **5.5 Insurance Subsidies and Incentives:** Advocate for government subsidies, grants, or incentives to make insurance more affordable and accessible to farmers engaged in conservation agriculture. Provide premium subsidies, risk-sharing mechanisms, or tax incentives to encourage farmers to purchase insurance coverage. **5.6 Extension and Education:** Educate farmers about the benefits of insurance as a risk management tool and the importance of incorporating insurance into their farm management strategies. Provide training, workshops, and

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Barriers	**Measures**
	informational materials on insurance literacy, policy options, and claims processes. **5.7 Insurance Awareness Campaigns:** Launch awareness campaigns to promote insurance uptake among farmers and build trust in insurance products and providers. Highlight success stories, case studies, and testimonials from farmers who have benefited from insurance coverage in managing production risks. **5.8 Partnerships with Insurance Providers:** Collaborate with insurance companies, brokers, and cooperatives to expand the availability of insurance products for conservation agriculture practitioners. Facilitate partnerships that leverage insurers' expertise, underwriting capacity, and distribution networks to reach rural and underserved communities. **5.9 Crop Insurance Pools:** Establish crop insurance pools or mutuals that pool risk among farmers practicing conservation agriculture. Enable farmers to collectively share risk, lower premiums, and access insurance coverage that might otherwise be unaffordable or unavailable to individual producers. **5.10 Policy Advocacy and Regulatory Reform:** Advocate for policy reforms that support the development and implementation of insurance solutions for conservation agriculture. Lobby policymakers to create an enabling regulatory environment, streamline administrative processes, and incentivize private sector investment in agricultural insurance. By implementing these strategies, stakeholders can address insurance availability in conservation agriculture, improve farmers' resilience to production risks, and promote sustainable agricultural practices that enhance food security and livelihoods.

6.0 Subsidy Structures	
In Lesotho, where the legacy farming system is conventional agriculture despite the high risk of soil erosion and land degradation, government subsidies and support structures are not aligned with the adoption of conservation agriculture practices. Thus, farmers are more inclined to adopt technologies that are more heavily subsidized.	Addressing subsidy structures in conservation agriculture involves aligning incentives, promoting sustainable practices, and fostering equitable distribution of support to farmers. Here are some ways to tackle this challenge: **6.1 Targeted Subsidies:** Redirect existing agricultural subsidies towards supporting conservation agriculture practices. Design subsidy programs that prioritize investments in soil health, water conservation, biodiversity conservation, and climate resilience, thereby incentivizing farmers to adopt sustainable farming practices. **6.2 Performance-Based Subsidies:** Implement performance-based subsidy schemes that reward farmers for achieving specific conservation outcomes, such as soil carbon sequestration, water-use efficiency, or habitat restoration. Link subsidy payments to measurable indicators of environmental stewardship and agricultural sustainability. **6.3 Input Subsidy Reform:** Revise input subsidy programs to promote the use of environmentally friendly inputs, such as organic fertilizers, biopesticides, and cover crop seeds, in conservation agriculture systems. Offer subsidies for inputs that enhance soil fertility, reduce erosion, and improve ecosystem services. **6.4 Training and Extension Services:** Allocate subsidy funds to training, extension services, and technical assistance programs that support farmers in adopting and implementing conservation agriculture practices. Invest in capacity building, farmer education, and knowledge transfer to enhance the effectiveness and sustainability of agricultural subsidies. **6.5 Incentives for Innovation:** Provide incentives, grants, or tax credits to farmers, agribusinesses, and research institutions that develop and adopt innovative technologies, practices, or solutions that advance conservation agriculture objectives. Encourage experimentation, research, and adaptive management to drive continuous improvement in sustainable farming practices.

	6.6 Outcome-Based Payments: Explore outcome-based payment schemes, such as payments for ecosystem services (PES), that compensate farmers for the environmental benefits generated by conservation agriculture practices. Reward farmers for sequestering carbon, preserving biodiversity, improving water quality, or mitigating climate change impacts through their farming activities. **6.7 Risk Management Support:** Offer risk management support, such as insurance subsidies or risk-sharing mechanisms, to farmers practicing conservation agriculture. Reduce the financial risk associated with transitioning to sustainable farming systems by providing subsidized insurance premiums or access to emergency relief funds in case of crop failures or natural disasters. **6.8 Subsidy Transparency and Accountability:** Ensure transparency and accountability in subsidy allocation and distribution processes to prevent misuse, inefficiencies, and inequities. Implement robust monitoring, evaluation, and reporting mechanisms to track subsidy outcomes, assess program effectiveness, and inform policy decisions. **6.9 Consultation and Stakeholder Engagement:** Engage farmers, agricultural organizations, environmental NGOs, policymakers, and other stakeholders in the design, implementation, and evaluation of subsidy structures for conservation agriculture. Foster inclusive decision-making processes that reflect diverse perspectives and priorities. **6.10 Policy Integration and Coherence**: Integrate conservation agriculture objectives into broader agricultural policies, strategies, and subsidy frameworks to ensure coherence and alignment across different policy domains. Coordinate efforts across government agencies, departments, and sectors to maximize synergies and minimize trade-offs between conservation and agricultural development goals. By implementing these strategies, policymakers can address subsidy structures in conservation agriculture, promote

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Barriers	**Measures**
	sustainable farming practices, and support farmers in transitioning to more environmentally friendly and resilient agricultural systems.

7.0 Land Tenure Issues Uncertainties related to land tenure can act as an economic barrier. Farmers are reluctant to invest in long-term conservation practices if they do not have secure land rights, fearing potential land-use changes.	Addressing land tenure issues in conservation agriculture involves implementing strategies to secure land tenure rights, promote sustainable land management practices, and facilitate access to land for farmers practicing conservation agriculture. Here are some ways to tackle this challenge: **7.1 Secure Land Rights:** Advocate for the recognition and formalization of land tenure rights for farmers practicing conservation agriculture, particularly smallholder farmers and indigenous communities. Ensure that farmers have secure tenure over their land through land titling, registration, or customary tenure arrangements. **7.2 Legal Reform and Policy Support:** Advocate for legal reforms and policy support that strengthen land tenure security and protect land rights for conservation agriculture practitioners. Lobby for legislation that recognizes and protects customary land tenure systems, promotes gender-equitable land rights, and safeguards land from encroachment or expropriation. **7.3 Community Land Management:** Promote community-based land management approaches that empower local communities to collectively manage and steward land resources for conservation agriculture. Establish community land trusts, user groups, or cooperatives to govern land use, enforce conservation practices, and resolve tenure-related conflicts. **7.4 Participatory Land Use Planning:** Facilitate participatory land use planning processes that engage stakeholders, including farmers, landowners, government agencies, and civil society organizations, in decision-making about land allocation, zoning, and management. Ensure that conservation agriculture practices are integrated into land use plans and regulations. **7.5 Land Access and Redistribution:** Advocate for policies and programs that facilitate access to land for farmers interested in practicing conservation agriculture, including land redistribution, land leasing, or land tenure reform initiatives. Support land redistribution schemes

	that prioritize access for landless or marginalized farmers. **7.6 Land Tenure Formalization:** Support efforts to formalize informal land tenure arrangements through land registration, certification, or documentation processes. Provide technical assistance, legal support, and financial incentives to help farmers formalize their land tenure rights and secure land titles or leases. **7.7 Conflict Resolution Mechanisms:** Establish mechanisms for resolving land tenure disputes, conflicts, and grievances related to conservation agriculture. Develop mediation, arbitration, or customary dispute resolution mechanisms that are accessible, transparent, and culturally appropriate for affected communities. **7.8 Land Conservation Incentives:** Introduce incentives for landowners to conserve and sustainably manage their land for conservation agriculture purposes. Offer tax incentives, payment for ecosystem services (PES) schemes, or conservation easements that reward landowners for maintaining or enhancing ecological values on their land. **7.9 Capacity Building and Legal Awareness:** Provide capacity building and legal awareness programs to farmers, landowners, and local communities on land tenure rights, laws, and regulations related to conservation agriculture. Empower stakeholders with knowledge and skills to navigate land tenure issues and advocate for their rights. **7.10 Partnerships and Collaboration:** Foster partnerships and collaboration among government agencies, civil society organizations, research institutions, and private sector actors to address land tenure issues in conservation agriculture. Pool resources, expertise, and networks to develop innovative solutions and implement effective interventions. By implementing these strategies, stakeholders can address land tenure issues in conservation agriculture, secure land rights for farmers, and promote sustainable land management

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Barriers	**Measures**
	practices that enhance environmental stewardship and food security.

8.0 Limited Return on Investment Assurance Farmers perceive a lack of certainty regarding the return on investment for conservation agriculture technology. This uncertainty can deter adoption, especially when compared to more conventional and familiar farming practices.	Addressing limited return on investment (ROI) assurance in conservation agriculture involves implementing strategies to mitigate risks, enhance profitability, and provide incentives for farmers to adopt sustainable farming practices. Here are some ways to tackle this challenge: **8.1 Cost-Benefit Analysis:** Conduct cost-benefit analyses to assess the economic viability and potential returns of conservation agriculture practices compared to conventional farming methods. Highlight the long-term benefits, such as improved soil health, reduced input costs, and increased resilience to climate change, to demonstrate the value proposition of conservation agriculture. **8.2 Financial Risk Management:** Develop financial risk management strategies to minimize investment risks and uncertainties associated with conservation agriculture. Offer insurance products, risk-sharing mechanisms, or input financing schemes that protect farmers against production losses, price volatility, and market fluctuations. **8.3 Subsidies and Incentives:** Provide subsidies, grants, or financial incentives to offset the initial costs of adopting conservation agriculture practices and encourage farmers to invest in sustainable land management. Offer targeted support for purchasing equipment, seeds, inputs, or infrastructure needed to implement conservation practices. **8.4 Value-Added Marketing:** Promote value-added marketing opportunities for conservation agriculture products, such as organic certification, fair trade labeling, or niche market branding, to capture premium prices and improve returns for farmers. Connect farmers with markets that value sustainability and environmental stewardship. **8.5 Market Access Improvement:** Address market access barriers and constraints that limit farmers' ability to realize returns on investment in conservation agriculture. Invest in market infrastructure, transportation networks,

	and market information systems to facilitate market linkages and reduce transaction costs for farmers. **8.6 Diversification and Value Chain Integration:** Encourage diversification and value chain integration to enhance income generation and risk spreading for farmers engaged in conservation agriculture. Promote crop diversification, intercropping, or livestock integration to create additional revenue streams and market opportunities. **8.7 Carbon Credits and Payment for Ecosystem Services**: Explore opportunities for farmers to generate additional revenue through carbon credits, payment for ecosystem services (PES) schemes, or other environmental payment programs that reward conservation agriculture practices. Monetize the environmental benefits of soil carbon sequestration, biodiversity conservation, and watershed protection. **8.8 Technical Assistance and Extension Support:** Provide technical assistance, extension services, and agronomic support to help farmers implement and optimize conservation agriculture practices effectively. Offer training, demonstration plots, field days, and on-farm trials to build farmers' capacity and confidence in adopting new techniques. **8.9 Research and Innovation:** Invest in research and innovation to develop and disseminate cost-effective technologies, practices, and solutions that improve the productivity, profitability, and sustainability of conservation agriculture. Support applied research, technology transfer, and knowledge exchange platforms to accelerate adoption and scale-up. **8.10 Partnerships and Collaboration:** Foster partnerships and collaboration among stakeholders, including government agencies, NGOs, research institutions, and private sector actors, to address barriers to return on investment in conservation agriculture. Pool resources, expertise, and networks to co-create solutions and support farmers in realizing the full economic potential of sustainable farming practices.

Identified Economic and Financial Barriers and Measures for Conservation Agriculture Technology	
Barriers	**Measures**
	By implementing these strategies, stakeholders can address limited return on investment assurance in conservation agriculture, enhance profitability, and incentivize farmers to adopt sustainable land management practices that deliver economic, environmental, and social benefits.

9.0 Training and Capacity Building Costs Training farmers to use new technologies and implementing capacity-building programs can entail additional costs. Thus, limited resources for education and training can be a financial barrier to widespread adoption.	Addressing training and capacity building costs in conservation agriculture involves implementing strategies to make training more accessible, affordable, and effective for farmers. Here are some ways to tackle this challenge: **9.1 Digital Training Platforms:** Develop digital training platforms, online courses, and educational resources that provide farmers with convenient access to training materials, tutorials, and instructional videos on conservation agriculture practices. Utilize mobile apps, webinars, and e-learning platforms to reach a wider audience and reduce training costs. **9.2 Extension Services:** Strengthen extension services and agricultural advisory systems to deliver personalized, hands-on training and technical assistance to farmers practicing conservation agriculture. Train extension agents, field officers, and community facilitators to provide on-site demonstrations, group trainings, and farmer-to-farmer knowledge exchange sessions. **9.3 Demonstration Farms:** Establish demonstration farms, field schools, or learning centres that serve as hubs for training and capacity building on conservation agriculture. Allow farmers to visit demonstration sites to observe best practices, experiment with new techniques, and receive practical training from experts and experienced farmers. **9.4 Farmer Field Schools:** Facilitate farmer field schools (FFS) or participatory learning groups where farmers collaborate, learn, and experiment together under the guidance of trained facilitators. Use FFS methodologies to promote experiential learning, problem-solving, and peer-to-peer knowledge sharing among farmers. **9.5 Training of Trainers (ToT):** Conduct training of trainers (ToT) programs to build the capacity of local trainers, extension agents, and lead farmers to deliver high-quality training and extension services on conservation agriculture. Equip trainers with the skills, knowledge, and materials needed to effectively transfer information and support farmers.

	9.6 Tailored Training Modules: Develop tailored training modules, curricula, and educational materials that address the specific needs, contexts, and challenges faced by farmers practicing conservation agriculture. Customize training content to cater to different agroecological zones, cropping systems, and farmer preferences. **9.7 Participatory Approaches:** Use participatory training approaches, such as farmer-led demonstrations, participatory video, or theater-based education, to engage farmers actively in the learning process and empower them to take ownership of their training and capacity building efforts. **9.8 Public-Private Partnerships:** Forge partnerships with private sector companies, agribusinesses, input suppliers, and value chain actors to co-finance training and capacity building initiatives in conservation agriculture. Leverage corporate social responsibility (CSR) funds, sponsorship agreements, or in-kind contributions to support training programs for farmers. **9.9 Community-Based Organizations (CBOs):** Collaborate with community-based organizations, cooperatives, women's groups, and grassroots networks to mobilize resources and coordinate training activities at the local level. Tap into existing social capital, community structures, and networks to facilitate peer learning and knowledge exchange. **9.10 Incentives and Recognition:** Provide incentives, rewards, or certification schemes to motivate farmers to participate in training and capacity building activities related to conservation agriculture. Recognize and celebrate achievements, innovation, and leadership in adopting sustainable farming practices. By implementing these strategies, stakeholders can address training and capacity building costs in conservation agriculture, empower farmers with the knowledge and skills to adopt sustainable practices, and enhance the resilience and productivity of agricultural systems.

10.0Lack of Financial Incentives In Lesotho, given the limited financial incentives for adopting conservation agriculture, farmers may be less motivated to invest in these technologies, particularly in the light of competing priorities for limited resources.	Addressing the lack of financial incentives in conservation agriculture involves implementing strategies to incentivize farmers to adopt sustainable farming practices by providing economic rewards or benefits. Here are some ways to tackle this challenge: **10.1 Payment for Ecosystem Services** (PES): Establish payment for ecosystem services (PES) schemes that compensate farmers for the environmental benefits generated by conservation agriculture practices. Offer financial incentives for soil carbon sequestration, water conservation, biodiversity enhancement, and climate change mitigation. **10.2 Subsidies and Grants:** Provide subsidies, grants, or financial incentives to offset the costs of adopting conservation agriculture practices and promote their widespread adoption among farmers. Offer targeted support for purchasing equipment, seeds, inputs, or infrastructure needed to implement sustainable land management techniques. **10.3 Market Premiums:** Create market premiums or price incentives for sustainably produced agricultural products, such as organic certification, fair trade labeling, or environmental product certifications. Encourage consumers, retailers, and food companies to pay a premium for products that meet certain sustainability standards or environmental criteria. **10.4 Value-Added Marketing:** Promote value-added marketing opportunities for conservation agriculture products by highlighting their environmental benefits, quality attributes, and social responsibility credentials. Develop niche markets, specialty products, or branded labels that differentiate sustainably produced goods and command higher prices in the marketplace. **10.5 Carbon Offsetting Programs:** Participate in carbon offsetting programs that allow farmers to earn revenue from carbon credits generated by adopting conservation agriculture practices that sequester carbon dioxide from the atmosphere. Monetize the carbon sequestration

	potential of soil organic matter and vegetation through carbon trading platforms or offset markets. **10.6 Certification Programs:** Enrol in certification programs that recognize and reward farmers for implementing conservation agriculture practices and adhering to sustainable land management standards. Obtain certification labels, seals of approval, or eco-labels that signal to consumers and buyers that products are produced in an environmentally responsible manner. **10.7 Green Financing:** Access green financing mechanisms, such as green loans, green bonds, or sustainability-linked credit facilities, that offer favourable terms and conditions to farmers investing in conservation agriculture. Partner with financial institutions that prioritize lending to projects with positive environmental impacts. **10.8 Government Incentive Programs:** Advocate for government incentive programs that support conservation agriculture initiatives through tax incentives, subsidy programs, or direct payments to farmers. Lobby policymakers to allocate public funds or allocate resources to conservation agriculture projects that deliver environmental, social, and economic benefits. **10.9 Risk Reduction and Insurance:** Provide risk reduction measures and insurance products that protect farmers from financial losses associated with adopting conservation agriculture practices. Offer insurance coverage for crop failures, yield fluctuations, or adverse weather events to mitigate the perceived risks of transitioning to sustainable farming methods. **10.10 Capacity Building and Technical Assistance:** Invest in capacity building, training, and technical assistance programs that equip farmers with the knowledge, skills, and resources needed to implement conservation agriculture practices effectively. Provide financial support for farmer training, extension services, and agronomic support to facilitate adoption and uptake.

Identified Economic and Financial Barriers and Measures for Conservation Agriculture Technology	
Barriers	**Measures**
	By implementing these strategies, stakeholders can address the lack of financial incentives in conservation agriculture, incentivize farmers to adopt sustainable practices, and promote the widespread adoption of environmentally friendly farming techniques.

3-2. Non -Financial Barriers and Measures Identified for Conservation Agriculture Technology

Identified non-Economic and non-financial barriers and measures for Conservation Agriculture Technology	
Barriers	**Measures**
1.0 Knowledge and Awareness Limited understanding and awareness of conservation agriculture practices act as a significant non-economic barrier. The lack of knowledge and awareness amongst extension agents exacerbates the farmers' lack of familiarity with the principles and benefits of conservation agriculture, hindering adoption.	**1.1 Education and Extension Services**: Develop comprehensive educational programs and extension services to increase awareness and understanding of conservation agriculture practices among farmers. **1.2 Demonstration Farms:** Establish demonstration farms where farmers can observe successful implementation of conservation agriculture, providing tangible examples and building confidence in the effectiveness of these practices. **1.3 Community Engagement:** Facilitate community engagement initiatives to address social dynamics and encourage the adoption of conservation agriculture. Peer learning and community support can be powerful non-economic drivers. **1.4 Policy Alignment:** Develop and implement policies that support and promote conservation agriculture practices. Clear and supportive regulatory frameworks are essential for creating an enabling environment. **1.5 Partnerships with NGOs:** Collaborate with NGOs, CBOs and academia to provide on-the-ground support, knowledge transfer, and assistance in implementing conservation agriculture. **1.6 Extension Services:** Strengthen extension services to provide ongoing support and guidance to farmers adopting conservation agriculture by ensuring that they have the necessary knowledge and resources for successful implementation.; helping them establish platforms for sharing experiences and networking.

2.0 Traditional Farming Practices In Lesotho, deep-rooted reliance on conventional farming methods impedes the adoption of conservation agriculture. Resistance to change and scepticism about the effectiveness of new practices may pose a non-financial obstacle.	Addressing traditional farming practices in conservation agriculture involves promoting the adoption of sustainable land management techniques while respecting and integrating traditional knowledge and practices. Here are some ways to tackle this challenge: **2.1 Community Engagement and Participation:** Engage local communities, traditional leaders, and indigenous knowledge holders in the design, implementation, and monitoring of conservation agriculture initiatives. Respect traditional farming systems, cultural practices, and ecological knowledge while promoting the adoption of sustainable techniques. **2.2 Knowledge Sharing and Exchange:** Facilitate knowledge sharing and exchange between traditional farmers and conservation agriculture practitioners to foster mutual learning and innovation. Organize farmer-to-farmer exchanges, field demonstrations, and community dialogues to showcase successful conservation agriculture practices and their compatibility with traditional farming systems. **2.3 Adaptive Management Approaches**: Adopt adaptive management approaches that integrate traditional ecological knowledge with modern scientific principles to develop context-specific solutions for conservation agriculture. Combine indigenous practices, crop rotations, and agroforestry techniques with contemporary agroecological methods to enhance resilience and sustainability. **2.4 Demonstration and Learning Sites:** Establish demonstration plots, model farms, or learning sites that showcase the integration of traditional farming practices with conservation agriculture principles. Invite farmers, extension agents, and policymakers to visit demonstration sites to observe, learn, and exchange ideas about sustainable land management.

	2.5 Participatory Research and Innovation: Collaborate with local communities, research institutions, and agricultural organizations to co-design and co-implement participatory research and innovation projects that address the challenges and opportunities of integrating traditional farming practices into conservation agriculture systems. Involve farmers in research planning, data collection, and knowledge co-creation processes. **2.6 Cultural Revitalization and Preservation**: Support efforts to revitalize and preserve traditional farming practices, seed varieties, and crop diversity as integral components of conservation agriculture systems. Document indigenous knowledge, cultural traditions, and agricultural rituals associated with sustainable land management and biodiversity conservation. **2.7 Incentive Mechanisms:** Provide incentives, rewards, or recognition for farmers who adopt and maintain traditional farming practices that contribute to conservation agriculture objectives, such as soil conservation, water management, or agroecosystem resilience. Offer financial incentives, grants, or access to markets for products produced using traditional methods. **2.8 Policy Support and Recognition:** Advocate for policy support and recognition of traditional farming systems within national agricultural policies, strategies, and programs. Ensure that policies promote the preservation of indigenous agricultural heritage, support indigenous land rights, and integrate traditional knowledge into agricultural research and extension services. **2.9 Capacity Building and Training:** Invest in capacity building and training programs that empower traditional farmers with the skills, knowledge, and resources needed to adopt conservation agriculture practices while preserving their cultural identity and heritage. Provide training

Identified non-Economic and non-financial barriers and measures for Conservation Agriculture Technology	
Barriers	**Measures**
	on sustainable land management, agroecology, and climate-smart farming techniques tailored to local contexts. **2.10 Interdisciplinary Collaboration:** Foster interdisciplinary collaboration among agronomists, anthropologists, sociologists, and indigenous scholars to co-produce knowledge and co-develop solutions that bridge the gap between conservation agriculture and traditional farming systems. Embrace a holistic approach that recognizes the interconnectedness of social, cultural, and ecological dimensions of agriculture. By implementing these strategies, stakeholders can address traditional farming practices in conservation agriculture, harnessing the strengths of both traditional and modern farming systems to promote sustainable land management, preserve cultural heritage, and enhance food security and resilience.

3.0 Access to Information and Extension Services Conservation agriculture is a practice formally adopted by the Ministry of Agriculture, Food Security and Nutrition in Lesotho and is advocated for in strategic policy documents. Nevertheless, inadequate access to information and extension services hinders the dissemination of knowledge about conservation agriculture. Limited outreach and support for farmers can slow down the adoption process.	Addressing access to information and extension issues in conservation agriculture involves improving farmers' access to knowledge, resources, and technical support to facilitate the adoption and implementation of sustainable farming practices. Here are some ways to tackle this challenge: **3.1 Digital Extension Services:** Develop and deploy digital extension services, mobile apps, and online platforms that provide farmers with access to agricultural information, best practices, and technical assistance on conservation agriculture. Utilize mobile phone networks, internet connectivity, and information and communication technologies (ICTs) to reach remote and underserved farming communities. **3.2 Radio and Broadcasting:** Utilize radio programs, community radio stations, and agricultural broadcasting channels to disseminate agricultural information, weather forecasts, and extension messages to farmers. Produce radio shows, talk programs, and interactive call-in sessions that feature expert advice, farmer testimonials, and success stories related to conservation agriculture. **3.3 Farmers' Field Schools:** Establish farmers' field schools (FFS) or participatory learning groups where farmers come together to learn, experiment, and exchange knowledge about conservation agriculture practices. Facilitate hands-on training, field demonstrations, and experiential learning activities led by trained extension agents or lead farmers. **3.4 Extension Worker Training:** Invest in training and capacity building programs for extension workers, agricultural advisors, and community facilitators to enhance their knowledge, skills, and competencies in conservation agriculture. Provide training on sustainable land management, agroecology, climate-smart farming techniques, and participatory extension methods.

	3.5 Knowledge Centres and Resource Hubs: Establish knowledge centres, resource hubs, or agricultural libraries that serve as repositories of information, technical publications, training materials, and multimedia resources on conservation agriculture. Provide farmers with access to print materials, videos, posters, and audiovisual aids for self-directed learning and reference. **3.6 Demonstration Plots and Model Farms:** Set up demonstration plots, model farms, or learning sites that showcase conservation agriculture practices and their performance under local agroecological conditions. Invite farmers, extension agents, and policymakers to visit demonstration sites to observe, learn, and interact with experts and experienced farmers. **3.7 Extension Networks and Partnerships:** Strengthen extension networks and partnerships by collaborating with government agencies, NGOs, research institutions, agricultural cooperatives, and private sector organizations to deliver extension services and technical assistance to farmers. Leverage existing networks, farmer organizations, and community-based organizations to extend the reach and impact of extension activities. **3.8 Tailored Information and Advisory Services**: Provide farmers with tailored information, advisory services, and decision support tools that address their specific needs, contexts, and challenges related to conservation agriculture. Offer personalized recommendations, agronomic advice, and crop management strategies based on local soil, climate, and cropping conditions. **3.9 Community-Based Extension Approaches:** Implement community-based extension approaches that empower farmers to take ownership of their learning and development process. Facilitate participatory planning, needs assessment, and

Identified non-Economic and non-financial barriers and measures for Conservation Agriculture Technology	
Barriers	**Measures**
	priority setting exercises that involve farmers in co-designing and co-implementing extension activities. **3.10 Monitoring and Evaluation:** Establish monitoring and evaluation systems to assess the effectiveness, reach, and impact of extension services and information dissemination efforts in promoting conservation agriculture. Collect feedback from farmers, track adoption rates, and measure changes in knowledge, attitudes, and practices over time. By implementing these strategies, stakeholders can address access to information and extension issues in conservation agriculture, empower farmers with the knowledge and skills needed to adopt sustainable farming practices, and enhance the resilience and productivity of agricultural systems.

4.0 Technological Literacy Many farmers, including extension officers lack the necessary technological literacy to implement conservation agriculture practices, particularly when it involves the use of advanced equipment or precision farming technologies	Addressing technological literacy in conservation agriculture involves providing farmers with the knowledge, skills, and access to appropriate technologies to effectively adopt and utilize modern agricultural innovations. Here are some ways to tackle this challenge: **4.1 Training and Capacity Building:** Offer training programs, workshops, and hands-on demonstrations to build farmers' capacity and confidence in using agricultural technologies relevant to conservation agriculture. Provide practical training on the use of farm machinery, precision agriculture tools, and digital platforms for data collection and analysis. **4.2 Extension Services:** Strengthen extension services and advisory systems to deliver tailored information and technical support to farmers on adopting and utilizing agricultural technologies in conservation agriculture. Train extension agents, agronomists, and community facilitators to provide on-site assistance, troubleshooting, and guidance on technology adoption. **4.3 Technology Demonstrations:** Organize technology demonstrations, field days, and farmer field schools that showcase the performance and benefits of agricultural technologies in conservation agriculture. Allow farmers to observe, interact with, and evaluate different technologies in action to better understand their potential and applicability. **4.4 Digital Literacy Programs:** Provide digital literacy training and support to farmers to enhance their ability to access, navigate, and utilize digital tools, mobile apps, and online platforms related to conservation agriculture. Offer training on basic computer skills, internet usage, and mobile phone applications relevant to agricultural management. **4.5 ICT Access and Connectivity:** Improve farmers' access to information and communication technologies (ICTs), such as mobile phones,

	internet connectivity, and rural telecommunication infrastructure, to facilitate technology adoption and knowledge sharing in conservation agriculture. Expand mobile network coverage, provide affordable internet services, and promote digital inclusion initiatives in rural areas. **4.6** **Technology Transfer Partnerships:** Foster partnerships and collaboration between technology providers, research institutions, agricultural companies, and farmer organizations to facilitate technology transfer and adoption in conservation agriculture. Establish demonstration plots, pilot projects, and technology hubs where farmers can access and test new innovations. **4.7** **User-Friendly Technologies:** Develop and promote user-friendly agricultural technologies that are accessible, affordable, and adaptable to the needs and preferences of smallholder farmers practicing conservation agriculture. Design technologies with intuitive interfaces, simple operation procedures, and low maintenance requirements to overcome barriers to adoption. **4.8** **Peer Learning Networks:** Facilitate peer learning networks, knowledge exchange platforms, and farmer-to-farmer extension approaches that enable farmers to share experiences, lessons learned, and best practices related to agricultural technology adoption. Encourage collaboration, networking, and knowledge sharing among farmers to accelerate technology diffusion and innovation. **4.9** **Technical Support Services:** Establish technical support services, helpdesks, or call centers staffed by trained technicians or agronomists to provide remote assistance, troubleshooting, and advisory services to farmers on agricultural technology use. Offer telephone hotlines, SMS helplines, or online chat support for timely response to farmers' queries and concerns.

Identified non-Economic and non-financial barriers and measures for Conservation Agriculture Technology	
Barriers	**Measures**
	4.10 Incentive Mechanisms: Provide incentives, rewards, or subsidies to encourage farmers to adopt and invest in agricultural technologies that improve productivity, efficiency, and sustainability in conservation agriculture. Offer financial support for purchasing equipment, machinery, or inputs that enhance soil health, water management, or pest control practices. By implementing these strategies, stakeholders can address technological literacy gaps in conservation agriculture, empower farmers with the knowledge and skills needed to adopt and utilize agricultural technologies effectively, and enhance the resilience and productivity of agricultural systems.

5.0 Water Management Challenges Technically and practically, conservation agriculture is a superior system for water management. However, for lack of knowledge, in regions where water scarcity is a concern, farmers may perceive conservation agriculture as a risk due to uncertainties about water availability and the effectiveness of water-saving techniques.	Addressing water management challenges in conservation agriculture involves implementing strategies to optimize water use efficiency, enhance soil moisture retention, and mitigate the impacts of water scarcity and variability on agricultural productivity. Here are some ways to tackle this challenge: **5.1 Soil Conservation Practices:** Implement soil conservation practices, such as conservation tillage, mulching, and cover cropping, to reduce soil erosion, improve soil structure, and enhance water infiltration and retention in the soil. Minimize tillage operations to maintain soil organic matter and reduce water runoff. **5.2 Water Harvesting and Storage:** Adopt water harvesting techniques, such as rainwater harvesting, runoff collection, and small-scale reservoirs, to capture and store rainwater for irrigation and supplemental water supply during dry periods. Construct water storage infrastructure, such as ponds, tanks, and cisterns, to capture and store runoff for agricultural use. **5.3 Drip Irrigation and Micro-irrigation:** Invest in drip irrigation, micro-irrigation, and precision irrigation systems that deliver water directly to the root zone of crops, minimizing water losses due to evaporation, runoff, and deep percolation. Use efficient irrigation technologies, such as drip lines, sprinklers, and drip tapes, to optimize water application and distribution. **5.4 Water-Efficient Crops and Varieties:** Select drought-tolerant crop varieties and water-efficient crops that require less water and have higher tolerance to water stress. Choose crop species and cultivars adapted to local agroecological conditions, rainfall patterns, and soil types to maximize water productivity and resilience to climate variability. **5.5 Crop Rotation and Intercropping:** Practice crop rotation, intercropping, and agroforestry systems

	that diversify cropping patterns, improve soil health, and enhance water use efficiency in conservation agriculture. Rotate crops with different water requirements to optimize water utilization and minimize the risk of water-related yield losses. **5.6 Precision Farming Technologies:** Adopt precision farming technologies, such as remote sensing, GIS mapping, and soil moisture sensors, to monitor and manage water resources more effectively in conservation agriculture. Use real-time data and digital tools to optimize irrigation scheduling, monitor soil moisture levels, and make informed water management decisions. **5.7 Water Conservation Practices:** Promote water conservation practices, such as deficit irrigation, controlled drainage, and furrow diking, to reduce water wastage and optimize water use in agricultural production systems. Implement water-saving techniques that improve irrigation efficiency, minimize water losses, and maximize crop yields per unit of water applied. **5.8 Water Quality Management:** Manage water quality in agricultural landscapes by minimizing pollution, sedimentation, and nutrient runoff from farm fields into water bodies. Implement riparian buffers, vegetative filter strips, and conservation buffers to intercept and filter runoff water, protecting water quality and aquatic ecosystems. **5.9 Community-Based Water Management:** Engage local communities, water user associations, and farmer groups in participatory water management initiatives that promote collective action, water sharing agreements, and equitable distribution of water resources. Foster collaboration and dialogue among stakeholders to address water conflicts, resolve disputes, and ensure sustainable water use practices.

Identified non-Economic and non-financial barriers and measures for Conservation Agriculture Technology	
Barriers	**Measures**
	5.10 Policy and Regulatory Support: Advocate for policy and regulatory reforms that promote sustainable water management practices in agriculture, such as water pricing mechanisms, water rights allocation, and water use regulations. Lobby policymakers to incentivize water-saving technologies, provide financial support for water infrastructure investments, and strengthen water governance frameworks. By implementing these strategies, stakeholders can address water management challenges in conservation agriculture, optimize water use efficiency, and promote sustainable water stewardship practices that enhance agricultural productivity, resilience, and environmental sustainability.

6.0 Market Access and Crop Prices Concerns about market access and the prices of crops produced through conservation agriculture can influence adoption. Farmers may be hesitant if they perceive a lack of demand or lower market prices for such crops.	Addressing market access and crop prices in conservation agriculture involves improving farmers' access to markets, enhancing market linkages, and promoting value-added products to capture premium prices. Here are some ways to tackle this challenge: **6.1 Market Information Systems:** Establish market information systems that provide farmers with timely and accurate information on crop prices, market demand, and supply chain dynamics. Utilize mobile apps, SMS alerts, and online platforms to disseminate market information to farmers in real-time, enabling them to make informed decisions about crop production and marketing. **6.2 Market Infrastructure Development**: Invest in market infrastructure development, such as roads, storage facilities, processing centers, and cold chains, to improve market access and reduce post-harvest losses in conservation agriculture. Upgrade rural market facilities and transportation networks to connect farmers to distant markets and increase their bargaining power. **6.3 Market Diversification:** Diversify market channels and outlets for conservation agriculture products by exploring alternative marketing opportunities, such as direct sales to consumers, farmers' markets, community-supported agriculture (CSA) schemes, and online platforms. Tap into niche markets, specialty stores, and gourmet restaurants that value sustainably produced goods. **6.4 Value-Added Processing:** Add value to conservation agriculture products through processing, packaging, and branding to differentiate them in the marketplace and command higher prices. Explore opportunities for value-added processing, such as organic certification, fair trade labeling, or specialty product branding, that appeal to discerning consumers. **6.5 Cooperative Marketing:** Form farmer cooperatives, producer associations, or marketing

	groups to collectively market and sell conservation agriculture products, pool resources, and negotiate better prices with buyers and traders. Strengthen farmers' collective bargaining power and market influence through collaborative marketing arrangements. **6.6 Contract Farming**: Engage in contract farming arrangements with agribusinesses, food companies, or exporters that provide guaranteed markets, price premiums, and technical support to farmers practicing conservation agriculture. Negotiate contracts that offer fair and transparent terms, quality standards, and price incentives for sustainable production practices. **6.7 Market Linkage Programs:** Participate in market linkage programs, trade fairs, and business matchmaking events that connect farmers with buyers, processors, and retailers interested in sourcing sustainably produced agricultural products. Foster partnerships and collaboration along the value chain to facilitate market access for conservation agriculture products. **6.8 Supply Chain Coordination**: Coordinate supply chain actors, including farmers, traders, processors, retailers, and consumers, to streamline market transactions, reduce transaction costs, and ensure fair and transparent pricing mechanisms in conservation agriculture. Promote traceability, quality assurance, and social responsibility throughout the supply chain. **6.9 Market Intelligence and Analysis:** Conduct market intelligence and analysis to identify emerging trends, consumer preferences, and market opportunities for conservation agriculture products. Monitor market dynamics, price fluctuations, and demand-supply imbalances to make informed decisions about crop selection, production planning, and marketing strategies.

Identified non-Economic and non-financial barriers and measures for Conservation Agriculture Technology	
Barriers	**Measures**
	6.10 Policy Support and Incentives: Advocate for policy support and incentives that promote market access and fair crop prices for farmers practicing conservation agriculture. Lobby policymakers to address trade barriers, market distortions, and regulatory constraints that hinder farmers' ability to access markets and receive fair compensation for their products. By implementing these strategies, stakeholders can address market access and crop prices in conservation agriculture, unlock value-added opportunities, and create sustainable market linkages that benefit farmers, consumers, and the environment.

7.0 Community Dynamics Social dynamics within farming communities can impact the adoption of conservation agriculture. Resistance or support from peers, local leaders, and community norms can play a role in shaping individual farmers' decisions.	Addressing community dynamics in conservation agriculture involves fostering inclusive decision-making processes, building social cohesion, and promoting collective action among community members to support sustainable farming practices. Here are some ways to tackle this challenge: **7.1 Community Participation**: Encourage active participation and involvement of community members in the planning, implementation, and evaluation of conservation agriculture initiatives. Facilitate inclusive meetings, workshops, and consultations where farmers can voice their opinions, share knowledge, and contribute to decision-making processes. **7.2 Stakeholder Engagement:** Engage diverse stakeholders, including farmers, local leaders, women's groups, youth associations, and indigenous communities, in collaborative efforts to promote conservation agriculture. Foster dialogue, collaboration, and partnership among stakeholders to build consensus, address concerns, and mobilize resources for collective action. **7.3 Social Capital Development:** Strengthen social capital within communities by nurturing trust, reciprocity, and solidarity among community members. Promote social cohesion, cooperation, and mutual support through community-based organizations, farmer groups, and self-help networks that facilitate knowledge sharing, resource pooling, and collective problem-solving. **7.4 Conflict Resolution Mechanisms:** Establish conflict resolution mechanisms and dispute resolution processes to address conflicts, disagreements, or tensions that may arise within communities over land use, water rights, or resource allocation in conservation agriculture. Promote dialogue, mediation, and negotiation to resolve conflicts peacefully and foster reconciliation among stakeholders.

	7.5 Leadership Development: Identify and empower local leaders, opinion influencers, and change agents within communities who can champion conservation agriculture initiatives and mobilize community support. Provide leadership training, capacity building, and mentoring to empower individuals to become effective advocates and facilitators of sustainable farming practices. **7.6 Gender Inclusion:** Ensure gender inclusion and women's participation in conservation agriculture programs by promoting women's empowerment, leadership roles, and decision-making authority within community-based organizations and farmer groups. Recognize and value the contributions of women farmers to agricultural production, natural resource management, and community development. **7.7 Cultural Sensitivity:** Respect and incorporate cultural traditions, indigenous knowledge, and local practices into conservation agriculture interventions to ensure relevance, acceptance, and sustainability within communities. Consult with cultural elders, traditional leaders, and indigenous knowledge holders to integrate cultural values and customs into project design and implementation. **7.8 Community Learning and Exchange**: Facilitate community learning and knowledge exchange activities, such as farmer field days, study tours, and peer-to-peer exchanges, that enable farmers to learn from each other, share experiences, and adopt best practices in conservation agriculture. Encourage cross-learning, innovation diffusion, and knowledge co-creation among community members. **7.9 Resource Mobilization:** Mobilize local resources, collective investments, and community contributions to support conservation agriculture initiatives and sustain their long-term impact. Encourage community members to invest their

Identified non-Economic and non-financial barriers and measures for Conservation Agriculture Technology	
Barriers	**Measures**
	time, labor, and resources in project activities, such as land preparation, seed distribution, and infrastructure development, to enhance ownership and sustainability. **7.10** **Celebration of Success:** Celebrate and recognize community achievements, milestones, and successes in adopting and implementing conservation agriculture practices. Organize community events, festivals, or awards ceremonies to acknowledge the contributions of farmers, volunteers, and community leaders to sustainable farming and environmental stewardship. By implementing these strategies, stakeholders can address community dynamics in conservation agriculture, foster social cohesion, and mobilize collective action for sustainable agricultural development and natural resource management.

8.0 Perceived Risks Farmers may perceive risks associated with transitioning to conservation agriculture, such as potential yield losses or uncertainties about the economic returns. Overcoming these perceptions is crucial for successful adoption.	Addressing perceived risks in conservation agriculture involves implementing strategies to mitigate uncertainties, build resilience, and enhance farmers' confidence in adopting sustainable farming practices. Here are some ways to tackle this challenge: **8.1 Risk Assessment and Management:** Conduct comprehensive risk assessments to identify and prioritize potential risks and uncertainties associated with conservation agriculture, such as weather variability, market fluctuations, pest outbreaks, and agronomic challenges. Develop risk management plans and strategies to mitigate, transfer, or absorb risks through diversification, insurance, and contingency planning. **8.2 Technical Assistance and Support:** Provide farmers with technical assistance, agronomic support, and advisory services to address technical challenges and agronomic uncertainties related to conservation agriculture practices. Offer training, mentoring, and on-farm demonstrations to build farmers' capacity and confidence in implementing sustainable farming techniques. **8.3 Trial and Demonstration Plots**: Establish trial plots, demonstration farms, or adaptive management sites where farmers can experiment with new conservation agriculture practices, test different crop varieties, and observe firsthand the performance and benefits of sustainable farming methods. Encourage participatory learning, adaptive management, and farmer-led experimentation to reduce perceived risks and uncertainties. **8.4 Information and Education Campaigns:** Launch information and education campaigns to raise awareness, dispel misconceptions, and communicate the benefits and potential risks of conservation agriculture to farmers, stakeholders, and the wider community. Provide evidence-based information, case studies, and success stories that

	illustrate the positive outcomes and long-term benefits of adopting sustainable farming practices. **8.5** **Risk-Sharing Mechanisms:** Develop risk-sharing mechanisms, such as crop insurance, contract farming, or cooperative marketing arrangements, that spread risks across multiple stakeholders and provide financial protection to farmers against yield losses, price fluctuations, and production risks associated with conservation agriculture. Partner with insurance companies, financial institutions, and agribusinesses to design tailored risk management solutions for farmers. **8.6** **Market Access and Price Stability**: Strengthen market access and price stability for conservation agriculture products by diversifying market channels, establishing forward contracts, and promoting value-added products that command premium prices in the marketplace. Explore opportunities for direct marketing, niche markets, and specialty certifications that reduce market risks and increase farmers' profitability. **8.7** **Climate-Smart Agriculture Practices**: Promote climate-smart agriculture practices that enhance resilience to climate variability and mitigate the impacts of extreme weather events on agricultural production. Encourage the adoption of agroecological techniques, water-saving measures, and diversified cropping systems that buffer against climate-related risks and contribute to sustainable farming. **8.8** **Peer Learning Networks**: Facilitate peer learning networks, farmer-to-farmer exchanges, and community-based learning groups where farmers can share experiences, learn from each other's successes and failures, and collectively address perceived risks and uncertainties associated with conservation agriculture. Foster a culture of knowledge exchange, collaboration, and mutual

Identified non-Economic and non-financial barriers and measures for Conservation Agriculture Technology	
Barriers	**Measures**
	support among farmers to build confidence and resilience. **8.9 Policy Support and Incentives:** Advocate for policy support and incentives that promote the adoption of conservation agriculture practices and reduce the perceived risks and barriers faced by farmers. Lobby policymakers to allocate resources, provide financial incentives, and implement supportive policies that facilitate the transition to sustainable farming systems and reward environmental stewardship. **8.10 Long-Term Planning and Adaptation:** Encourage farmers to adopt a long-term perspective and engage in adaptive management practices that allow for flexibility, learning, and continuous improvement in conservation agriculture. Emphasize the importance of resilience, innovation, and adaptive capacity in navigating uncertainties and managing risks over the agricultural production cycle. By implementing these strategies, stakeholders can address perceived risks in conservation agriculture, build farmers' confidence in adopting sustainable practices, and promote the transition to resilient and environmentally friendly farming systems.

9.0 Policy and Regulatory Frameworks Inconsistent or unclear policies related to conservation agriculture practices can pose non-economic barriers. Lack of supportive regulations or conflicting policies may discourage farmers from adopting new techniques.	Addressing policy and regulatory frameworks in conservation agriculture involves advocating for supportive policies, promoting regulatory reforms, and fostering institutional coordination to create an enabling environment for sustainable farming practices. Here are some ways to tackle this challenge: **9.1 Policy Advocacy:** Engage in policy advocacy efforts to raise awareness, build consensus, and mobilize support for conservation agriculture among policymakers, legislators, government agencies, and relevant stakeholders. Advocate for the inclusion of conservation agriculture objectives, principles, and practices in national agricultural policies, strategies, and action plans. **9.2 Policy Analysis and Research:** Conduct policy analysis, research studies, and impact assessments to evaluate the effectiveness, gaps, and constraints of existing policies and regulatory frameworks related to conservation agriculture. Generate evidence-based recommendations and policy proposals to inform decision-making and policy dialogue at the national and local levels. **9.3 Stakeholder Engagement**: Foster multi-stakeholder dialogue, consultation, and collaboration among government agencies, farmers' organizations, civil society groups, research institutions, and private sector actors to co-design and co-implement policies and programs that promote conservation agriculture. Create platforms for inclusive participation, knowledge exchange, and consensus-building among stakeholders. **9.4 Capacity Building for Policymakers:** Provide capacity building and training programs for policymakers, government officials, and regulatory authorities to enhance their understanding of conservation agriculture concepts, principles, and best practices. Organize workshops, seminars, and training sessions on sustainable land management,

	agroecology, and climate-smart agriculture to build technical expertise and policy literacy. **9.5** **Policy Integration and Mainstreaming:** Integrate conservation agriculture considerations into sectoral policies, plans, and programs across relevant policy domains, such as agriculture, environment, natural resource management, rural development, and climate change adaptation. Mainstream sustainable farming practices into broader policy agendas to ensure coherence, alignment, and synergies across different policy areas. **9.6** **Incentive Mechanisms:** Design and implement incentive mechanisms, financial instruments, and support measures that incentivize farmers to adopt conservation agriculture practices and invest in sustainable land management. Offer subsidies, grants, tax incentives, and preferential credit terms for conservation agriculture inputs, equipment, and infrastructure investments. **9.7** **Regulatory Reforms:** Advocate for regulatory reforms and legal frameworks that facilitate the adoption and scaling-up of conservation agriculture, streamline administrative procedures, and remove regulatory barriers that hinder farmers' access to sustainable farming practices. Lobby for the revision of outdated regulations, land tenure policies, and agricultural laws to better support conservation agriculture. **9.8** **Market-Based Instruments**: Explore the use of market-based instruments, such as eco-labelling schemes, certification programs, and carbon markets, to create economic incentives for farmers to adopt conservation agriculture practices and produce environmentally friendly agricultural products. Promote the valuation of ecosystem services and the internalization of environmental externalities in agricultural markets.

Identified non-Economic and non-financial barriers and measures for Conservation Agriculture Technology	
Barriers	**Measures**
	9.9 Monitoring and Evaluation: Establish monitoring and evaluation systems to assess the implementation, impact, and outcomes of conservation agriculture policies and programs. Monitor progress towards policy objectives, track performance indicators, and evaluate the effectiveness of policy interventions in promoting sustainable farming practices and achieving environmental outcomes. **9.10 International Cooperation and Partnerships:** Strengthen international cooperation, collaboration, and knowledge sharing on conservation agriculture policy development and implementation through regional initiatives, partnerships, and South-South cooperation. Learn from best practices, lessons learned, and experiences of other countries in promoting sustainable agriculture and landscape management. By implementing these strategies, stakeholders can address policy and regulatory frameworks in conservation agriculture, create an enabling environment for sustainable farming practices, and advance the transition towards resilient, productive, and environmentally friendly agricultural systems.

4-1. Economic and Financial Barriers and Measure for Water Reclamation, Treatment and Reuse Technology

Identified Economic and Financial Barriers and Measures for Water Reclamation, Treatment and Reuse Technology	
Barriers	**Measures**
1.0 Operational and Maintenance Costs Ongoing operational and maintenance expenses can be substantial, impacting the economic feasibility of water reuse projects. .	**1.1 Government Subsidies and Grants:** Providing financial support through subsidies or grants can help offset the initial capital costs of implementing water reuse technologies, encouraging widespread adoption. **1.2 Tax Incentives:** Offering tax credits or deductions for investments in water reuse infrastructure can stimulate private sector participation and attract capital to fund projects. **1.3 Low-Interest Loans:** Establishing financial mechanisms that offer low-interest loans for water reuse projects can make funding more accessible and cost-effective for both public and private entities. **1.4 User Fees and Tariffs**: Implementing fair and transparent user fees or tariffs for water services, including water reuse, ensures that the costs are appropriately distributed among users, supporting project sustainability. **1.5 Performance-Based Contracts:** Introducing performance-based contracts can align the financial interests of service providers with the efficiency and effectiveness of water reuse technologies, promoting accountability. **1.6 Public-Private Partnerships (PPPs):** Encouraging collaboration between public and private entities through PPPs can attract private investment and expertise, sharing both risks and rewards in water reuse projects. **1.7 Water Trading Systems:** Establishing water trading systems or markets can create economic incentives for efficient water use, including water reuse, by allowing entities to buy and sell water rights. **1.8 Insurance Mechanisms:** Developing insurance products or risk-sharing mechanisms can mitigate financial risks associated with water reuse projects, providing a safety net for investors and project developers. **1.9 Capacity Building:** Investing in training programs and capacity building for local water utilities and industries can

Identified Economic and Financial Barriers and Measures for Water Reclamation, Treatment and Reuse Technology	
Barriers	**Measures**
	enhance their ability to manage and maintain water reuse technologies efficiently. **1.10 Research and Development Funding:** Allocating funds for research and development in water reuse technologies can drive innovation, reduce costs, and improve the overall economic viability of these solutions. These economic and financial measures should be part of a comprehensive strategy that considers the specific context, needs, and stakeholders involved in water reuse projects.
2.0 Limited Funding Insufficient public and private funding for water reuse initiatives can impede the development and widespread adoption of these technologies.	Addressing limited funding for water reuse involves implementing strategies to mobilize resources, leverage financing mechanisms, and prioritize investments in water reuse projects. Here are some ways to tackle this challenge: **2.1 Public-Private Partnerships (PPPs):** Foster partnerships between government agencies, private sector entities, and civil society organizations to jointly fund and implement water reuse projects. Engage private investors, water utilities, and technology providers in financing, operating, and maintaining water reuse infrastructure through PPPs that share risks and rewards. **2.2 Government Budget Allocation**: Increase government budget allocations and investment commitments for water reuse initiatives by prioritizing water reuse projects in national development plans, sectoral budgets, and infrastructure investment programs. Advocate for dedicated funding streams, earmarked funds, and fiscal incentives to support the development and expansion of water reuse infrastructure. **2.3 International Aid and Donor Support:** Seek financial assistance, technical support, and capacity building opportunities from international donors, development agencies, and multilateral institutions to finance water reuse projects in regions facing limited funding constraints. Access grants, concessional loans, and technical assistance programs to supplement domestic resources and bridge financing gaps.

Identified Economic and Financial Barriers and Measures for Water Reclamation, Treatment and Reuse Technology	
Barriers	**Measures**
	2.4 Water Tariffs and User Fees: Introduce or adjust water tariffs, user fees, and service charges to generate revenue streams for financing water reuse projects and covering operation and maintenance costs. Implement pricing mechanisms that reflect the true cost of water services and promote cost recovery while ensuring affordability for users, particularly low-income households. **2.5 Innovative Financing Instruments:** Explore innovative financing instruments, such as green bonds, impact investments, and social impact bonds, to attract private capital and institutional investors to water reuse projects. Structure financing mechanisms that align financial returns with environmental and social outcomes, incentivizing investment in sustainable water management solutions. **2.6 Local Government Funding:** Encourage local governments, municipalities, and regional authorities to allocate resources and establish dedicated funds for water reuse infrastructure development and implementation. Empower local decision-makers to prioritize water reuse projects based on local needs, priorities, and sustainability criteria. **2.7 Community Contributions:** Mobilize community contributions, voluntary contributions, and in-kind support from water users, community groups, and stakeholders to co-finance water reuse projects and demonstrate local ownership and commitment. Promote community-based fundraising campaigns, crowdfunding initiatives, and participatory budgeting processes to engage citizens in financing water reuse initiatives. **2.8 Capacity Building for Financial Management:** Strengthen the financial management capacity of water utilities, government agencies, and project implementers to effectively plan, budget, and manage funds for water reuse projects. Provide training, technical assistance, and mentoring to finance professionals and decision-makers on project finance, budgeting, and revenue management practices.

Identified Economic and Financial Barriers and Measures for Water Reclamation, Treatment and Reuse Technology	
Barriers	**Measures**
	2.9 Risk Mitigation Mechanisms: Mitigate financial risks associated with water reuse investments by implementing risk-sharing mechanisms, insurance products, and guarantees that provide assurance to investors and lenders. Establish risk mitigation funds, reserve accounts, or contingency funds to cover unforeseen costs and financial liabilities arising from water reuse projects. **2.10 Policy and Regulatory Support:** Create an enabling policy and regulatory environment that incentivizes investment in water reuse infrastructure and promotes financial sustainability. Streamline permitting processes, facilitate regulatory approvals, and provide regulatory certainty to investors to reduce investment risks and enhance the attractiveness of water reuse projects. By implementing these strategies, stakeholders can address limited funding for water reuse, unlock financing opportunities, and accelerate the adoption of sustainable water management practices that contribute to water security, resource conservation, and environmental sustainability.
3.0 Lack of Financial Incentives The absence of financial incentives, such as tax breaks or subsidies, may discourage organizations from investing in water reuse technologies.	Addressing the lack of financial incentives for water reuse involves implementing strategies to create economic benefits, reduce costs, and incentivize investments in water reuse projects. Here are some ways to tackle this challenge: **3.1 Economic Valuation of Water Resources:** Conduct economic valuation studies to quantify the economic benefits and cost savings associated with water reuse, including reduced water supply costs, avoided wastewater treatment expenses, and enhanced water security. Highlight the financial value of water reuse in terms of resource conservation, risk mitigation, and economic productivity to attract investment. **3.2 Cost-Benefit Analysis:** Perform cost-benefit analyses to assess the financial viability and return on investment of water reuse projects compared to conventional water supply and wastewater treatment options. Evaluate the economic feasibility, net present value, and internal rate of return of

Identified Economic and Financial Barriers and Measures for Water Reclamation, Treatment and Reuse Technology	
Barriers	**Measures**
	water reuse initiatives to demonstrate their financial attractiveness to investors and decision-makers. **3.3 Tariff and Pricing Policies:** Implement tariff structures, pricing mechanisms, and financial incentives that promote water reuse and reward water-saving behaviours among users. Introduce differential pricing for recycled water, offer discounts or rebates for recycled water customers, and adjust water tariffs to reflect the true cost of water services and incentivize conservation. **3.4 Subsidies and Grants:** Provide financial support, subsidies, and grants to offset the upfront capital costs, infrastructure investments, and operational expenses associated with water reuse projects. Offer financial incentives for pilot projects, demonstration sites, and early adopters to encourage investment in innovative water reuse technologies and practices. **3.5 Tax Incentives and Rebates:** Introduce tax incentives, deductions, or credits for businesses, industries, and utilities that invest in water reuse infrastructure, equipment, and technologies. Offer tax breaks for capital expenditures, depreciation allowances, and energy savings associated with water recycling and reuse initiatives to stimulate private sector investment. **3.6 Public-Private Partnerships (PPPs):** Foster partnerships between public entities, private sector companies, and financial institutions to develop, finance, and operate water reuse projects through PPPs. Leverage private sector expertise, capital investment, and risk-sharing arrangements to accelerate the implementation of water reuse initiatives and maximize financial returns. **3.7 Market-Based Mechanisms:** Explore market-based mechanisms, such as water trading platforms, water markets, and tradable water rights, to create economic incentives for water reuse and allocate water resources more efficiently. Establish market mechanisms that enable the buying, selling, and trading of recycled water allocations, providing financial rewards for water reuse practices.

Identified Economic and Financial Barriers and Measures for Water Reclamation, Treatment and Reuse Technology	
Barriers	**Measures**
	3.8 Value-Added Products: Develop value-added products and services derived from recycled water, such as irrigation water for agriculture, industrial process water, cooling water for power plants, and non-potable water for landscaping and urban uses. Identify niche markets, premium customers, and revenue streams that capture the economic value of recycled water products. **3.9 Green Bonds and Impact Investments:** Issue green bonds, social impact bonds, or sustainability bonds to finance water reuse projects and attract socially responsible investors interested in environmental stewardship and sustainable development. Mobilize capital from impact investors, institutional funds, and green finance initiatives to support water reuse initiatives that deliver positive environmental and social outcomes. **3.10 Regulatory Reform:** Advocate for regulatory reform and policy incentives that promote water reuse, streamline permitting processes, and remove regulatory barriers to investment. Lobby policymakers to enact legislation, regulations, and standards that facilitate the development, financing, and operation of water reuse infrastructure and projects. By implementing these strategies, stakeholders can address the lack of financial incentives for water reuse, unlock investment opportunities, and accelerate the adoption of sustainable water management practices that enhance water resilience, resource efficiency, and environmental sustainability.
4.0 Uncertain Return on Investment Uncertainties surrounding the economic benefits and long-term savings of water reuse projects may deter potential investors.	Addressing uncertain returns on investments for water reuse involves implementing strategies to assess risks, enhance financial predictability, and create favourable investment conditions. Here are some ways to tackle this challenge: **4.1 Risk Assessment and Management:** Conduct comprehensive risk assessments to identify and quantify potential risks and uncertainties associated with water reuse projects, including regulatory risks, market risks, technical risks, and financial risks. Develop risk management

Identified Economic and Financial Barriers and Measures for Water Reclamation, Treatment and Reuse Technology	
Barriers	**Measures**
	strategies, contingency plans, and mitigation measures to address and mitigate key investment uncertainties. **4.2** **Long-Term Financial Planning:** Adopt a long-term financial planning approach that accounts for the lifecycle costs, revenue streams, and financial performance of water reuse projects over their operational lifespan. Incorporate financial modeling, sensitivity analysis, and scenario planning to assess the financial viability and resilience of investments in water reuse infrastructure. **4.3** **Public-Private Partnerships (PPPs):** Engage in public-private partnerships (PPPs) that leverage the expertise, resources, and risk-sharing capabilities of both public and private sector entities to finance, develop, and operate water reuse projects. Structure PPP arrangements that allocate risks, responsibilities, and rewards equitably among project stakeholders to enhance financial predictability and attract investment. **4.4** **Performance-Based Contracts:** Implement performance-based contracts, service level agreements, or output-based financing mechanisms that link financial incentives to the achievement of predefined performance targets, such as water quality standards, operational efficiency, and cost-effectiveness. Align contract terms and payment structures with project outcomes to incentivize performance improvement and risk management. **4.5** **Revenue Diversification:** Diversify revenue streams and sources of income for water reuse projects by tapping into multiple market segments, customer groups, and end users. Explore alternative revenue streams, such as water sales, service fees, resource recovery, and value-added products, to reduce reliance on a single source of revenue and mitigate investment risks. **4.6** **Financial Guarantees and Insurance:** Secure financial guarantees, insurance coverage, or risk mitigation instruments that provide protection against revenue shortfalls, project delays, or unexpected losses for water reuse investments. Obtain insurance policies, surety bonds,

Identified Economic and Financial Barriers and Measures for Water Reclamation, Treatment and Reuse Technology	
Barriers	**Measures**
	or credit enhancements that mitigate investment risks and enhance investor confidence in project outcomes. **4.7 Government Support and Subsidies:** Seek government support, subsidies, or financial incentives to offset the costs, reduce the financial burden, and improve the financial viability of water reuse projects. Access grants, subsidies, tax incentives, or concessional financing programs that promote investment in sustainable water management and environmental conservation initiatives. **4.8 Market Development Initiatives:** Promote market development initiatives, awareness campaigns, and stakeholder engagement activities to stimulate demand for recycled water, create new market opportunities, and expand the customer base for water reuse products and services. Educate potential users, investors, and decision-makers about the benefits, value proposition, and economic advantages of water reuse investments. **4.9 Policy Stability and Regulatory Certainty:** Advocate for policy stability, regulatory certainty, and favorable investment conditions that provide clarity, predictability, and transparency for water reuse investors. Lobby policymakers to establish clear rules, regulations, and permitting processes that facilitate investment decision-making and reduce regulatory uncertainty for water reuse projects. **4.10 Knowledge Sharing and Best Practices:** Share knowledge, lessons learned, and best practices from successful water reuse projects to build investor confidence, replicate successful models, and promote industry standards and benchmarks for financial performance. Foster collaboration, networking, and knowledge exchange among stakeholders to learn from each other's experiences and improve investment outcomes. By implementing these strategies, stakeholders can address uncertain returns on investments for water reuse, enhance financial predictability, and create an enabling environment for sustainable investment in water reuse infrastructure and projects.

Identified Economic and Financial Barriers and Measures for Water Reclamation, Treatment and Reuse Technology	
Barriers	**Measures**
5.0 Inadequate Cost Recovery Mechanisms Water pricing structures may not adequately reflect the actual cost of water, making it challenging for water reuse projects to recover their expenses.	Addressing inadequate cost recovery mechanisms for water reuse involves implementing strategies to ensure that the full costs of water reuse projects are recovered through appropriate pricing, financing, and revenue generation mechanisms. Here are some ways to tackle this challenge: **5.1 Full Cost Accounting:** Conduct full cost accounting assessments to accurately estimate the total costs associated with planning, designing, constructing, operating, and maintaining water reuse infrastructure over its lifecycle. Include all direct and indirect costs, such as capital expenditures, operational expenses, maintenance costs, and financing charges, in cost recovery calculations. **5.2 Tariff and Pricing Reform:** Review and revise water tariffs, pricing structures, and fee schedules to reflect the true cost of providing recycled water services and cover the full lifecycle costs of water reuse projects. Implement volumetric pricing, user charges, and cost-based tariffs that recover the costs of water treatment, distribution, and storage while promoting water conservation and efficiency. **5.3 Cost Allocation and Recovery:** Allocate costs fairly and equitably among different user groups, beneficiaries, and stakeholders based on their usage of recycled water services, benefits derived, and ability to pay. Adopt cost allocation methodologies, cost-sharing agreements, and cross-subsidization mechanisms that ensure financial sustainability and social equity in cost recovery efforts. **5.4 Demand Management Strategies:** Implement demand management strategies, water conservation measures, and efficiency incentives to reduce water consumption, optimize water use, and increase revenue from recycled water sales. Encourage water-saving behaviours, promote water-efficient technologies, and offer financial incentives for water reuse adoption to stimulate demand and enhance cost recovery. **5.5 Non-Tariff Revenue Sources:** Explore alternative revenue sources and non-tariff income streams to supplement cost recovery efforts for water reuse projects. Generate revenue

Identified Economic and Financial Barriers and Measures for Water Reclamation, Treatment and Reuse Technology	
Barriers	**Measures**
	from ancillary services, value-added products, resource recovery, and co-benefits associated with water reuse, such as energy generation, nutrient recycling, and ecosystem services. **5.6 Public Financing Mechanisms:** Mobilize public financing mechanisms, such as government grants, subsidies, loans, and bond issuances, to bridge funding gaps, cover capital costs, and support the development of water reuse infrastructure. Allocate budgetary resources, earmarked funds, and dedicated financing mechanisms for water reuse projects in national and local government budgets. **5.7 Public-Private Partnerships (PPPs):** Engage in public-private partnerships (PPPs) that leverage private sector investment, expertise, and innovation to finance, develop, and operate water reuse projects. Structure PPP arrangements that align incentives, share risks, and ensure equitable distribution of costs and benefits between public and private sector partners. **5.8 User Fees and Service Charges:** Introduce user fees, service charges, or connection fees for recycled water customers to recover the costs of providing water reuse services and maintain the financial sustainability of water reuse infrastructure. Implement cost recovery mechanisms that allocate costs based on the level of service provided, usage patterns, and service levels agreed upon. **5.9 Tariff Design Innovations:** Innovate tariff design methodologies, pricing models, and payment mechanisms to enhance cost recovery for water reuse projects. Explore options such as block tariffs, seasonal pricing, peak-load pricing, and tiered pricing structures that reflect variations in water demand, supply costs, and affordability considerations among different user groups. **5.10 Regulatory Support and Incentives:** Advocate for regulatory support, policy incentives, and legal frameworks that facilitate cost recovery for water reuse projects and promote sustainable financing mechanisms. Lobby policymakers to enact legislation, establish regulatory

Identified Economic and Financial Barriers and Measures for Water Reclamation, Treatment and Reuse Technology	
Barriers	**Measures**
	guidelines, and provide financial incentives that encourage investment in water reuse infrastructure and services. By implementing these strategies, stakeholders can address inadequate cost recovery mechanisms for water reuse, enhance financial sustainability, and ensure the long-term viability of water reuse projects and programs.
6.0 Regulatory Barriers Complex or stringent regulations can increase compliance costs and create uncertainties, hindering the economic viability of water reuse technologies.	Addressing regulatory barriers for water reuse involves implementing strategies to streamline permitting processes, clarify regulatory requirements, and create an enabling environment for the development and implementation of water reuse projects. Here are some ways to tackle this challenge: **6.1 Regulatory Review and Reform:** Conduct a comprehensive review of existing regulations, permitting procedures, and regulatory frameworks governing water reuse at the national, regional, and local levels. Identify regulatory barriers, inconsistencies, and gaps that hinder the deployment of water reuse projects and advocate for regulatory reform to remove obstacles and streamline approval processes. **6.2 Regulatory Harmonization:** Harmonize regulations, standards, and guidelines related to water reuse across different jurisdictions, government agencies, and regulatory bodies to create a uniform regulatory framework that provides clarity, consistency, and predictability for project developers, investors, and stakeholders. Coordinate regulatory efforts and align regulatory objectives to facilitate compliance and reduce regulatory burden. **6.3 Risk-Based Regulation:** Adopt risk-based approaches to regulation that assess the potential risks and benefits of water reuse projects based on scientific evidence, risk assessments, and risk management strategies. Tailor regulatory requirements, permitting conditions, and compliance obligations to the level of risk posed by different types of water reuse applications, ensuring proportionate regulation that protects public health and the environment without imposing undue barriers.

Identified Economic and Financial Barriers and Measures for Water Reclamation, Treatment and Reuse Technology	
Barriers	**Measures**
	6.4 Performance-Based Standards: Establish performance-based standards, criteria, and benchmarks for water quality, treatment effectiveness, and environmental protection that focus on achieving desired outcomes rather than prescribing specific technologies or processes. Allow flexibility in compliance options, treatment alternatives, and monitoring protocols to encourage innovation and adaptation to site-specific conditions. **6.5 Regulatory Guidance and Technical Assistance:** Provide regulatory guidance, technical assistance, and capacity building support to regulatory agencies, permitting authorities, and project developers to navigate complex regulatory requirements, interpret regulatory guidelines, and address regulatory compliance issues related to water reuse. Offer training programs, workshops, and seminars on water reuse regulations, permitting processes, and best practices. **6.6** Public Engagement and Stakeholder Consultation:* Engage in meaningful public consultation, stakeholder engagement, and community outreach efforts to solicit input, address concerns, and build public trust and confidence in water reuse projects. Involve affected stakeholders, local communities, environmental advocates, and public health officials in the regulatory decision-making process to ensure transparency, accountability, and social acceptance of water reuse initiatives. **6.7 Demonstration Projects and Pilot Studies:** Promote the development of demonstration projects, pilot studies, and research initiatives that showcase the feasibility, safety, and effectiveness of water reuse technologies and practices. Use demonstration projects as learning opportunities to gather empirical data, assess performance metrics, and demonstrate compliance with regulatory requirements, informing regulatory decision-making and fostering public acceptance of water reuse. **6.8 Regulatory Flexibility and Expedited Permitting:** Provide regulatory flexibility, expedited permitting procedures, and fast-track approval processes for water reuse

Identified Economic and Financial Barriers and Measures for Water Reclamation, Treatment and Reuse Technology	
Barriers	**Measures**
	projects that meet predefined criteria, demonstrate compliance with regulatory standards, and pose minimal risks to public health and the environment. Streamline permitting timelines, reduce administrative burdens, and simplify regulatory procedures to accelerate project development and implementation. **6.9 Public Health Protection Measures:** Incorporate public health protection measures, risk management strategies, and monitoring protocols into water reuse regulations to ensure the safety and quality of recycled water for intended uses. Implement robust water quality monitoring, pathogen detection, and risk assessment protocols that safeguard public health and address regulatory concerns related to microbial contamination, chemical pollutants, and emerging contaminants. **6.10 Capacity Building for Regulatory Agencies:** Strengthen the capacity of regulatory agencies, permitting authorities, and environmental regulators to effectively administer and enforce water reuse regulations through training, technical assistance, and institutional capacity building initiatives. Enhance regulatory oversight, enforcement capabilities, and compliance monitoring efforts to uphold regulatory standards and safeguard environmental integrity. By implementing these strategies, stakeholders can address regulatory barriers for water reuse, streamline permitting processes, and create an enabling regulatory environment that facilitates the development and deployment of sustainable water reuse projects and programs.
7.0 Lack of Standardized Economic Valuation The absence of universally accepted methods for economically valuing the benefits of water reuse makes it challenging to assess and compare the financial advantages of different projects	Addressing the lack of standardized economic valuation for water reuse involves establishing consistent methodologies, metrics, and guidelines for assessing the economic benefits, costs, and financial implications of water reuse projects. Here are some ways to tackle this challenge: **7.1** Development of Economic Valuation Guidelines: Establish comprehensive guidelines, frameworks, or protocols for conducting economic valuation studies of water reuse

Identified Economic and Financial Barriers and Measures for Water Reclamation, Treatment and Reuse Technology	
Barriers	**Measures**
	projects, including cost-benefit analysis, cost-effectiveness analysis, and financial feasibility assessments. Develop standardized methodologies, data requirements, and reporting formats to ensure consistency, comparability, and transparency in economic valuation practices. **7.2 Economic Impact Assessments:** Conduct economic impact assessments to quantify the economic contributions, job creation, and income generation potential of water reuse projects at the local, regional, and national levels. Evaluate the direct and indirect economic benefits, multiplier effects, and value-added contributions of water reuse investments to the economy, businesses, and communities. **7.3 Lifecycle Cost Analysis:** Perform lifecycle cost analysis to estimate the total costs of water reuse projects over their operational lifespan, including capital expenditures, operating expenses, maintenance costs, and financing charges. Compare the lifecycle costs of water reuse options with conventional water supply and wastewater treatment alternatives to assess their economic viability and long-term affordability. **7.4 Net Present Value Analysis:** Calculate the net present value (NPV) of water reuse investments by discounting future cash flows, revenues, and cost savings associated with recycled water production, distribution, and use to their present value. Use NPV analysis to evaluate the financial returns, profitability, and investment attractiveness of water reuse projects over their economic life. **7.5 Benefit-Cost Ratio Estimation:** Estimate the benefit-cost ratio (BCR) of water reuse projects by comparing the present value of benefits, such as water savings, avoided costs, and environmental benefits, to the present value of costs, including investment costs, operation and maintenance expenses, and financing charges. Use BCR analysis to assess the economic efficiency and net social benefits of water reuse investments. **7.6 Sensitivity Analysis:** Conduct sensitivity analysis to assess the robustness of economic valuation results to changes in

Identified Economic and Financial Barriers and Measures for Water Reclamation, Treatment and Reuse Technology	
Barriers	**Measures**
	key input parameters, assumptions, and scenarios, such as discount rates, project costs, water demand projections, and market conditions. Identify sensitivity factors, uncertainty sources, and risk factors that may affect the economic viability and financial sustainability of water reuse projects. **7.7 Standardization of Economic Metrics:** Standardize economic metrics, performance indicators, and financial benchmarks for water reuse projects to facilitate cross-project comparisons, benchmarking exercises, and industry best practices. Define common economic indicators, such as levelized cost of water, water productivity, and economic value added, to assess the economic performance and competitiveness of water reuse options. **7.8 Data Sharing and Knowledge Exchange:** Promote data sharing, knowledge exchange, and collaboration among researchers, practitioners, and policymakers to improve the availability, quality, and accessibility of economic valuation data and methodologies for water reuse. Share best practices, case studies, and lessons learned from economic valuation studies to inform decision-making and policy development. **7.9 Capacity Building and Training:** Provide capacity building, training programs, and professional development opportunities for economists, planners, engineers, and decision-makers on economic valuation techniques, financial analysis tools, and cost-benefit methodologies for water reuse projects. Enhance technical expertise, analytical skills, and institutional capacity to conduct rigorous economic assessments and inform evidence-based decision-making. **7.10 Integration of Economic Considerations:** Integrate economic considerations, financial considerations, and economic valuation results into decision-making processes, policy formulation, and project planning for water reuse. Consider economic factors, such as investment costs, revenue streams, cost recovery mechanisms, and financial risks, alongside technical, environmental, and social

Identified Economic and Financial Barriers and Measures for Water Reclamation, Treatment and Reuse Technology	
Barriers	**Measures**
	considerations to optimize resource allocation and maximize economic efficiency. By implementing these strategies, stakeholders can address the lack of standardized economic valuation for water reuse, enhance the credibility and reliability of economic assessments, and promote informed decision-making and investment in sustainable water reuse projects and programs.

4-2. Non- Financial Barriers and Measure for Water Reclamation, Treatment and Reuse Technology

Identified Non-Economic and Non-Financial Barriers and Measures for Water Reclamation, Treatment and Reuse Technology	
Barriers	**Measures**
Addressing these non-economic barriers requires comprehensive education and outreach programs, clear communication strategies, collaborative governance structures, and efforts to build trust among stakeholders.	
1.0 Public Perception and Acceptance: Concerns or resistance from the public regarding the safety and acceptance of recycled water for various uses can be a significant non-economic barrier.	**1.1 Public Awareness Campaigns:** Implementing educational initiatives and awareness campaigns to inform the public about the safety and benefits of water reuse can address concerns and build acceptance. **1.2 Stakeholder Engagement and Collaboration:** Actively involving and collaborating with various stakeholders, including local communities, environmental groups, and industry, can foster support and minimize resistance to water reuse projects. **1.3 Clear Regulatory Framework:** Establishing transparent and clear regulations for water reuse, including water quality standards, can provide certainty to potential users and investors, facilitating project implementation. **1.4 Capacity Building and Training:** Providing training programs and capacity-building initiatives for professionals involved in water management enhances their understanding and expertise in implementing water reuse technologies. **1.5 Demonstration Projects:** Launching pilot or demonstration projects can showcase the effectiveness and safety of water reuse technologies, helping to build confidence and trust among stakeholders. **1.6 Community Engagement and Consultation:** Actively involving local communities in the decision-making process, seeking their input, and addressing their concerns can contribute to the successful implementation of water reuse initiatives. **1.7 Government Policies and Support:** Developing supportive policies at the governmental level, along with clear mandates and targets for water reuse, can create a conducive environment for adoption and investment. **1.8 Research and Development Initiatives:** Encouraging research and development efforts in water reuse technology

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	can lead to advancements, improved efficiency, and cost reduction, supporting long-term sustainability. **1.9 Incentives for Innovation:** Offering incentives for innovative water reuse solutions and technologies can stimulate the development of cutting-edge approaches in the water sector. **1.10 Cross-Sectoral Coordination:** Facilitating coordination and communication between different sectors, such as agriculture, industry, and urban planning, can help overcome intersectoral competition for water resources and promote collaborative solutions. These non-economic measures complement economic strategies and contribute to creating an enabling environment for the successful implementation of water reuse technologies in the water sector.
2.0 Lack of Awareness and Education Insufficient awareness and understanding of water reuse technologies among stakeholders, including policymakers, communities, and businesses, can hinder adoption.	Addressing the lack of awareness in education for water reuse involves implementing strategies to raise awareness, promote understanding, and foster knowledge dissemination about the benefits, challenges, and opportunities of water reuse among various stakeholders, including students, educators, policymakers, professionals, and the general public. Here are some ways to tackle this challenge: **2.1 Education and Training Programs:** Develop educational curricula, training modules, and certification programs on water reuse for schools, universities, vocational institutions, and professional organizations. Incorporate water reuse topics into science, technology, engineering, and mathematics (STEM) education, environmental studies, and water resource management courses to build knowledge and skills among students and professionals. **2.2 Public Awareness Campaigns:** Launch public awareness campaigns, outreach initiatives, and community engagement activities to inform and educate the general public about the importance of water reuse, its benefits for water conservation, and its role in sustainable water management. Use multimedia channels, social media platforms, and

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	digital communication tools to reach diverse audiences and disseminate educational messages effectively. **2.3 Stakeholder Workshops and Seminars**: Organize stakeholder workshops, seminars, and knowledge-sharing events to facilitate dialogue, exchange of experiences, and capacity building on water reuse topics among policymakers, government officials, industry stakeholders, environmental advocates, and community leaders. Provide opportunities for networking, collaboration, and peer learning to enhance awareness and understanding of water reuse issues. **2.4 Demonstration Projects and Site Visits:** Showcase water reuse technologies, demonstration projects, and best practices through site visits, field trips, and interactive exhibits to provide firsthand experience and practical insights into the operation, benefits, and challenges of water reuse. Invite students, professionals, decision-makers, and the public to visit water reuse facilities and learn about their role in sustainable water management. **2.5 Partnerships with Educational Institutions:** Collaborate with educational institutions, research centres, and academic institutions to integrate water reuse topics into their research agendas, curriculum development efforts, and outreach activities. Foster partnerships between academia, industry, and government agencies to promote interdisciplinary research, innovation, and knowledge exchange on water reuse. **2.6 Professional Development and Continuing Education:** Offer professional development opportunities, continuing education courses, and workshops on water reuse for water professionals, engineers, planners, and policymakers to enhance their knowledge, skills, and competencies in water reuse planning, design, and management. Provide certification programs and accreditation schemes to recognize expertise in water reuse practices. **2.7 Information Resources and Publications:** Develop informative materials, fact sheets, guidelines, and technical

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	publications on water reuse technologies, regulations, and case studies for dissemination to educators, students, practitioners, and the public. Create online repositories, resource libraries, and knowledge platforms to centralize information and facilitate access to relevant resources on water reuse. **2.8 Engagement with Media and Communication Channels:** Engage with mainstream media outlets, industry publications, and communication channels to raise awareness and promote understanding of water reuse issues through news articles, feature stories, interviews, and documentaries. Collaborate with journalists, writers, and content creators to highlight success stories, innovations, and challenges in water reuse. **2.9 Youth Engagement and Student Competitions**: Empower youth, students, and young professionals to become advocates for water reuse through youth engagement programs, student competitions, and innovation challenges focused on sustainable water management solutions. Encourage students to develop creative projects, research initiatives, and community outreach activities that promote awareness and action on water reuse. **2.10 Policy Advocacy and Public Participation:** Advocate for policy reforms, regulatory incentives, and funding priorities that support education and awareness-raising efforts for water reuse at the local, national, and international levels. Engage stakeholders in policy dialogue, public consultations, and participatory decision-making processes to ensure that education and awareness are integrated into water governance and planning initiatives. By implementing these strategies, stakeholders can address the lack of awareness in education for water reuse, build a knowledgeable and informed society, and foster a culture of water stewardship and sustainability that supports the widespread adoption of water reuse practices.
3.0 Technical Challenges	Addressing technical challenges for water reuse involves implementing strategies to overcome barriers related to water

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The complexity and technical intricacies of certain water reuse technologies may pose barriers, especially for smaller water utilities or regions with limited technical expertise.	treatment, distribution, quality, and infrastructure. Here are some ways to tackle this challenge: **3.1** **Advanced Treatment Technologies:** Invest in research and development of advanced treatment technologies, such as membrane filtration, reverse osmosis, advanced oxidation, and UV disinfection, to effectively remove contaminants and pathogens from recycled water. Explore innovative treatment processes, such as membrane bioreactors, ozonation, and nanofiltration, to improve water quality and meet stringent reuse standards. **3.2** **Integrated Treatment Systems:** Implement integrated treatment systems that combine multiple treatment processes and unit operations to achieve comprehensive removal of contaminants and ensure the production of high-quality recycled water. Design treatment trains that optimize treatment efficiency, minimize energy consumption, and reduce operational costs through process optimization and control. **3.3** **Monitoring and Control Systems:** Deploy robust monitoring and control systems for real-time monitoring, analysis, and optimization of water treatment processes, distribution networks, and recycled water quality. Utilize sensor technologies, online analyzers, and automation systems to continuously monitor key water quality parameters, detect anomalies, and adjust treatment operations to maintain compliance with reuse standards. **3.4** **Quality Assurance Programs:** Establish quality assurance programs, quality control measures, and standard operating procedures (SOPs) for water reuse operations to ensure consistent production of safe, reliable, and high-quality recycled water. Implement rigorous testing protocols, sampling procedures, and quality management practices to verify compliance with regulatory requirements and user expectations. **3.5** **Source Water Management:** Implement source water management strategies, watershed protection measures, and source control practices to minimize contamination risks and

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	protect raw water sources from pollution, runoff, and upstream impacts. Implement land use planning, pollution prevention measures, and best management practices to safeguard source water quality and ensure a sustainable supply of feedwater for reuse. **3.6 Asset Management and Maintenance:** Adopt proactive asset management strategies, preventive maintenance programs, and asset renewal plans to optimize the performance, reliability, and longevity of water reuse infrastructure and equipment. Conduct regular inspections, condition assessments, and rehabilitation activities to identify maintenance needs, prioritize investments, and mitigate infrastructure risks. **3.7 Capacity Building and Training:** Provide training, capacity building, and technical assistance to water reuse professionals, operators, and maintenance personnel on best practices, emerging technologies, and industry standards for water reuse. Offer certification programs, workshops, and hands-on training sessions to enhance technical expertise, operational skills, and knowledge transfer in water reuse operations. **3.8 Pilot Projects and Demonstration Sites:** Implement pilot projects, demonstration sites, and research initiatives to test, evaluate, and demonstrate the feasibility of innovative water reuse technologies and practices. Collaborate with research institutions, utilities, and technology providers to pilot new treatment technologies, validate performance data, and demonstrate compliance with regulatory requirements. **3.9 Cross-Sector Collaboration:** Foster collaboration, knowledge exchange, and technology transfer between the water sector, academia, industry, and other relevant sectors to leverage expertise, resources, and lessons learned in addressing technical challenges for water reuse. Encourage interdisciplinary research, joint projects, and public-private partnerships that integrate insights from different disciplines and sectors to tackle complex technical issues.

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	3.10 Continuous Improvement and Innovation: Foster a culture of continuous improvement, innovation, and adaptive management in water reuse operations by encouraging experimentation, learning from failures, and embracing technological innovation. Support research and development initiatives, pilot-scale testing, and field demonstrations of promising technologies to address emerging technical challenges and drive continuous advancement in water reuse practices. By implementing these strategies, stakeholders can address technical challenges for water reuse, improve treatment performance, and ensure the reliable production of high-quality recycled water for various beneficial uses, contributing to water security, resource conservation, and environmental sustainability.
4.0 Institutional and Governance Issues Poorly defined institutional frameworks, governance structures, or unclear responsibilities among stakeholders can create obstacles for implementing water reuse projects.	Addressing institutional and governance issues for water reuse involves implementing strategies to enhance coordination, collaboration, and governance structures among relevant stakeholders, regulatory authorities, and institutional actors. Here are some ways to tackle this challenge: **4.1 Multi-Stakeholder Coordination:** Establish multi-stakeholder platforms, working groups, or task forces that bring together diverse stakeholders, including government agencies, water utilities, industry representatives, environmental NGOs, academia, and community groups, to coordinate efforts, share knowledge, and address institutional challenges related to water reuse. **4.2 Interagency Collaboration:** Foster collaboration and information exchange among relevant government agencies, regulatory authorities, and oversight bodies responsible for water management, environmental protection, public health, and urban planning. Facilitate interagency coordination mechanisms, joint decision-making processes, and shared governance structures to address overlapping mandates and streamline regulatory oversight of water reuse. **4.3 Policy Alignment and Integration:** Align water reuse policies, regulations, and guidelines with broader water management objectives, sustainability goals, and integrated

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	water resources management (IWRM) frameworks to promote synergies, minimize conflicts, and maximize co-benefits across different water-related sectors. Integrate water reuse considerations into national water strategies, urban development plans, and sectoral policies to mainstream reuse practices and overcome institutional silos. **4.4 Legal and Regulatory Frameworks:** Develop comprehensive legal frameworks, regulatory regimes, and permitting processes that provide clear guidance, regulatory certainty, and accountability for water reuse activities while protecting public health, safeguarding environmental integrity, and ensuring compliance with water quality standards. Enact legislation, regulations, and enforceable standards that establish clear roles, responsibilities, and liabilities for water reuse stakeholders. **4.5 Capacity Building and Institutional Strengthening:** Strengthen the institutional capacity, technical expertise, and governance structures of water utilities, regulatory agencies, and relevant institutions responsible for water reuse planning, regulation, and oversight. Provide training, technical assistance, and institutional support to build human resources, improve decision-making processes, and enhance governance effectiveness in water reuse management. **4.6 Public Participation and Stakeholder Engagement:** Foster public participation, stakeholder engagement, and community involvement in water reuse decision-making processes, policy development, and project planning to ensure transparency, accountability, and inclusiveness. Empower communities, local stakeholders, and marginalized groups to participate in governance processes, voice their concerns, and contribute to the development of water reuse initiatives that reflect their needs and priorities. **4.7 Knowledge Sharing and Best Practices:** Promote knowledge sharing, exchange of experiences, and dissemination of best practices on water reuse governance, institutional arrangements, and regulatory frameworks among water reuse practitioners, policymakers, and

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	decision-makers. Facilitate peer learning, networking opportunities, and south-south cooperation initiatives that enable cross-border knowledge transfer and mutual learning among countries facing similar institutional challenges. **4.8 Public Awareness and Capacity Building:** Raise public awareness, build institutional capacity, and enhance stakeholder understanding of water reuse governance issues through education, outreach, and communication campaigns. Provide training, workshops, and capacity-building programs on governance principles, regulatory compliance, and institutional arrangements for water reuse stakeholders, decision-makers, and the general public. **4.9 Incentive Mechanisms and Economic Instruments:** Develop incentive mechanisms, economic instruments, and financial incentives that promote responsible water reuse practices, encourage investment in water reuse infrastructure, and reward compliance with regulatory requirements. Explore options such as subsidies, tax incentives, performance-based payments, and market-based mechanisms that align economic incentives with environmental objectives and societal benefits. **4.10 Adaptive Management and Learning Networks:** Establish adaptive management frameworks, learning networks, and knowledge-sharing platforms that enable iterative decision-making, continuous improvement, and adaptive governance of water reuse systems. Foster a culture of learning, experimentation, and innovation that allows stakeholders to adapt governance structures, policies, and practices in response to evolving challenges, emerging opportunities, and lessons learned from experience. By implementing these strategies, stakeholders can address institutional and governance issues for water reuse, strengthen regulatory frameworks, and foster effective governance structures that support the sustainable management and responsible development of water reuse initiatives.
5.0 Water Quality Standards and Regulations	Addressing water quality standards and regulations for water reuse involves implementing strategies to establish clear, science-based

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Ambiguous or restrictive water quality standards and regulations may create uncertainty for potential users and investors, impacting the adoption of water reuse technologies	standards, regulatory frameworks, and monitoring protocols that ensure the safety, reliability, and acceptability of recycled water for various beneficial uses. Here are some ways to tackle this challenge: **5.1** **Risk-Based Approach:** Adopt a risk-based approach to setting water quality standards and regulations for recycled water that assesses potential risks to human health, environmental quality, and public safety based on scientific evidence, risk assessments, and exposure pathways. Establish risk-based targets, guidelines, and performance criteria that prioritize protection of public health while allowing for beneficial reuse of recycled water. **5.2** **Health-Based Standards:** Develop health-based water quality standards and guidelines for recycled water that establish maximum contaminant levels (MCLs) or action levels for priority pollutants, pathogens, and chemical constituents of concern based on their toxicological properties, exposure pathways, and health effects. Align water quality standards with established drinking water guidelines, public health benchmarks, and international best practices to ensure protection of human health. **5.3** **Multiple Barrier Approach:** Implement a multiple barrier approach to water treatment, risk reduction, and pathogen removal in recycled water systems that combines physical, chemical, and biological treatment processes with protective measures, such as source water protection, pathogen monitoring, and operational controls. Design treatment trains that incorporate redundancy, resilience, and multiple treatment barriers to ensure robust pathogen removal and water quality assurance. **5.4** **Treatment Requirements:** Specify treatment requirements, performance standards, and treatment objectives for different types of recycled water applications based on the intended use, exposure pathways, and risk mitigation goals. Tailor treatment processes, disinfection methods, and filtration technologies to achieve targeted reductions in microbial pathogens, chemical contaminants, and emerging pollutants to meet water quality standards.

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	5.5 Monitoring and Surveillance Programs: Establish comprehensive monitoring and surveillance programs for recycled water systems that systematically monitor key water quality parameters, microbial indicators, and chemical constituents throughout the treatment process, distribution network, and end-use applications. Implement regular sampling, analysis, and reporting protocols to verify compliance with water quality standards, track performance trends, and detect potential risks. **5.6 Adaptive Management Frameworks:** Develop adaptive management frameworks, response protocols, and contingency plans that allow for timely adjustments to water quality management strategies, operational practices, and regulatory requirements in response to changing conditions, emerging contaminants, and evolving risks. Incorporate feedback mechanisms, performance indicators, and risk assessment tools into regulatory frameworks to enable adaptive governance of water reuse systems. **5.7 Public Health Risk Assessment:** Conduct comprehensive public health risk assessments, exposure assessments, and hazard analyses to evaluate potential health risks associated with recycled water use, considering both acute and chronic exposure pathways, vulnerable populations, and sensitive receptors. Use epidemiological studies, quantitative microbial risk assessment (QMRA), and exposure modelling to quantify health risks, inform risk management decisions, and support regulatory decision-making. **5.8 Stakeholder Engagement and Consultation:** Engage stakeholders, including public health officials, environmental regulators, water utilities, industry representatives, and community groups, in the development, review, and revision of water quality standards and regulations for recycled water. Facilitate stakeholder consultation, public participation, and transparent decision-making processes to build consensus, address concerns, and promote acceptance of regulatory measures.

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	5.9 **Harmonization and Consistency:** Harmonize water quality standards, regulations, and guidelines for recycled water across different jurisdictions, regulatory agencies, and governmental entities to ensure consistency, coherence, and interoperability in regulatory frameworks. Align recycled water regulations with existing water quality standards, environmental regulations, and public health guidelines to avoid duplication, conflicts, and regulatory ambiguity. **5.10** **Capacity Building and Training:** Provide training, capacity building, and technical assistance to regulatory authorities, water professionals, and stakeholders involved in implementing and enforcing water quality standards and regulations for recycled water. Offer education programs, workshops, and certification courses on water quality management, risk assessment methodologies, and regulatory compliance to enhance technical expertise and regulatory capacity. By implementing these strategies, stakeholders can address water quality standards and regulations for water reuse, ensure the safety and reliability of recycled water, and promote the responsible and sustainable use of recycled water for various beneficial purposes.
6.0 **Land Use and Space Constraints** Limited available space for infrastructure and potential conflicts with existing land uses may impede the implementation of water reuse projects.	Addressing land use and space constraints for water reuse involves implementing strategies to optimize land use, maximize space efficiency, and overcome spatial limitations in the deployment of water reuse infrastructure. Here are some ways to tackle this challenge: **6.1** Compact Design and Footprint: Design water reuse facilities, treatment plants, and distribution networks with compact layouts, modular configurations, and minimized footprints to maximize space efficiency and reduce land requirements. Utilize vertical integration, multi-story construction, and underground installations to minimize land use while maximizing treatment capacity and operational flexibility. **6.2** **Reuse of Existing Infrastructure:** Identify opportunities to repurpose, retrofit, or co-locate water reuse facilities within

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	existing infrastructure, such as wastewater treatment plants, industrial facilities, or urban developments, to leverage existing land assets and minimize the need for additional land acquisition. Integrate water reuse components into existing water supply systems, irrigation networks, and industrial processes to optimize resource utilization and minimize spatial impacts. **6.3** **Land Use Planning and Zoning:** Incorporate water reuse considerations into land use planning, zoning regulations, and urban development policies to promote compatible land uses, buffer zones, and setback requirements that accommodate water reuse infrastructure while minimizing conflicts with surrounding land uses. Designate areas for water reuse facilities, reclaimed water storage, and distribution networks in land use plans to ensure compatibility with surrounding uses and minimize land use conflicts. **6.4** **Flexible Siting Options:** Explore flexible siting options, such as decentralized water reuse systems, distributed treatment facilities, and mobile treatment units, that can be deployed in diverse locations, including urban areas, industrial sites, agricultural regions, and remote communities, to overcome spatial constraints and meet local water reuse needs. Adopt flexible siting criteria, land use regulations, and permitting processes that facilitate the deployment of water reuse infrastructure in diverse settings. **6.5** **Vertical Integration and Co-location:** Foster vertical integration and co-location of water reuse facilities with complementary uses, such as stormwater management facilities, green infrastructure projects, and urban redevelopment initiatives, to maximize synergies, share resources, and optimize land use efficiency. Explore opportunities for co-locating water reuse facilities with other infrastructure projects, such as renewable energy installations, transportation corridors, and public amenities, to enhance spatial efficiency and community benefits.

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	6.6 **Innovative Land Use Solutions:** Explore innovative land use solutions, such as rooftop gardens, green roofs, and urban agriculture, that integrate water reuse technologies and practices into built environments to maximize space efficiency, promote sustainable development, and enhance urban resilience. Implement green infrastructure projects, such as rain gardens, bioswales, and permeable pavements, that capture, treat, and reuse stormwater on-site to minimize land use impacts and enhance water reuse opportunities. **6.7** **Land Banking and Strategic Acquisition:** Identify and acquire strategic land parcels, development rights, or easements for water reuse infrastructure projects through land banking, land trusts, or strategic land acquisition programs to secure suitable sites, buffer zones, and expansion areas for future water reuse development. Collaborate with landowners, developers, and stakeholders to negotiate land use agreements, lease arrangements, or land swaps that support water reuse objectives and facilitate project implementation. **6.8** **Public-Private Partnerships (PPPs):** Form public-private partnerships (PPPs) with private developers, landowners, and investors to leverage private sector expertise, resources, and land assets for water reuse projects. Collaborate with private entities to co-develop mixed-use developments, industrial parks, or innovation hubs that integrate water reuse infrastructure, sustainable design features, and economic development opportunities to optimize land use and maximize community benefits. **6.9** **Smart Growth Principles:** Apply smart growth principles, such as compact development, infill development, and transit-oriented development, to promote efficient land use patterns, minimize urban sprawl, and concentrate development in areas with existing infrastructure and services. Encourage mixed-use development, higher density zoning, and pedestrian-friendly design to reduce land consumption, preserve open space, and support water reuse integration in urban areas.

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	6.10 Community Engagement and Planning: Engage stakeholders, local communities, and decision-makers in participatory planning processes, visioning exercises, and land use assessments that incorporate water reuse considerations into community development plans, comprehensive plans, and master plans. Foster collaboration, consensus-building, and public dialogue on land use decisions, water resource management strategies, and sustainable development goals to ensure that water reuse is integrated into long-term land use planning efforts. By implementing these strategies, stakeholders can address land use and space constraints for water reuse, optimize land utilization, and promote sustainable development practices that enhance the resilience, efficiency, and liveability of communities while advancing water reuse objectives.
7.0 Risk Aversion Perceived or real risks associated with water reuse, including concerns about liability, may discourage stakeholders from embracing these technologies.	Addressing risk aversion for water reuse involves implementing strategies to identify, assess, mitigate, and communicate risks associated with recycled water projects to stakeholders and decision-makers. Here are some ways to tackle this challenge: **7.1 Comprehensive Risk Assessment:** Conduct comprehensive risk assessments that evaluate potential risks and uncertainties associated with water reuse projects, including health risks, environmental impacts, regulatory compliance, public perception, and financial viability. Use risk assessment tools, such as risk matrices, fault tree analysis, and scenario modeling, to identify hazards, assess consequences, and prioritize risk mitigation measures. **7.2 Scientific Evidence and Data:** Gather and analyze scientific evidence, data, and research findings on the safety, reliability, and performance of recycled water systems to inform risk assessments and decision-making processes. Compile epidemiological studies, microbial monitoring data, and water quality research to demonstrate the effectiveness of treatment processes, pathogen removal

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	technologies, and protective measures in ensuring the safety of recycled water. **7.3 Regulatory Compliance:** Ensure compliance with regulatory requirements, water quality standards, and public health guidelines for recycled water use by adhering to established treatment criteria, monitoring protocols, and risk management practices. Work closely with regulatory authorities, public health agencies, and environmental regulators to address regulatory concerns, clarify compliance requirements, and obtain necessary permits and approvals for water reuse projects. **7.4 Public Health Protection:** Prioritize public health protection by implementing robust water treatment processes, disinfection strategies, and risk mitigation measures that minimize potential health risks associated with recycled water use. Employ multiple barriers to pathogen removal, such as physical filtration, chemical disinfection, and UV irradiation, to ensure the safety and reliability of recycled water for various applications. **7.5 Stakeholder Engagement:** Engage stakeholders, including community members, public officials, water users, and advocacy groups, in transparent and inclusive dialogue about water reuse risks, benefits, and trade-offs. Provide opportunities for stakeholder input, concerns, and feedback on risk management strategies, risk communication efforts, and decision-making processes to build trust, credibility, and consensus around water reuse initiatives. **7.6 Communication and Education:** Communicate risk information, mitigation measures, and safety assurances to stakeholders, decision-makers, and the public through clear, transparent, and accessible communication channels. Provide educational materials, fact sheets, and outreach campaigns that explain the science behind recycled water, dispel misconceptions, and address concerns about water quality, public health, and environmental impacts associated with water reuse.

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	7.7 Demonstration Projects: Implement demonstration projects, pilot studies, and field trials that showcase the safety, efficacy, and benefits of recycled water use in real-world settings to demonstrate proof of concept, build confidence, and reduce uncertainty surrounding water reuse technologies and practices. Invite stakeholders, decision-makers, and community members to visit demonstration sites, tour treatment facilities, and observe recycled water applications to witness firsthand the reliability and performance of recycled water systems. **7.8 Independent Review and Validation:** Seek independent review, validation, and peer evaluation of water reuse projects by reputable scientific institutions, technical experts, and third-party auditors to verify compliance with regulatory standards, validate risk assessments, and ensure the credibility of recycled water quality data. Commission independent studies, expert panels, or risk assessments to evaluate specific concerns, address stakeholder inquiries, and provide objective assessments of water reuse risks. **7.9 Continuous Monitoring and Surveillance:** Implement robust monitoring, surveillance, and quality assurance programs that continuously monitor water quality, pathogen levels, and treatment performance throughout the recycled water system to detect potential risks, deviations, or anomalies. Utilize real-time monitoring technologies, automated sensors, and remote sensing tools to provide early warning of water quality issues and enable prompt response actions to mitigate risks. **7.10 Adaptive Management and Learning:** Embrace adaptive management principles, iterative decision-making processes, and continuous improvement cycles that allow for flexibility, learning, and adjustment of risk management strategies in response to changing conditions, new information, and evolving risks. Establish feedback mechanisms, performance indicators, and monitoring protocols that enable ongoing evaluation, adaptation, and

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	refinement of risk management approaches for water reuse projects. By implementing these strategies, stakeholders can address risk aversion for water reuse, build confidence in the safety and reliability of recycled water systems, and foster acceptance of water reuse as a sustainable and resilient water management solution.
8.0 Intersectoral Competition Competition for water resources among different sectors, such as agriculture, industry, and urban development, can create challenges for reallocating treated water for reuse.	Addressing intersectoral competition for water reuse involves implementing strategies to promote collaboration, coordination, and equitable allocation of recycled water resources among competing sectors. Here are some ways to tackle this challenge: **8.1 Integrated Water Resources Management (IWRM):** Adopt an integrated approach to water resources management that considers the needs, priorities, and constraints of multiple sectors, including agriculture, industry, urban development, and environmental conservation. Develop IWRM plans, policies, and strategies that balance competing water demands, optimize resource allocation, and promote synergies between water users to maximize the overall efficiency and sustainability of water use. **8.2 Water Reuse Planning and Coordination:** Establish centralized or decentralized water reuse planning mechanisms, coordinating bodies, or interagency committees that bring together stakeholders from diverse sectors to coordinate water reuse projects, share information, and resolve conflicts. Facilitate dialogue, collaboration, and joint decision-making processes among water users, utilities, regulators, and policymakers to identify common interests, negotiate agreements, and address intersectoral competition for recycled water resources. **8.3 Priority Setting and Allocation:** Prioritize water reuse allocations and resource allocations based on the social, economic, and environmental value of water for different sectors, considering factors such as water scarcity, water

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	quality, economic productivity, and ecological sustainability. Develop allocation criteria, decision-support tools, and multi-criteria analysis (MCDA) frameworks that enable transparent and equitable allocation of recycled water resources among competing sectors, taking into account sectoral needs, water rights, and public interest considerations. **8.4 Market-Based Approaches:** Explore market-based mechanisms, economic incentives, and pricing mechanisms that promote efficient allocation and utilization of recycled water resources while incentivizing conservation, innovation, and water stewardship practices across different sectors. Implement water pricing policies, water trading schemes, and market mechanisms that reflect the true value of water, internalize externalities, and encourage responsible water use behaviours among water users. **8.5 Water Recycling Networks:** Develop water recycling networks, regional partnerships, and collaborative arrangements that allow multiple sectors to share recycled water resources, infrastructure, and treatment capacity to meet their respective water needs more cost-effectively and sustainably. Establish water reuse agreements, memoranda of understanding (MOUs), or cooperative arrangements between water utilities, industrial users, agricultural producers, and municipalities to facilitate reciprocal exchanges, water sharing agreements, and mutual benefits. **8.6 Flexible Allocation Rules:** Implement flexible allocation rules, adaptive management strategies, and dynamic allocation mechanisms that adjust water allocations in response to changing conditions, seasonal variations, and fluctuating water availability. Design allocation frameworks that allow for reallocation of recycled water resources based on changing sectoral demands, water supply conditions, and environmental considerations to ensure equitable access and optimize resource utilization. **8.7 Policy Coordination and Harmonization:** Coordinate water reuse policies, regulations, and incentives across

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	different sectors and administrative levels to promote coherence, consistency, and alignment of regulatory frameworks. Harmonize water reuse guidelines, permitting procedures, and regulatory standards to streamline administrative processes, reduce regulatory burdens, and facilitate cross-sectoral collaboration on water reuse projects. **8.8** **Capacity Building and Awareness:** Build capacity, raise awareness, and promote understanding of water reuse benefits, opportunities, and challenges among stakeholders from different sectors through education, outreach, and training programs. Provide technical assistance, knowledge-sharing platforms, and capacity-building initiatives that empower water users, decision-makers, and community leaders to make informed choices, adopt sustainable practices, and participate in water reuse initiatives. **8.9** **Conflict Resolution Mechanisms:** Establish conflict resolution mechanisms, dispute resolution procedures, and mediation processes to address conflicts, disputes, and disagreements among water users competing for recycled water resources. Facilitate negotiation, mediation, and consensus-building efforts to resolve conflicts of interest, reconcile competing demands, and find mutually acceptable solutions that balance sectoral interests and promote the common good. **8.10** **Research and Innovation:** Invest in research, innovation, and technology development that enhance the efficiency, reliability, and sustainability of water reuse practices across different sectors. Support interdisciplinary research, pilot projects, and demonstration initiatives that explore new water reuse technologies, management strategies, and governance models to address intersectoral competition, overcome barriers, and unlock synergies between water users. By implementing these strategies, stakeholders can address intersectoral competition for water reuse, promote collaboration,

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	and achieve more efficient and equitable allocation of recycled water resources among competing sectors, contributing to water security, economic development, and environmental sustainability.
9.0 Cultural and Social Factors Cultural beliefs and social attitudes towards water reuse, including the stigma associated with recycled water, can influence the acceptance and implementation of these technologies.	Addressing cultural and social factors for water reuse involves implementing strategies to promote acceptance, engagement, and participation in recycled water initiatives by addressing cultural beliefs, social norms, and community perceptions related to water reuse. Here are some ways to tackle this challenge: **9.1 Community Engagement and Participation:** Foster community engagement, participation, and involvement in water reuse planning, decision-making, and implementation processes through outreach, education, and public consultation initiatives. Empower local communities, stakeholders, and residents to voice their concerns, preferences, and aspirations regarding water reuse projects, and incorporate their input into project design and implementation. **9.2 Stakeholder Collaboration:** Build partnerships, coalitions, and networks with diverse stakeholders, including community groups, religious organizations, tribal leaders, youth associations, and cultural influencers, to promote awareness, understanding, and acceptance of water reuse practices within culturally sensitive communities. Collaborate with trusted local leaders, opinion leaders, and community champions to facilitate dialogue, dispel myths, and build support for water reuse initiatives. **9.3 Cultural Sensitivity and Respect:** Demonstrate cultural sensitivity, respect, and humility in engaging with culturally diverse communities by acknowledging their cultural values, traditions, and beliefs regarding water, sanitation, and hygiene practices. Recognize the cultural significance of water in different cultural contexts, and tailor communication messages, outreach materials, and educational programs to resonate with local cultural norms and sensitivities.

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Barriers	**Measures**
	9.4 **Cultural Competence Training:** Provide cultural competence training, diversity awareness programs, and cross-cultural communication skills to water professionals, outreach workers, and project staff involved in water reuse initiatives to enhance their understanding of cultural perspectives, preferences, and sensitivities related to water reuse. Foster a culture of inclusivity, diversity, and cultural humility within water reuse organizations to ensure respectful engagement with culturally diverse communities. **9.5** **Tailored Messaging and Outreach:** Develop tailored messaging, outreach materials, and communication strategies that resonate with the cultural values, beliefs, and priorities of target communities to effectively communicate the benefits, safety, and importance of water reuse practices. Use culturally relevant symbols, metaphors, and narratives to convey messages about water conservation, environmental stewardship, and public health protection in culturally sensitive ways. **9.6** **Community-Led Initiatives:** Support community-led initiatives, grassroots movements, and bottom-up approaches that empower local communities to take ownership of water reuse projects, design culturally appropriate solutions, and mobilize collective action around water reuse issues. Foster community ownership, leadership, and empowerment through capacity-building, skill development, and resource mobilization efforts that enable communities to address their own water challenges. **9.7** **Cultural Integration in Design:** Integrate cultural considerations, preferences, and aesthetics into the design, planning, and implementation of water reuse projects to ensure that recycled water infrastructure and facilities are culturally appropriate, socially acceptable, and visually appealing to local communities. Incorporate elements of local architecture, landscaping, and public art that reflect cultural identity, heritage, and values to enhance community acceptance and pride in water reuse initiatives.

Identified Non-Economic and Non-Financial Barriers and Measures for Water Reclamation, Treatment and Reuse Technology	
Barriers	**Measures**
	9.8 Demonstration and Learning Sites: Establish demonstration sites, living labs, or showcase projects in culturally diverse communities that highlight the benefits, functionality, and safety of water reuse technologies and practices in real-world settings. Invite community members, leaders, and stakeholders to visit demonstration sites, participate in hands-on activities, and engage in interactive learning experiences to increase awareness and confidence in water reuse. **9.9 Social Marketing and Behaviour Change:** Employ social marketing techniques, behaviour change interventions, and community-based social marketing campaigns to promote positive attitudes, perceptions, and behaviours towards water reuse among target audiences. Utilize social media, storytelling, and peer influence strategies to amplify messages, inspire action, and mobilize support for water reuse initiatives within culturally diverse communities. **9.10 Capacity Building and Training:** Build the capacity of local organizations, community groups, and cultural institutions to effectively engage with water reuse issues, advocate for their interests, and participate in decision-making processes related to water reuse. Provide training, technical assistance, and capacity-building support to community leaders, educators, and grassroots organizations to equip them with the knowledge, skills, and resources needed to champion water reuse within their communities. By implementing these strategies, stakeholders can address cultural and social factors for water reuse, foster acceptance, and build trust among culturally diverse communities, ultimately contributing to the successful implementation and long-term sustainability of water reuse initiatives.
10.0 Resource Constraints Limited human resources, expertise, and technical know-how within organizations or regions may hinder the	Addressing resource constraints for water reuse involves implementing strategies to optimize resource utilization, leverage available funding sources, and maximize the efficiency of water reuse projects despite limited financial, technical, or institutional resources. Here are some ways to tackle this challenge:

Identified Non-Economic and Non-Financial Barriers and Measures for Water Reclamation, Treatment and Reuse Technology	
Barriers	**Measures**
successful implementation of water reuse initiatives.	**10.1 Cost-Effective Technologies:** Prioritize the adoption of cost-effective, low-maintenance, and energy-efficient water reuse technologies that offer high performance and reliability at a reasonable cost. Explore innovative treatment processes, decentralized systems, and modular solutions that minimize capital expenditures, operational costs, and resource requirements while maximizing water recovery and quality. **10.2 Reuse of Existing Infrastructure:** Leverage existing water infrastructure, treatment facilities, and distribution networks to expand water reuse capacity and capabilities without significant capital investments. Retrofit, upgrade, or repurpose existing assets to accommodate recycled water production, storage, and distribution, thereby reducing the need for new infrastructure and minimizing resource constraints. **10.3 Public-Private Partnerships (PPPs):** Explore public-private partnerships (PPPs), joint ventures, or collaborative arrangements with private sector entities, utilities, and investors to leverage private sector expertise, resources, and investment capital for water reuse projects. Engage private partners in project development, financing, and operation to share risks, mobilize funding, and accelerate project implementation while maximizing value for money. **10.4 Grant Funding and Subsidies:** Seek grant funding, subsidies, and financial incentives from government agencies, philanthropic organizations, and development partners to support water reuse projects, particularly in underserved communities or economically disadvantaged areas facing resource constraints. Apply for competitive grants, innovation funds, and matching grants programs that provide financial assistance for feasibility studies, pilot projects, and infrastructure investments in water reuse. **10.5 Alternative Financing Mechanisms:** Explore alternative financing mechanisms, such as public-private partnerships, performance-based contracting, and pay-for-success

Identified Non-Economic and Non-Financial Barriers and Measures for Water Reclamation, Treatment and Reuse Technology	
Barriers	**Measures**
	models, that leverage private sector investment, align financial incentives, and promote cost recovery for water reuse projects. Implement user fees, surcharges, or tariffs for recycled water services that generate revenue streams to cover operation and maintenance costs while ensuring affordability for water users. **10.6 Capacity Building and Training:** Invest in capacity building, training, and technical assistance programs to develop local expertise, build institutional capacity, and enhance human resources for water reuse planning, design, and management. Provide training workshops, certification courses, and knowledge-sharing platforms that empower water professionals, regulators, and stakeholders with the skills and knowledge needed to implement and sustain water reuse initiatives. **10.7 Technology Transfer and Innovation:** Facilitate technology transfer, knowledge exchange, and collaboration with research institutions, technology providers, and international partners to access cutting-edge water reuse technologies, best practices, and innovation solutions that address resource constraints and enhance project viability. Foster innovation ecosystems, incubators, and technology hubs that support the development and commercialization of cost-effective water reuse technologies tailored to local needs. **10.8 Lifecycle Cost Analysis:** Conduct lifecycle cost analysis, cost-benefit assessments, and financial modelling to evaluate the long-term economic viability, affordability, and sustainability of water reuse projects over their operational lifespan. Consider the full costs and benefits of water reuse, including capital investments, operational expenses, environmental impacts, and societal benefits, to inform decision-making and resource allocation. **10.9 Regulatory Streamlining and Permitting:** Streamline regulatory processes, permitting requirements, and administrative procedures for water reuse projects to reduce regulatory barriers, expedite approvals, and lower

Identified Non-Economic and Non-Financial Barriers and Measures for Water Reclamation, Treatment and Reuse Technology	
Barriers	**Measures**
	transaction costs associated with project development. Work with regulatory agencies, permitting authorities, and policymakers to harmonize regulations, standardize permitting procedures, and establish clear guidelines for water reuse implementation. **10.10 Risk Management and Contingency Planning:** Implement risk management strategies, contingency plans, and resilience measures to mitigate potential risks, uncertainties, and disruptions associated with water reuse projects, such as water quality issues, supply shortages, or regulatory changes. Develop risk mitigation plans, emergency response protocols, and business continuity strategies that anticipate and address resource constraints while ensuring the reliability and resilience of recycled water systems. By implementing these strategies, stakeholders can address resource constraints for water reuse, optimize resource utilization, and enhance the feasibility, sustainability, and resilience of water reuse projects despite limited financial, technical, or institutional resources.

5-1. Financial Barriers and Measures Identified for Boreholes as Drought Intervention for Domestic Water Supply

Identified Economic and Financial Barriers and Measures for Boreholes as Drought Intervention for Domestic Water Supply	
Barriers	**Measures**
Addressing these economic and financial barriers for borehole implementation as a drought intervention requires a combination of supportive policies, financial incentives, and strategies for sustainable funding and cost recovery.	
1.0 High Initial Investment Costs Drilling boreholes involves significant upfront expenses, including the cost of drilling equipment, labour, and materials, which can be a substantial economic barrier.	**1.1** **Government Funding and Subsidies:** Providing financial support through government funding or subsidies can help offset the initial costs of borehole drilling, making it more financially viable for communities. **1.2** **Public-Private Partnerships (PPPs):** Encouraging collaborations between public and private entities through PPPs can attract private investment and expertise, leveraging resources for borehole implementation. **1.3** **Microfinance and Loan Programs:** Establishing microfinance or loan programs for communities or individuals can offer financial assistance for borehole projects, with manageable repayment terms. **1.4** **Tax Incentives:** Offering tax incentives for individuals or businesses investing in boreholes encourages private sector participation and can reduce the overall financial burden. **1.5** **User Fees and Tariffs:** Implementing transparent user fees or tariffs for water usage from boreholes can create a sustainable revenue stream for maintenance and operational costs. **1.6** **Community Contributions:** Encouraging communities to contribute financially, either through direct contributions or community fundraising initiatives, promotes a sense of ownership and responsibility for borehole projects. **1.7** **Water Pricing Policies:** Establishing water pricing policies that reflect the true cost of water, including the expenses associated with borehole implementation and maintenance, can incentivize sustainable use.

Identified Economic and Financial Barriers and Measures for Boreholes as Drought Intervention for Domestic Water Supply	
Barriers	**Measures**
	1.8 Insurance Mechanisms: Developing insurance products or risk-sharing mechanisms can mitigate financial risks associated with borehole projects, providing a safety net for investors and communities. **1.9 Capacity Building Investments:** Investing in training programs and capacity building for local communities enhances their ability to manage and maintain borehole systems efficiently, ensuring long-term financial sustainability. **1.10 Research and Development Funding:** Allocating funds for research and development in borehole technologies can drive innovation, reduce costs, and improve the overall economic viability of these interventions. These economic and financial measures, when implemented strategically, can facilitate the successful deployment of boreholes as a drought intervention for domestic water supply, ensuring both short-term relief and long-term resilience.
2.0 Operational and Maintenance Expenses: Ongoing operational and maintenance costs for borehole systems, including pump maintenance and water quality monitoring, can strain budgets and pose financial challenges.	Addressing maintenance and operation expenses for rainwater collection from groundwater involves implementing strategies to optimize system performance, minimize maintenance requirements, and manage operational costs effectively. Here are some ways to tackle this challenge: **2.1 Proper System Design** ✓ Ensure that rainwater collection systems from groundwater are designed appropriately to minimize maintenance needs and operational costs. ✓ Design systems with durable, low-maintenance materials, components, and equipment that can withstand environmental conditions and require minimal upkeep over time. **2.2 Regular Inspection and Maintenance** ✓ Establish a proactive maintenance schedule for rainwater collection systems, including regular inspection, cleaning, and servicing of components such as pumps, filters, pipes, and storage tanks.

Identified Economic and Financial Barriers and Measures for Boreholes as Drought Intervention for Domestic Water Supply	
Barriers	**Measures**
	✓ Conduct routine maintenance tasks, such as debris removal, sediment flushing, and equipment lubrication, to prevent clogs, blockages, and mechanical failures that can lead to costly repairs. **2.3 Training and Capacity Building** ✓ Provide training and capacity-building programs for system operators, maintenance personnel, and end-users to ensure proper operation, maintenance, and troubleshooting of rainwater collection systems. ✓ Educate stakeholders on best practices, safety procedures, and maintenance protocols to promote efficient system performance and extend equipment lifespan. **2.4 Asset Management and Inventory Control** ✓ Implement asset management strategies and inventory control measures to track equipment, spare parts, and consumables for rainwater collection systems effectively. ✓ Maintain an inventory of critical components, replacement parts, and maintenance supplies to facilitate timely repairs, minimize downtime, and optimize maintenance costs. **2.5 Performance Monitoring and Data Analysis** ✓ Establish performance monitoring protocols and data analysis procedures to track system performance, water quality parameters, and operational metrics over time. ✓ Use monitoring data to identify trends, detect abnormalities, and optimize system operation, scheduling maintenance activities based on actual usage patterns and performance indicators. **2.6 Efficient Pumping and Distribution** ✓ Optimize pumping and distribution practices to minimize energy consumption, reduce operational costs, and maximize water delivery efficiency. ✓ Use energy-efficient pumps, variable-speed drives, and automated controls to optimize pump operation,

Identified Economic and Financial Barriers and Measures for Boreholes as Drought Intervention for Domestic Water Supply	
Barriers	**Measures**
	reduce energy waste, and lower electricity expenses associated with groundwater pumping. **2.7 Preventive Maintenance Planning** ✓ Develop a preventive maintenance plan that outlines scheduled maintenance tasks, frequency of inspections, and maintenance procedures for each component of the rainwater collection system. ✓ Prioritize preventive maintenance activities, such as lubrication, alignment checks, and corrosion protection, to prevent equipment deterioration and prolong asset life. **2.8 Vendor Partnerships and Service Contracts** ✓ Establish partnerships with equipment suppliers, vendors, and service providers to access technical support, maintenance services, and spare parts for rainwater collection systems. ✓ Negotiate service contracts, maintenance agreements, or warranties that provide access to timely repairs, replacement parts, and technical assistance to minimize downtime and ensure system reliability. **2.9 Risk Management and Contingency Planning** ✓ Develop risk management strategies and contingency plans to address potential operational risks, emergencies, and disruptions that may impact rainwater collection systems. ✓ Identify potential failure modes, assess risk probabilities, and develop response protocols to mitigate risks, minimize downtime, and ensure continuity of water supply during emergencies. **2.10 Community Engagement and User Education** ✓ Engage the community, system users, and stakeholders in system operation, maintenance, and sustainability efforts through education, outreach, and participation initiatives. ✓ Foster a sense of ownership, responsibility, and stewardship among system users by involving them in decision-making, training programs, and maintenance

Identified Economic and Financial Barriers and Measures for Boreholes as Drought Intervention for Domestic Water Supply	
Barriers	**Measures**
	activities to promote long-term system viability and user satisfaction. By implementing these strategies, stakeholders can address maintenance and operation expenses for rainwater collection from groundwater, optimize system performance, and ensure the sustainability and reliability of water supply systems over time.
3.0 Limited Funding Sources Insufficient availability of funding, either through government allocations, donor support, or community contributions, may impede the implementation of boreholes for drought intervention.	Addressing limited funding sources for rainwater collection from groundwater involves leveraging existing resources, exploring alternative financing mechanisms, and seeking external funding opportunities to support project development and implementation. Here are some ways to tackle this challenge: **3.1 Grant Funding** ✓ Identify and pursue grant funding opportunities from government agencies, foundations, non-profit organizations, and international development agencies that support water conservation, climate resilience, and sustainable development initiatives. ✓ Research grant programs, funding competitions, and donor initiatives that provide financial support for rainwater collection projects, and tailor grant proposals to meet funding criteria and priorities. **3.2 Public-Private Partnerships (PPPs)** ✓ Explore partnerships with private sector entities, investors, and businesses to leverage private sector investment, expertise, and resources for rainwater collection projects. ✓ Collaborate with private companies, developers, and investors to co-finance project development, share project risks, and access capital for infrastructure investments through PPP arrangements, joint ventures, or equity partnerships. **3.3 Community Contributions** ✓ Mobilize community support and contributions through crowdfunding campaigns, community fundraising events, and local sponsorship initiatives to

Identified Economic and Financial Barriers and Measures for Boreholes as Drought Intervention for Domestic Water Supply	
Barriers	**Measures**
	supplement project funding for rainwater collection systems. ✓ Engage community members, stakeholders, and beneficiaries in fundraising efforts, awareness campaigns, and advocacy activities to generate local support and ownership for rainwater projects. **3.4 Government Subsidies and Incentives** ✓ Advocate for government subsidies, tax incentives, and financial incentives for rainwater collection projects to offset project costs, incentivize investment, and promote adoption of water-saving technologies. ✓ Work with government agencies, policymakers, and elected officials to advocate for policy reforms, funding allocations, and incentive programs that support rainwater harvesting and groundwater recharge initiatives. **3.5 Impact Investment** ✓ Attract impact investors, social impact funds, and impact-oriented financing institutions that prioritize environmental sustainability, water security, and community resilience in their investment portfolios. ✓ Position rainwater collection projects as impact investment opportunities that deliver measurable social, environmental, and financial returns to investors while addressing water challenges and promoting sustainable development goals. **3.6 Project Financing** ✓ Explore project financing options, such as loans, lines of credit, and project finance arrangements, from financial institutions, development banks, and infrastructure funds to finance rainwater collection projects. ✓ Develop project finance structures, investment models, and revenue streams that demonstrate the financial viability and creditworthiness of rainwater projects to attract financing from lenders and investors.

Identified Economic and Financial Barriers and Measures for Boreholes as Drought Intervention for Domestic Water Supply	
Barriers	**Measures**
	3.7 Performance-Based Contracts ✓ Consider performance-based contracts, pay-for-success models, or outcome-based financing mechanisms that tie project payments to the achievement of specific project outcomes, such as water savings, groundwater recharge, or community benefits. ✓ Structure contracts with service providers, vendors, or project developers that incentivize performance, innovation, and cost-effectiveness while aligning financial interests with project objectives. **3.8 Pooling and Blending Funds** ✓ Pool funding from multiple sources, including government grants, private investments, community contributions, and philanthropic donations, to create a diversified funding pool for rainwater collection projects. ✓ Explore opportunities for blending funds from different sources, such as blending grants with loans, equity investments, or impact investments, to optimize project financing and leverage complementary funding streams. **3.9 Capacity Building for Fundraising** ✓ Invest in capacity building, technical assistance, and fundraising training for project developers, community organizations, and non-profit groups to enhance their fundraising capabilities and access funding opportunities for rainwater collection projects. ✓ Provide support, mentorship, and resources to help organizations develop fundraising strategies, grant proposals, and donor relationships to secure funding for project implementation. **3.10 Partnerships and Collaboration** ✓ Strengthen partnerships, collaborations, and alliances with stakeholders, donors, and funding agencies to

Identified Economic and Financial Barriers and Measures for Boreholes as Drought Intervention for Domestic Water Supply	
Barriers	**Measures**
	leverage collective resources, expertise, and networks for rainwater collection projects. ✓ Foster collaboration between government agencies, non-profit organizations, academia, and the private sector to pool resources, share knowledge, and coordinate efforts to address water challenges and mobilize funding for sustainable water management initiatives. By implementing these strategies, stakeholders can address limited funding sources for rainwater collection from groundwater, mobilize resources, and unlock financing opportunities to support project development, implementation, and sustainability.
4.0 Lack of Financial Incentives The absence of financial incentives, such as subsidies or tax breaks, may discourage individuals, communities, or governments from investing in borehole projects.	Addressing the lack of financial incentives for rainwater collection from groundwater involves implementing strategies to create economic value, generate financial returns, and incentivize investment in rainwater harvesting initiatives. Here are some ways to tackle this challenge: **4.1 Cost Savings Analysis** ✓ Conduct cost-benefit analysis and financial feasibility studies to quantify the economic benefits, cost savings, and return on investment (ROI) associated with rainwater collection from groundwater. ✓ Highlight the potential cost savings from reduced water bills, irrigation costs, and stormwater management expenses, as well as the long-term economic benefits of water security, resilience, and property value enhancement. **4.2 Utility Rebates and Incentive Programs** ✓ Advocate for utility rebates, financial incentives, and subsidy programs from water utilities, local governments, and regulatory agencies to encourage adoption of rainwater harvesting systems. ✓ Work with utilities to develop rebate programs, tiered pricing structures, and incentive mechanisms that reward water conservation, onsite water reuse, and stormwater management practices.

Identified Economic and Financial Barriers and Measures for Boreholes as Drought Intervention for Domestic Water Supply	
Barriers	**Measures**
	4.3 Tax Incentives and Credits ✓ Lobby for tax incentives, tax credits, and tax breaks for property owners, businesses, and homeowners who invest in rainwater collection infrastructure or implement groundwater recharge projects. ✓ Advocate for tax deductions, accelerated depreciation, or property tax exemptions for rainwater harvesting systems to reduce upfront costs and improve the financial attractiveness of investments. **4.4 Green Building Certification** ✓ Pursue green building certification programs, such as Leadership in Energy and Environmental Design (LEED), WELL Building Standard, or Living Building Challenge, that recognize and reward sustainable water management practices, including rainwater harvesting and groundwater recharge. ✓ Seek certification credits, points, or incentives for incorporating rainwater collection systems into new construction or renovation projects. **4.5 Water Trading and Offsets** ✓ Explore water trading schemes, water markets, and water offset programs that allow water users to buy, sell, or trade water rights, allocations, or credits derived from rainwater collection and groundwater recharge activities. ✓ Advocate for the establishment of water trading platforms, water banks, or water stewardship programs that facilitate transactions and incentivize investments in rainwater harvesting projects. **4.6 Ecosystem Services Payment** ✓ Promote the recognition and monetization of ecosystem services provided by rainwater harvesting and groundwater recharge, such as flood mitigation, groundwater replenishment, and habitat restoration. ✓ Advocate for payments for ecosystem services (PES) schemes, environmental markets, or conservation finance mechanisms that compensate landowners or

Identified Economic and Financial Barriers and Measures for Boreholes as Drought Intervention for Domestic Water Supply	
Barriers	**Measures**
	communities for providing water-related benefits through rainwater collection practices. **4.7 Performance-Based Contracts** ✓ Implement performance-based contracts, pay-for-performance agreements, or outcome-based financing mechanisms that tie financial incentives to the achievement of specific water-related outcomes, such as water savings, groundwater replenishment, or environmental improvements. ✓ Structure contracts with financial incentives linked to performance metrics, measurable targets, and verified outcomes to incentivize investment in rainwater harvesting projects. **4.8 Water Pricing Reform** ✓ Advocate for water pricing reforms, volumetric pricing structures, and progressive rate designs that reflect the true cost of water, internalize externalities, and incentivize water conservation and efficiency. ✓ Push for the adoption of water pricing policies that differentiate between potable water and non-potable water sources, such as rainwater, to promote the economic viability of rainwater harvesting. **4.9 Public-Private Partnerships (PPPs)** ✓ Form public-private partnerships (PPPs), joint ventures, or collaborative arrangements between government agencies, private sector entities, and community organizations to finance, develop, and operate rainwater collection projects. ✓ Engage private investors, developers, and financiers in PPPs that leverage private sector capital, expertise, and innovation to finance rainwater harvesting infrastructure and services. **4.10 Market Development and Innovation** ✓ Support market development initiatives, innovation funds, and technology incubators that promote the adoption of rainwater harvesting technologies, products, and services.

Identified Economic and Financial Barriers and Measures for Boreholes as Drought Intervention for Domestic Water Supply	
Barriers	**Measures**
	✓ Foster an ecosystem of innovation, entrepreneurship, and investment in rainwater harvesting through research funding, technology demonstrations, and business incubation programs that stimulate market demand and investment opportunities. By implementing these strategies, stakeholders can address the lack of financial incentives for rainwater collection from groundwater, create economic value, and incentivize investment in sustainable water management solutions that enhance water security, resilience, and environmental sustainability.
5.0 Uncertain Return on Investment The unpredictability of the long-term economic benefits, such as reduced dependence on alternative water sources or increased resilience to drought, may make potential investors hesitant.	Addressing the uncertain return on investment (ROI) for rainwater collection from groundwater involves implementing strategies to improve cost-effectiveness, enhance financial predictability, and mitigate investment risks associated with rainwater harvesting initiatives. Here are some ways to tackle this challenge: **5.1 Comprehensive Financial Analysis** ✓ Conduct a comprehensive financial analysis, including a thorough assessment of costs, benefits, and financial risks associated with rainwater collection from groundwater. ✓ Evaluate the potential ROI under different scenarios, considering factors such as water demand, system capacity, operating costs, and revenue streams, to assess the economic viability and financial feasibility of the investment. **5.2 Long-Term Cost-Benefit Assessment** ✓ Take a long-term perspective when evaluating the ROI of rainwater collection projects, considering both short-term costs and long-term benefits over the lifecycle of the system. ✓ Assess the cumulative financial returns, net present value (NPV), and internal rate of return (IRR) of the investment over its expected lifespan to account for future savings, revenue generation, and avoided costs. **5.3 Risk Management Strategies**

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Barriers	**Measures**
	✓ Implement risk management strategies and contingency plans to mitigate investment risks, uncertainties, and potential losses associated with rainwater collection projects. ✓ Identify and assess potential risks, such as regulatory changes, water quality issues, or market fluctuations, and develop risk mitigation measures, insurance coverage, or financial reserves to buffer against adverse impacts and safeguard investment returns. **5.4 Diversification of Revenue Streams** ✓ Explore opportunities to diversify revenue streams and income sources associated with rainwater collection from groundwater to reduce reliance on a single revenue source and improve financial stability. ✓ Consider alternative revenue streams, such as water sales, water credits, or ecosystem services payments, that can generate additional income and enhance the overall ROI of the investment. **5.5 Performance Guarantees and Contracts** ✓ Negotiate performance guarantees, service level agreements, or contractual arrangements that provide assurances of system performance, water quality, and reliability to investors, stakeholders, and end-users. ✓ Establish contractual mechanisms, warranties, or insurance policies that protect investors against performance failures, equipment malfunctions, or operational deficiencies that could impact ROI. **5.6 Government Support and Subsidies** ✓ Advocate for government support, subsidies, or financial incentives for rainwater collection projects to offset upfront costs, reduce investment risks, and enhance the ROI for investors. ✓ Lobby for tax incentives, grants, rebates, or low-interest loans from government agencies, utilities, or local authorities that promote rainwater harvesting and groundwater recharge initiatives. **5.7 Demonstration Projects and Pilots**

Identified Economic and Financial Barriers and Measures for Boreholes as Drought Intervention for Domestic Water Supply	
Barriers	**Measures**
	✓ Implement demonstration projects, pilot studies, or proof-of-concept initiatives to showcase the economic benefits, performance advantages, and ROI potential of rainwater collection from groundwater in real-world settings. ✓ Use demonstration projects to gather empirical data, validate investment assumptions, and build confidence among investors, stakeholders, and decision-makers in the financial viability of rainwater harvesting. **5.8 Public-Private Partnerships (PPPs)** ✓ Form public-private partnerships (PPPs) or collaborative ventures between government agencies, private sector entities, and community organizations to share investment risks, leverage resources, and enhance the ROI of rainwater collection projects. ✓ Engage private investors, developers, and financiers in PPPs that offer financial incentives, revenue-sharing arrangements, or risk-sharing mechanisms to optimize investment returns. **5.9 Market Development and Innovation** ✓ Support market development initiatives, innovation funds, and technology incubators that stimulate investment in rainwater harvesting technologies, products, and services. ✓ Foster an ecosystem of innovation, entrepreneurship, and investment in rainwater harvesting through research funding, technology demonstrations, and business incubation programs that catalyse market growth and unlock investment opportunities. **5.10 Capacity Building and Education** ✓ Provide capacity building, training, and education programs to investors, stakeholders, and decision-makers on the financial benefits, investment opportunities, and risk management strategies associated with rainwater collection from groundwater.

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Barriers	**Measures**
	✓ Offer workshops, seminars, and training sessions that build financial literacy, investment awareness, and confidence in rainwater harvesting as a viable investment option. By implementing these strategies, stakeholders can address the uncertain ROI for rainwater collection from groundwater, improve financial predictability, and mitigate investment risks, ultimately enhancing the attractiveness and viability of rainwater harvesting investments for investors, funders, and project developers.
6.0 Inadequate Cost Recovery Mechanisms Challenges in establishing effective cost recovery mechanisms, such as user fees, can impact the sustainability of borehole projects and hinder their economic viability.	Addressing inadequate cost recovery mechanisms for boreholes as drought intervention for domestic water supply involves implementing strategies to ensure that the costs associated with borehole construction, operation, and maintenance are adequately covered while ensuring affordability and equitable access for water users. Here are some ways to tackle this challenge: **6.1 User Fees and Tariffs** ✓ Implement user fees or tariffs for borehole water usage, charging households, businesses, or institutions based on their water consumption or metered usage to recover operational and maintenance costs. ✓ Establish transparent pricing structures and billing systems that reflect the actual costs of borehole operation and maintenance while considering the affordability constraints of low-income households and vulnerable communities. **6.2 Subsidy Targeting and Cross-Subsidization** ✓ Target subsidies and financial assistance to low-income households, marginalized communities, or vulnerable groups who may face affordability challenges in accessing borehole water, while gradually phasing out subsidies for higher-income users. ✓ Explore cross-subsidization mechanisms where revenues generated from higher-income users are

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Barriers	**Measures**
	used to subsidize water access for low-income households, ensuring that cost recovery is balanced with social equity considerations. **6.3 Prepaid Water Systems** ✓ Implement prepaid water metering systems or smart water meters for boreholes, allowing users to prepay for water credits or tokens that are deducted based on their actual water consumption, promoting transparency, accountability, and cost recovery. ✓ Provide incentives or discounts for prepaid water purchases to encourage timely payment and responsible water use behaviour among users, while minimizing revenue losses due to non-payment or non-revenue water. **6.4 Water User Associations (WUAs)** ✓ Establish water user associations (WUAs) or community-based organizations to manage borehole facilities, collect user fees, and administer cost recovery mechanisms in collaboration with local stakeholders, ensuring accountability and transparency in revenue management. ✓ Build capacity within WUAs to develop financial management skills, budgeting practices, and governance structures that support sustainable cost recovery and resource mobilization for borehole operation and maintenance. **6.5 Public-Private Partnerships (PPPs)** ✓ Engage private sector companies, water utilities, or service providers through public-private partnerships (PPPs) to manage borehole facilities, operate water distribution systems, and collect user fees on behalf of the community, leveraging private sector expertise and resources for efficient cost recovery. ✓ Negotiate performance-based contracts or service agreements with private operators that incentivize cost-effective operation, maintenance, and revenue

Identified Economic and Financial Barriers and Measures for Boreholes as Drought Intervention for Domestic Water Supply	
Barriers	**Measures**
	collection while ensuring service quality and affordability for water users. **6.6 Alternative Revenue Streams** ✓ Explore alternative revenue streams and income-generating activities associated with borehole projects, such as selling excess water to neighbouring communities, supplying water for agricultural irrigation, or providing water-related services, training, or consultancy to generate additional revenue. ✓ Diversify income sources through value-added services, such as water treatment, bulk water sales, or water quality testing, that capitalize on the expertise and infrastructure associated with borehole projects to maximize financial sustainability and cost recovery. **6.7 Community Engagement and Ownership** ✓ Foster community ownership and participation in borehole management and governance processes, ensuring that cost recovery mechanisms are developed in consultation with local stakeholders and aligned with community needs, preferences, and priorities. ✓ Conduct awareness campaigns, community meetings, and participatory workshops to educate water users about the importance of cost recovery, transparency, and collective responsibility in sustaining borehole infrastructure for long-term water security and resilience. **6.8 Policy and Regulatory Support** ✓ Advocate for supportive policy and regulatory frameworks that enable effective cost recovery for borehole projects while ensuring affordability, equity, and sustainability in water service delivery. ✓ Work with government authorities, regulators, and policymakers to address legal barriers, regulatory constraints, and institutional challenges that hinder the implementation of cost recovery mechanisms,

Identified Economic and Financial Barriers and Measures for Boreholes as Drought Intervention for Domestic Water Supply	
Barriers	**Measures**
	advocating for policy reforms that promote transparent, accountable, and financially viable water governance arrangements. By implementing these strategies, stakeholders can address inadequate cost recovery mechanisms for boreholes as drought intervention for domestic water supply, ensuring that the costs associated with borehole operation and maintenance are covered while promoting affordability, equity, and sustainability in water service delivery.
7.0 Regulatory Barriers Complex or unclear regulations related to borehole drilling permits, water rights, and environmental compliance can create additional costs and uncertainties, acting as economic deterrents.	Addressing regulatory barriers for boreholes as drought intervention for domestic water supply involves advocating for supportive policy frameworks, streamlining regulatory processes, and ensuring compliance with water resource management regulations. Here are some ways to tackle this challenge: **7.1 Policy Advocacy and Engagement** ✓ Advocate for the development of clear and supportive policies, regulations, and guidelines governing borehole construction, operation, and management, emphasizing the importance of water security, resilience, and sustainability in drought-prone regions. ✓ Engage with government agencies, regulatory authorities, and policymakers to raise awareness about the role of boreholes in drought mitigation, water supply augmentation, and community resilience, highlighting the need for flexible and enabling regulatory frameworks. **7.2 Regulatory Reform and Simplification** ✓ Lobby for regulatory reforms that streamline permitting processes, reduce bureaucratic red tape, and simplify compliance requirements for borehole development projects, accelerating the approval process and lowering administrative barriers to entry. ✓ Work with regulatory agencies to harmonize and standardize regulatory procedures, technical standards, and permit requirements across different

Identified Economic and Financial Barriers and Measures for Boreholes as Drought Intervention for Domestic Water Supply	
Barriers	**Measures**
	jurisdictions, ensuring consistency and clarity in regulatory implementation. **7.3 Stakeholder Consultation and Participation** ✓ Facilitate stakeholder consultation and participation in the regulatory process, involving local communities, water user groups, NGOs, and industry stakeholders in the development, review, and revision of regulatory policies and guidelines related to borehole projects. ✓ Establish multi-stakeholder platforms, advisory committees, or working groups to foster dialogue, collaboration, and consensus-building among diverse stakeholders on regulatory issues affecting borehole development, encouraging inclusive decision-making and stakeholder buy-in. **7.4 Capacity Building and Training** ✓ Build capacity within regulatory agencies, local governments, and relevant institutions to effectively implement and enforce regulatory frameworks governing borehole projects, providing training, technical assistance, and knowledge sharing on regulatory compliance, monitoring, and enforcement. ✓ Equip water resource management authorities with the tools, resources, and expertise needed to assess borehole applications, conduct hydrogeological assessments, and ensure compliance with environmental, health, and safety regulations. **7.5 Environmental Impact Assessment (EIA)** ✓ Ensure that borehole projects undergo comprehensive environmental impact assessments (EIAs) and regulatory reviews to assess potential environmental, social, and cultural impacts, including groundwater depletion, land use changes, and community displacement, as required by national or regional regulations. ✓ Integrate environmental considerations, mitigation measures, and monitoring requirements into borehole project planning and design, mitigating adverse

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Barriers	**Measures**
	impacts and ensuring compliance with regulatory safeguards for sustainable water resource management. **7.6 Licensing and Permitting Procedures** ✓ Streamline licensing and permitting procedures for borehole construction, drilling, and operation, reducing regulatory barriers and administrative delays by establishing clear criteria, standardized application forms, and expedited review processes for borehole permits. ✓ Develop online permitting systems, digital platforms, or one-stop shops that facilitate electronic submission, tracking, and processing of borehole permit applications, enhancing transparency, efficiency, and accessibility for stakeholders. **7.7 Compliance Monitoring and Enforcement** ✓ Strengthen compliance monitoring and enforcement mechanisms to ensure that borehole projects adhere to regulatory requirements, permit conditions, and technical standards, conducting regular inspections, site visits, and audits to verify compliance with applicable regulations. ✓ Establish penalties, sanctions, and enforcement measures for non-compliance with regulatory obligations, including fines, license revocation, or legal action against violators, deterring unauthorized borehole drilling, groundwater abstraction, or environmental pollution. **7.8 Policy Harmonization and Coordination** ✓ Promote policy harmonization and coordination among relevant government agencies, ministries, and departments responsible for water resources management, land use planning, environmental protection, and public health, fostering integrated approaches to borehole regulation and governance. ✓ Establish inter-agency coordination mechanisms, task forces, or inter-ministerial committees to facilitate

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	collaboration, information sharing, and joint decision-making on regulatory issues related to borehole development, ensuring coherence and alignment with broader development objectives. By implementing these strategies, stakeholders can address regulatory barriers for boreholes as drought intervention for domestic water supply, fostering an enabling regulatory environment that promotes responsible, sustainable, and equitable water resource management while facilitating the implementation of borehole projects to enhance water security and resilience in drought-prone areas.
8.0 Insurance and Liability Concerns Lack of insurance options or concerns about liability in case of borehole system failure or water quality issues may increase perceived risks and financial barriers.	Addressing insurance and liability concerns for boreholes as drought intervention for domestic water supply involves implementing risk management strategies, obtaining appropriate insurance coverage, and establishing liability frameworks to mitigate potential risks and liabilities associated with borehole projects. Here are some ways to tackle this challenge: **8.1 Risk Assessment and Management** ✓ Conduct comprehensive risk assessments to identify potential hazards, liabilities, and vulnerabilities associated with borehole projects, including geological risks, equipment failures, water quality issues, and operational challenges. ✓ Develop risk management plans that outline proactive measures, mitigation strategies, and contingency actions to minimize the likelihood and impact of adverse events, including emergency response protocols, asset protection measures, and community awareness initiatives. **8.2 Insurance Coverage** ✓ Obtain insurance coverage for borehole projects through specialized insurance products, such as property insurance, liability insurance, or water infrastructure insurance, tailored to the specific risks and needs of water supply infrastructure. ✓ Work with insurance brokers, underwriters, or risk management experts to assess insurance options,

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	negotiate policy terms, and secure adequate coverage limits that protect against property damage, business interruption, liability claims, and other potential financial losses. **8.3 Contractual Protections** ✓ Include indemnification clauses, liability limitations, and insurance requirements in contracts, agreements, and service contracts with contractors, suppliers, consultants, and other project stakeholders involved in borehole development, ensuring that liability risks are appropriately allocated and mitigated. ✓ Specify insurance obligations, coverage requirements, and claims procedures in contractual documents, establishing clear expectations and responsibilities for insurance coverage, claims handling, and dispute resolution in case of unforeseen events or accidents. **8.4 Community Liability Protection** ✓ Establish community liability protection mechanisms, such as community insurance funds, risk-sharing agreements, or mutual aid arrangements, to collectively pool resources and share liabilities among water users, stakeholders, and beneficiaries of borehole projects. ✓ Engage with local communities, water user groups, and community-based organizations to raise awareness about insurance options, risk management practices, and collective responsibility for borehole infrastructure, fostering a culture of risk awareness and preparedness at the grassroots level. **8.5 Government Backing and Support** ✓ Advocate for government backing and support for borehole insurance schemes, liability protections, or risk-sharing mechanisms through public-private partnerships (PPPs), government

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	guarantees, or subsidy programs that incentivize private sector participation and investment in water infrastructure. ✓ Work with government agencies, regulators, and policymakers to explore innovative financing mechanisms, risk-pooling arrangements, or catastrophe insurance schemes that provide financial support and risk transfer solutions for water supply projects in drought-prone areas. **8.6 Public Awareness and Education** ✓ Educate stakeholders, including water users, community leaders, policymakers, and insurance providers, about the importance of insurance and liability protection for borehole projects, highlighting the potential risks, benefits, and coverage options available. ✓ Conduct outreach campaigns, training workshops, and information sessions to increase awareness about insurance principles, risk management practices, and legal liabilities associated with borehole development, empowering stakeholders to make informed decisions and take proactive measures to mitigate risks. **8.7 Continued Monitoring and Review** ✓ Monitor and evaluate insurance coverage, liability exposures, and risk management practices for borehole projects on an ongoing basis, conducting regular reviews, assessments, and audits to identify emerging risks, gaps in coverage, or changes in circumstances that may affect insurance needs. ✓ Update insurance policies, risk management plans, and liability frameworks as needed to adapt to evolving conditions, regulatory requirements, and stakeholder expectations, ensuring that

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	borehole projects remain adequately protected and resilient to unforeseen events. By implementing these strategies, stakeholders can address insurance and liability concerns for boreholes as drought intervention for domestic water supply, enhancing risk management, financial protection, and community resilience while promoting the sustainable development and operation of borehole infrastructure in drought-prone regions.
9.0 Land Ownership and Access Issues Challenges related to land ownership, rights, and access for drilling boreholes may create economic barriers, particularly in areas with complex land tenure systems.	Addressing land ownership and access issues for boreholes as drought intervention for domestic water supply involves navigating legal frameworks, securing land tenure rights, and fostering community engagement to ensure equitable access to water resources. Here are some ways to tackle this challenge: **9.1 Stakeholder Engagement and Consultation** ✓ Engage with local communities, landowners, and relevant stakeholders early in the project planning process to understand land tenure arrangements, customary land use practices, and potential concerns related to borehole development. ✓ Facilitate participatory decision-making processes, community consultations, and stakeholder dialogues to build consensus, address grievances, and negotiate land access agreements that respect the rights, interests, and priorities of all parties involved. **9.2 Legal and Regulatory Compliance** ✓ Ensure compliance with national land laws, regulations, and customary land tenure systems governing land ownership, land use rights, and property rights, seeking legal advice and guidance to navigate complex land tenure issues and secure necessary approvals for borehole projects. ✓ Obtain land tenure documentation, permits, leases, or easements from relevant land authorities or landowners, formalizing land access agreements and clarifying the rights,

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	responsibilities, and obligations of all parties involved in borehole development. **9.3 Community Land Mapping and Tenure Recognition** ✓ Conduct participatory land mapping exercises, cadastral surveys, or participatory GIS (Geographic Information System) mapping with local communities to document customary land tenure boundaries, land use patterns, and resource management practices, enhancing land tenure security and recognition. ✓ Advocate for the formal recognition of community land rights, communal land titles, or collective ownership arrangements through legal reforms, land tenure regularization programs, or land registration initiatives that empower communities to assert their rights to land and natural resources. **9.4 Negotiation and Conflict Resolution** ✓ Facilitate negotiations, mediation, or conflict resolution processes to address land tenure disputes, conflicting land claims, or competing interests among different stakeholders, fostering dialogue, trust-building, and mutually acceptable solutions to land access challenges. ✓ Seek assistance from neutral third-party mediators, community leaders, or traditional authorities to facilitate constructive dialogue, reconcile conflicting interests, and reach agreements that balance the needs of landowners, communities, and borehole developers. **9.5 Partnerships and Collaboration** ✓ Forge partnerships with local governments, land administration agencies, traditional authorities, and civil society organizations to address land tenure issues collaboratively, leveraging local knowledge, institutional resources, and

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	community networks to navigate land access challenges. ✓ Collaborate with landowners, community-based organizations, and land user groups to establish land-sharing agreements, joint management arrangements, or community land trusts that enable multiple stakeholders to access and benefit from borehole infrastructure while respecting land rights and responsibilities. **9.6 Capacity Building and Legal Empowerment** ✓ Build capacity within local communities, especially women, youth, and marginalized groups, to understand their land rights, legal entitlements, and avenues for recourse under national and customary law, empowering them to advocate for their interests and participate effectively in land governance processes. ✓ Provide legal literacy training, paralegal support, and access to legal aid services to help communities navigate land tenure issues, understand their rights, and protect their interests in negotiations, land transactions, or dispute resolution proceedings. **9.7 Sustainable Land Use Planning** ✓ Promote sustainable land use planning and natural resource management practices that integrate borehole development into broader land use plans, environmental conservation strategies, and community development initiatives, minimizing conflicts and maximizing the social, economic, and environmental benefits of water infrastructure projects. ✓ Incorporate principles of participatory land use planning, environmental impact assessment, and social safeguards into borehole project design and implementation, ensuring that land access issues

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	are addressed holistically and in accordance with local aspirations and development priorities. By implementing these strategies, stakeholders can address land ownership and access issues for boreholes as drought intervention for domestic water supply, fostering inclusive governance, equitable resource allocation, and sustainable land management practices that support community resilience, water security, and socioeconomic development in drought-prone areas.
10.0 Community Contributions Dependence on community contributions for funding borehole projects may be challenging, especially in economically disadvantaged areas where communities may struggle to contribute financially.	Addressing community contributions for boreholes as drought intervention for domestic water supply involves engaging communities in the planning, financing, and management of borehole projects to ensure their active participation and ownership. Here are some ways to tackle this challenge: **10.1 Community Needs Assessment:** Conduct a thorough needs assessment to identify water access challenges, preferences, and priorities within the community, including existing water sources, demand patterns, and affordability constraints, to inform the design and implementation of borehole projects. **10.2 Community Consultation and Engagement** ✓ Facilitate community consultations, meetings, and focus group discussions to raise awareness about borehole projects, solicit feedback, and involve community members in decision-making processes related to site selection, technology options, and project design. ✓ Establish community water committees or user groups to represent the interests of water users, oversee project implementation, and coordinate community contributions, ensuring transparency, accountability, and inclusivity in decision-making. **10.3 Contribution Matching and Cost Sharing** ✓ Implement contribution matching schemes or cost-sharing arrangements where communities contribute labor, materials, or financial resources towards borehole construction, operation, or

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	maintenance, with contributions matched or supplemented by external funding sources, such as government grants, NGOs, or donors. ✓ Encourage community members to contribute in-kind resources, such as land for borehole siting, labor for construction, or locally available materials for infrastructure development, leveraging community assets and capabilities to reduce project costs and enhance sustainability. **10.4 Volunteerism and Community Labor** ✓ Mobilize community volunteers, youth groups, and skilled artisans to participate in borehole construction, installation, and maintenance activities, providing training, technical assistance, and supervision to ensure quality standards and safety protocols are met. ✓ Organize community workdays or labor-sharing events where residents contribute their time and labor towards borehole projects, fostering a sense of ownership, pride, and collective responsibility for water infrastructure development within the community. **10.5 Community Fundraising and Resource Mobilization** ✓ Organize community fundraising events, campaigns, or crowdfunding initiatives to mobilize financial resources for borehole projects, leveraging social networks, community solidarity, and local philanthropy to generate funds from individual donors, businesses, or diaspora networks. ✓ Establish community-based revolving funds, savings groups, or microfinance schemes that pool resources, accumulate savings, and provide loans or grants to finance borehole development, empowering community members to invest in their own water security and resilience. **10.6 Incentives and Rewards**

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	✓ Offer incentives, rewards, or recognition to community members who contribute actively to borehole projects, such as preferential access to water, priority membership in water user committees, or certificates of appreciation, acknowledging their contributions and fostering a sense of ownership and stewardship. ✓ Promote social cohesion, reciprocity, and collective action within the community by celebrating achievements, milestones, and successes related to borehole development, reinforcing positive behaviour and community engagement through public recognition and praise. **10.7 Capacity Building and Empowerment** ✓ Build capacity within the community to plan, implement, and manage borehole projects effectively, providing training, technical assistance, and mentorship on water resource management, infrastructure maintenance, and community-based governance. ✓ Empower community leaders, women's groups, and youth associations to take on leadership roles, decision-making responsibilities, and advocacy initiatives related to water supply, enabling them to drive change, mobilize resources, and advocate for their needs and priorities at the local level. **10.8 Long-Term Sustainability Planning** ✓ Develop long-term sustainability plans and exit strategies for borehole projects that outline community roles, responsibilities, and mechanisms for ongoing operation, maintenance, and financial management, ensuring that communities are equipped to sustainably manage water infrastructure beyond project completion. ✓ Foster partnerships with local governments, NGOs, and service providers to support capacity building, institutional strengthening, and policy

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	advocacy efforts that enhance community resilience, governance effectiveness, and sustainability in water service delivery. By implementing these strategies, stakeholders can address community contributions for boreholes as drought intervention for domestic water supply, fostering community ownership, empowerment, and collaboration in water infrastructure development while promoting sustainable, inclusive, and resilient water systems that meet the needs of all residents.

5-2. Non-Financial Barriers and Measures Identified for Boreholes as Drought Intervention for Domestic Water Supply.

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Addressing these non-economic barriers involves targeted community engagement, culturally sensitive approaches, effective communication strategies, and collaborative efforts among various stakeholders to ensure successful borehole implementation for drought intervention in domestic water supply	
1.0 Technical Challenges: The technical complexity of borehole drilling and maintenance may act as a non-economic barrier, especially in areas with limited technical expertise or access to skilled personnel.	**1.1 Hydrogeological Surveys:** Conduct detailed surveys to assess the feasibility of borehole installation, considering factors like groundwater availability, depth, and quality. **1.2 Proper Site Selection:** Choose optimal locations for borehole installation based on geological data and local hydrology to maximize water yield and minimize potential contamination risks. **1.3 Advanced Drilling Techniques:** Utilize advanced drilling technologies and techniques to penetrate different types of soil and rock formations efficiently. **1.4 Water Quality Testing:** Regularly test the water quality to ensure it meets safety standards for domestic use, addressing concerns about contamination and health risks. **1.5 Installation of Pumping Equipment:** Install suitable pumping equipment that is efficient and durable to extract water from the borehole effectively. **1.6 Maintenance and Monitoring:** Establish a system for routine maintenance and monitoring to detect and address technical issues promptly, ensuring the longevity and reliability of the borehole. **1.7 Capacity Building:** Provide training and capacity building to local communities or technicians on borehole operation, maintenance, and troubleshooting to

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	empower them to manage the infrastructure effectively. **1.8 Community Engagement:** Involve local communities in the planning and implementation process to ensure their needs and concerns are addressed, fostering ownership and sustainability of the intervention.
2.0 Environmental Impact and Compliance Concerns about the environmental impact of borehole drilling, potential land degradation, and compliance with environmental regulations may pose non-economic barriers.	Addressing environmental impact and compliance for boreholes as drought intervention for domestic water supply involves conducting thorough assessments, implementing mitigation measures, and complying with regulatory requirements to minimize negative environmental impacts and ensure sustainable water resource management. Here are some ways to tackle this challenge: **2.1 Environmental Impact Assessment (EIA)** ✓ Conduct comprehensive environmental impact assessments (EIAs) for borehole projects to evaluate potential environmental risks, including groundwater depletion, land subsidence, habitat disturbance, and water quality degradation, as required by national or regional regulations. ✓ Engage environmental experts, hydrogeologists, and ecologists to assess the potential impacts of borehole development on sensitive ecosystems, biodiversity hotspots, and protected areas, identifying mitigation measures and alternative site options to minimize adverse effects. **2.2 Site Selection and Design Criteria**

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	✓ Apply site selection criteria and design standards that prioritize environmentally sustainable locations for borehole development, avoiding environmentally sensitive areas, critical habitats, and areas prone to erosion, flooding, or contamination. ✓ Incorporate best management practices, such as setback distances from water bodies, buffer zones around borehole sites, and erosion control measures, into borehole design and construction plans to protect water quality, minimize soil erosion, and prevent habitat fragmentation. **2.3 Groundwater Management and Monitoring** ✓ Implement groundwater management plans that balance water abstraction rates with recharge rates, aquifer sustainability, and ecosystem needs, ensuring that borehole extraction does not exceed safe yield thresholds or cause long-term groundwater depletion. ✓ Establish groundwater monitoring networks, piezometers, or observation wells to monitor water levels, quality parameters, and hydrogeological conditions over time, providing early warning of potential impacts and informing adaptive management decisions. **2.4 Water Quality Protection Measures** ✓ Install water quality monitoring equipment, such as pH meters,

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	conductivity sensors, and contaminant detectors, to monitor borehole water quality and detect potential contamination sources, such as agricultural runoff, industrial discharges, or microbial pathogens. ✓ Implement water treatment technologies, such as filtration, disinfection, or reverse osmosis, to remove contaminants, pathogens, and pollutants from borehole water, ensuring compliance with drinking water quality standards and public health regulations. **2.5 Habitat Restoration and Conservation** ✓ Implement habitat restoration and conservation measures in areas impacted by borehole development, such as revegetation, reforestation, or wetland restoration projects, to mitigate habitat loss, enhance biodiversity, and restore ecological functions. ✓ Collaborate with local conservation organizations, environmental NGOs, and community groups to implement habitat enhancement initiatives, wildlife corridors, and ecosystem restoration programs that mitigate the ecological footprint of borehole projects and promote ecological resilience. **2.6 Compliance with Regulatory Requirements** ✓ Ensure compliance with national environmental laws, regulations, and permitting requirements governing

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	borehole development, water abstraction, and groundwater management, obtaining necessary permits, licenses, or approvals from relevant regulatory authorities. ✓ Establish environmental management plans, mitigation measures, and monitoring protocols that align with regulatory standards and industry best practices, demonstrating commitment to environmental stewardship and regulatory compliance throughout the project lifecycle. **2.7 Community Engagement and Awareness** ✓ Engage local communities, stakeholders, and indigenous groups in environmental education, awareness-raising, and capacity-building activities that promote environmental conservation, sustainable land use practices, and responsible water resource management. ✓ Foster community stewardship and citizen science initiatives that empower residents to monitor, protect, and advocate for the environmental integrity of borehole sites, fostering a sense of ownership and responsibility for local ecosystems and water resources. **2.8 Adaptive Management and Continuous Improvement** ✓ Implement adaptive management strategies that incorporate feedback loops, performance monitoring, and

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	adaptive learning into borehole projects, allowing for real-time adjustments, course corrections, and improvements based on evolving environmental conditions and stakeholder feedback. ✓ Foster a culture of continuous improvement, innovation, and knowledge sharing within the borehole development sector, promoting collaboration, research partnerships, and technology transfer initiatives that advance environmental sustainability and resilience in water supply infrastructure. By implementing these strategies, stakeholders can address environmental impact and compliance for boreholes as drought intervention for domestic water supply, ensuring that borehole projects are developed and managed in an environmentally responsible manner that protects ecosystems, conserves natural resources, and safeguards water quality for present and future generations.
3.0 Community Perceptions and Acceptance: Lack of awareness, misinformation, or negative perceptions about boreholes and groundwater usage may create resistance among local communities, acting as a non-economic barrier.	Addressing community perceptions and acceptance for boreholes as drought intervention for domestic water supply involves proactive communication, community engagement, and participatory decision-making processes to build trust, raise awareness, and address concerns. Here are some ways to tackle this challenge: **3.1 Community Consultation and Participation:** Engage with local communities early in the project planning process to understand their needs, preferences, and concerns regarding borehole development, conducting

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	community consultations, meetings, and focus groups to solicit feedback and involve residents in decision-making. Facilitate participatory approaches, such as community workshops, consensus-building exercises, and participatory mapping activities, to empower community members to express their views, priorities, and aspirations for water supply interventions. **3.2 Transparent Communication:** Provide clear, transparent, and accurate information about the purpose, benefits, and potential impacts of borehole projects to community members, using accessible language, visual aids, and multimedia tools to communicate complex technical concepts in ways that are easily understood. Foster open dialogue, two-way communication, and opportunities for feedback, creating channels for community members to ask questions, voice concerns, and express their opinions throughout the project lifecycle. **3.3 Local Leadership and Representation:** Work with local leaders, community elders, and trusted intermediaries to serve as liaisons between project implementers and the community, leveraging existing social networks, cultural norms, and communication channels to facilitate dialogue, build consensus, and foster acceptance. Empower community representatives, women's groups, youth associations, and marginalized populations to participate actively in decision-making processes, ensuring that diverse

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	perspectives, interests, and voices are represented and heard. **3.4 Tailored Engagement Strategies:** Customize engagement strategies, messaging, and outreach activities to address specific community concerns, cultural sensitivities, and communication preferences, recognizing that different demographic groups may have unique perspectives, values, and information needs. Use a variety of communication channels and platforms, including community meetings, radio broadcasts, mobile messaging, and social media, to reach diverse audiences and ensure that information reaches residents who may have limited access to traditional communication channels. **3.5 Demonstration and Pilot Projects:** Implement small-scale demonstration or pilot projects to showcase the benefits and functionality of borehole technology, allowing community members to observe firsthand how boreholes can improve water access, reliability, and quality in their local context. Encourage participation in project implementation, operation, and maintenance activities, inviting community members to volunteer, contribute labour, or provide feedback throughout the project lifecycle, fostering a sense of ownership and investment in project success. **3.6 Addressing Misconceptions and Myths:** Address misconceptions, myths, and misinformation about borehole technology, groundwater resources, and water quality through targeted education campaigns,

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	public awareness initiatives, and community-based trainings led by trusted local experts and authorities. Provide evidence-based information, scientific data, and case studies to debunk common myths, clarify misunderstandings, and build confidence in the safety, reliability, and sustainability of borehole projects as a drought intervention strategy. **3.7 Empowering Local Champions:** Identify and empower local champions, advocates, and peer influencers within the community who can serve as ambassadors for borehole projects, mobilizing support, dispelling rumours, and fostering positive attitudes towards water infrastructure development. Provide training, resources, and support to community leaders, women's groups, youth associations, and other stakeholders to enable them to effectively communicate, advocate for, and champion borehole projects within their respective networks and constituencies. **3.8 Long-Term Engagement and Trust Building:** Foster long-term relationships, trust, and collaboration with the community beyond the initial project implementation phase, maintaining regular communication, feedback loops, and ongoing engagement to address evolving needs, challenges, and opportunities. Demonstrate commitment to community welfare, social responsibility, and sustainable development by honouring promises, delivering on commitments, and actively seeking community input in

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	decision-making processes related to water supply interventions. By implementing these strategies, stakeholders can address community perceptions and acceptance for boreholes as drought intervention for domestic water supply, fostering trust, building partnerships, and mobilizing community support for water infrastructure projects that enhance resilience, improve livelihoods, and promote sustainable development in drought-prone areas.
4.0 Cultural and Social Factors Cultural beliefs and social norms regarding water sources, rituals, or traditions may influence acceptance or reluctance to adopt borehole technology.	Addressing cultural and social factors for boreholes as drought intervention for domestic water supply involves recognizing and respecting local customs, values, and social structures while integrating community perspectives, knowledge, and practices into project planning and implementation. Here are some ways to tackle this challenge: **4.1 Cultural Sensitivity and Respect:** Respect cultural norms, traditions, and customs related to water use, management, and access, acknowledging the significance of water in local rituals, ceremonies, and social practices, and ensuring that borehole projects are implemented in a culturally sensitive manner. Consult with local cultural leaders, traditional authorities, and community elders to seek their guidance, blessings, and support for borehole projects, recognizing their role as custodians of indigenous knowledge and stewards of cultural heritage. **4.2 Community Participation and Engagement:** ✓ Foster meaningful community participation and engagement in all

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	stages of the project lifecycle, from planning and design to implementation and management, by involving residents, women's groups, youth associations, and marginalized populations in decision-making processes. ✓ Create opportunities for inclusive dialogue, consensus-building, and collaborative decision-making that respects diverse perspectives, values, and interests within the community, ensuring that borehole projects reflect local priorities and aspirations. **4.3 Traditional Water Management Practices** ✓ Integrate traditional water management practices, indigenous knowledge systems, and customary governance structures into borehole projects, drawing upon local wisdom, adaptive strategies, and community-based approaches to water resource management. ✓ Document and preserve traditional water harvesting techniques, rainwater storage methods, and groundwater management practices that have sustained communities for generations, incorporating these insights into project design and implementation where appropriate. **4.4 Gender and Social Equity** ✓ Promote gender equity, social inclusion, and women's empowerment in borehole projects by ensuring that women, who often bear

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	the primary responsibility for water collection and management, are actively involved in decision-making, leadership roles, and benefit-sharing arrangements. ✓ Address gender-specific water needs, preferences, and priorities through gender-responsive programming, such as providing separate water points for women and girls, promoting women's participation in water user committees, and offering gender-sensitive training and capacity-building initiatives. **4.5 Cultural Appropriateness in Design** ✓ Design borehole infrastructure and water supply systems in a culturally appropriate manner that reflects local aesthetics, architectural styles, and preferences, incorporating indigenous building materials, artistic elements, and cultural symbols into project design and construction. ✓ Consult with community members, artisans, and local craftsmen to ensure that borehole facilities blend harmoniously with the natural landscape, architectural heritage, and cultural identity of the community, enhancing social acceptance and ownership of the infrastructure. **4.6 Education and Awareness** ✓ Raise awareness about the importance of cultural heritage, traditional knowledge, and indigenous practices in water resource management through community education

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	programs, storytelling sessions, and cultural exchanges that highlight the cultural significance of water and the role of borehole projects in preserving cultural identity. ✓ Foster intergenerational learning and knowledge sharing by engaging elders, youth, and community members in cultural revival activities, oral history projects, and intercultural dialogue forums that promote appreciation for cultural diversity and foster a sense of pride in local traditions. **4.7 Conflict Resolution and Reconciliation** ✓ Address historical grievances, social tensions, and intergroup conflicts related to water access, rights, and ownership through inclusive conflict resolution processes, mediation mechanisms, and community reconciliation initiatives that promote dialogue, understanding, and cooperation among different cultural and social groups. ✓ Facilitate joint decision-making, resource-sharing, and collaboration between neighbouring communities, ethnic groups, or indigenous peoples to resolve disputes over water resources, foster mutual respect, and build solidarity around common water management goals. **4.8 Capacity Building and Institutional Strengthening** ✓ Build the capacity of local institutions, community-based

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	organizations, and traditional authorities to play an active role in water governance, conflict resolution, and decision-making processes related to borehole projects, empowering them to represent community interests and uphold cultural values. ✓ Provide training, technical assistance, and support to community leaders, cultural practitioners, and grassroots organizations to document, preserve, and transmit traditional knowledge, cultural practices, and water-related rituals that are integral to community identity and resilience. By implementing these strategies, stakeholders can address cultural and social factors for boreholes as drought intervention for domestic water supply, fostering cultural resilience, social cohesion, and community empowerment while promoting sustainable water resource management practices that respect and uphold cultural diversity.
5.0 Land Use and Space Constraints Limited available space for drilling or concerns about the impact on existing land use may present non-economic barriers to borehole implementation.	Addressing land use and space constraints for boreholes as drought intervention for domestic water supply involves creative site selection, compact infrastructure design, and collaboration with landowners and local authorities to optimize land utilization while minimizing environmental impact. Here are some ways to tackle this challenge: **5.1 Multi-Use Land Strategies** ✓ Identify multi-use land parcels or underutilized spaces within communities that can accommodate borehole infrastructure without

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	displacing existing land uses or encroaching on sensitive habitats, agricultural land, or cultural sites. ✓ Explore opportunities for integrated land use planning that combines borehole development with compatible activities such as community gardens, green spaces, or recreational areas, maximizing the benefits of limited land resources while enhancing community resilience. **5.2 Compact Infrastructure Design** ✓ Design borehole infrastructure, including wellheads, pump houses, and storage tanks, to minimize land footprint and optimize space utilization, employing compact layouts, vertical storage solutions, and underground installations where feasible. ✓ Explore innovative design options such as borehole clustering, shared infrastructure, or modular systems that enable multiple boreholes to be installed within a smaller footprint, reducing land requirements while maximizing water access and distribution efficiency. **5.3 Vertical Integration and Stacking** ✓ Adopt vertical integration strategies that stack borehole components vertically or utilize vertical space to maximize land efficiency, such as installing elevated storage tanks, overhead pipelines, or multi-level pump stations that minimize land

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	footprint while optimizing water distribution. ✓ Explore opportunities for underground storage solutions, such as aquifer storage and recovery (ASR) systems or borehole recharge schemes, that store water underground during wet seasons for later use during dry periods, reducing the need for surface land storage facilities. **5.4 Flexibility in Site Selection** ✓ Consider alternative borehole siting options, such as roadside locations, vacant lots, or marginal lands, that require minimal land preparation and infrastructure development, facilitating rapid deployment of borehole projects in densely populated or land-constrained areas. ✓ Prioritize sites with existing infrastructure, such as road access, utilities, or drainage systems, that can minimize land development costs and streamline project implementation, leveraging existing assets to optimize land use efficiency. **5.5 Mixed-Use Zoning and Planning** ✓ Advocate for mixed-use zoning and land use regulations that allow for flexible land allocation and compatible coexistence of borehole infrastructure with other urban or rural land uses, promoting compact development patterns and sustainable land management practices.

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	✓ Collaborate with local planning authorities, land use planners, and urban designers to integrate borehole projects into comprehensive land use plans, neighbourhood revitalization initiatives, or urban regeneration schemes that balance competing land uses and spatial needs. **5.6 Public-Private Partnerships (PPPs)** ✓ Explore public-private partnerships (PPPs) or collaborative arrangements with private landowners, businesses, or institutions to leverage underutilized land assets for borehole development, negotiating lease agreements, easements, or joint ventures that benefit both parties. ✓ Foster partnerships with land developers, real estate firms, or housing developers to incorporate borehole infrastructure into new development projects, integrating water supply systems with residential, commercial, or industrial land uses in a coordinated manner. **5.7 Community Land Trusts and Cooperatives** ✓ Establish community land trusts, cooperatives, or land pooling arrangements that consolidate land holdings, facilitate joint land management, and allocate land for essential public infrastructure, such as boreholes, community water points, or sanitation facilities. ✓ Mobilize community resources, volunteer labour, and collective

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	action to identify, secure, and manage land parcels for borehole projects, pooling land resources and expertise to overcome individual land use constraints and achieve shared water security goals. **5.8 Incentives for Landowners** ✓ Provide incentives, such as tax breaks, land tenure security, or development rights, to landowners who dedicate land for borehole infrastructure, incentivizing participation and cooperation in land use planning efforts that support water resource management objectives. ✓ Explore innovative financing mechanisms, such as land value capture or impact fees, that capture the economic value generated by borehole projects and reinvest it into land conservation, habitat restoration, or sustainable land use practices that benefit the broader community. By implementing these strategies, stakeholders can address land use and space constraints for boreholes as drought intervention for domestic water supply, optimizing land utilization, minimizing environmental impact, and maximizing water access in areas where land availability is limited or contested.
6.0 Competition for Groundwater Resources Conflicts arising from competition for groundwater resources among various users, including agriculture, industry, and	Addressing competition for groundwater resources for boreholes as drought intervention for domestic water supply requires careful management, collaboration, and sustainable use practices to balance competing demands and

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Barrier	**Measures**
domestic users, may hinder borehole projects.	ensure equitable access for all users. Here are some ways to tackle this challenge: **6.1 Groundwater Governance Frameworks** ✓ Establish groundwater governance frameworks, regulations, and institutional mechanisms that govern the allocation, use, and management of groundwater resources, including boreholes, to prevent over-extraction, minimize conflicts, and safeguard long-term sustainability. ✓ Implement groundwater monitoring, assessment, and regulatory compliance mechanisms to track groundwater levels, quality, and abstraction rates, enabling informed decision-making and adaptive management in response to changing hydrological conditions. **6.2 Stakeholder Engagement and Participation** ✓ Engage with diverse stakeholders, including local communities, farmers, industries, and environmental groups, in participatory groundwater management processes that promote dialogue, collaboration, and consensus-building around shared water resource challenges and solutions. ✓ Facilitate multi-stakeholder platforms, water user associations, or groundwater management committees that bring together different interests and perspectives to jointly manage groundwater resources, fostering transparency,

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Barrier	**Measures**
	trust, and accountability in decision-making. **6.3 Water Use Efficiency and Conservation** ✓ Promote water use efficiency, conservation, and demand management practices among borehole users, including farmers, households, and industries, through education, outreach, and technical assistance programs that encourage responsible water stewardship and reduce wasteful consumption. ✓ Implement water-saving technologies, irrigation efficiency measures, and drought-resistant crops that optimize water use and minimize groundwater abstraction, helping to stretch available water supplies and reduce pressure on borehole resources during periods of scarcity. **6.4 Alternative Water Sources and Diversification** ✓ Explore alternative water sources and diversification strategies, such as rainwater harvesting, stormwater management, and greywater recycling, to supplement borehole water supplies and reduce reliance on groundwater resources, particularly during dry seasons or droughts. ✓ Invest in decentralized water supply solutions, such as community-scale desalination, water reuse facilities, or surface water augmentation projects, that provide additional sources of potable water without exacerbating

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Barrier	**Measures**
	competition for groundwater resources. **6.5 Economic Instruments and Incentives** ✓ Introduce economic instruments, such as groundwater extraction fees, water pricing mechanisms, or market-based incentives, that internalize the social and environmental costs of groundwater use, incentivize conservation, and promote efficient allocation of water resources. ✓ Explore payment for ecosystem services (PES) schemes, groundwater banking arrangements, or water trading platforms that compensate landowners for sustainable groundwater management practices, incentivizing conservation measures and reducing over-exploitation. **6.6 Hydrological Assessments and Modelling** ✓ Conduct hydrological assessments, groundwater modelling, and risk assessments to understand the dynamics of groundwater systems, predict future water availability, and assess the potential impacts of increased borehole abstraction on groundwater recharge rates and aquifer sustainability. ✓ Use scientific data, hydrogeological maps, and predictive modelling tools to inform land use planning decisions, zoning regulations, and groundwater management strategies that protect sensitive recharge areas and high-

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Barrier	**Measures**
	value aquifer resources from over-exploitation. **6.7 Conflict Resolution Mechanisms** ✓ Develop conflict resolution mechanisms, mediation processes, and dispute resolution mechanisms to address conflicts over groundwater resources, including borehole access rights, water quality concerns, and competing land uses, facilitating negotiated agreements and mutually acceptable solutions. ✓ Provide training, capacity building, and technical assistance to local authorities, water user groups, and community leaders in conflict management, negotiation skills, and consensus-building techniques that promote constructive dialogue and peaceful resolution of water disputes. **6.8 Integrated Water Resource Management (IWRM)** ✓ Adopt an integrated water resource management (IWRM) approach that considers the interconnectedness of surface water and groundwater systems, as well as the social, economic, and environmental dimensions of water resource management, in decision-making processes. ✓ Promote collaboration across sectors, jurisdictions, and scales to coordinate water management efforts, share data and information, and implement coordinated strategies that address groundwater challenges holistically

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Barrier	**Measures**
	while maximizing synergies and minimizing trade-offs. By implementing these strategies, stakeholders can address competition for groundwater resources for boreholes as drought intervention for domestic water supply, fostering sustainable groundwater management practices, promoting equitable access, and safeguarding water security for present and future generations.
7.0 Interference with Existing Water Sources Concerns about potential interference with existing water sources, such as wells or rivers, may act as a non-economic barrier to borehole implementation	Addressing interference with existing water resources for boreholes as drought intervention for domestic water supply involves careful planning, impact assessment, and mitigation measures to minimize negative impacts on surface water bodies, wetlands, and other groundwater users. Here are some ways to tackle this challenge: **7.1 Hydrogeological Studies and Impact Assessments** ✓ Conduct comprehensive hydrogeological studies and environmental impact assessments (EIAs) prior to borehole development to understand the hydrological dynamics, groundwater interactions, and potential impacts on existing water resources, including surface water bodies, streams, and aquifers. ✓ Evaluate the potential risks of borehole abstraction, such as groundwater drawdown, reduced streamflow, or ecological disturbance, on adjacent water resources and sensitive ecosystems, identifying mitigation measures to prevent or minimize adverse effects. **7.2 Buffer Zones and Setback Requirements**

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	✓ Establish buffer zones, setback distances, and protective measures around borehole sites to minimize interference with existing water resources, wetlands, riparian areas, and ecological habitats, ensuring that borehole development does not encroach upon sensitive hydrological features. ✓ Adhere to regulatory requirements, zoning regulations, and land use planning guidelines that specify minimum setback distances from water bodies, groundwater recharge areas, or protected natural areas to prevent contamination, habitat fragmentation, or hydraulic interference. **7.3 Water Resource Monitoring and Management** ✓ Implement water resource monitoring networks, stream gauges, and groundwater observation wells to track changes in water levels, flow patterns, and water quality parameters before, during, and after borehole development, providing early warning of potential impacts and informing adaptive management decisions. ✓ Establish groundwater management plans, flow monitoring programs, and adaptive management strategies that integrate borehole abstraction data with surface water hydrology to optimize water allocation, prevent

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Barrier	**Measures**
	over-extraction, and maintain ecological flows. **7.4 Mitigation Measures and Best Practices** ✓ Implement mitigation measures and best management practices to minimize interference with existing water resources, such as pump optimization techniques, flow control devices, or water level monitoring systems that regulate borehole abstraction rates and mitigate adverse impacts on surrounding hydrological systems. ✓ Adopt low-impact drilling technologies, well construction techniques, and borehole design standards that minimize hydraulic connectivity between boreholes and adjacent aquifers, reducing the risk of cross-contamination, saline intrusion, or groundwater depletion. **7.5 Water Sharing Agreements and Cooperation** ✓ Negotiate water sharing agreements, cooperative arrangements, or joint management protocols with neighbouring water users, communities, or jurisdictions to coordinate borehole development activities, share water resources equitably, and avoid conflicts over water allocation during periods of scarcity. ✓ Facilitate multi-stakeholder dialogues, collaborative decision-making processes, and participatory water governance initiatives that

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Barrier	**Measures**
	engage diverse stakeholders in managing shared water resources sustainably and resolving conflicts through consensus-based approaches. **7.6 Environmental Conservation and Restoration** ✓ Implement environmental conservation and restoration measures, such as riparian zone restoration, wetland conservation, or habitat enhancement projects, to mitigate the ecological impacts of borehole development on aquatic ecosystems, biodiversity, and ecosystem services. ✓ Prioritize ecosystem-based approaches to water resource management that recognize the interconnectedness of surface water and groundwater systems, preserving natural hydrological processes, and enhancing ecosystem resilience to climate change and human disturbances. **7.7 Regulatory Compliance and Enforcement** ✓ Ensure compliance with environmental regulations, water licensing requirements, and permit conditions governing borehole development, groundwater abstraction, and water resource management, obtaining necessary approvals and adhering to regulatory standards to protect existing water resources.

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Barrier	**Measures**
	✓ Strengthen regulatory enforcement mechanisms, monitoring programs, and compliance inspections to deter unauthorized borehole drilling, illegal water abstraction, or unsustainable water use practices that may exacerbate interference with existing water resources. **7.8 Public Awareness and Education** ✓ Raise public awareness about the importance of protecting existing water resources, maintaining ecological integrity, and minimizing human impacts on hydrological systems through community outreach, education campaigns, and stakeholder engagement initiatives. ✓ Promote responsible water stewardship, sustainable land use practices, and integrated water resource management principles among borehole users, landowners, and the broader community, fostering a culture of environmental conservation and collective responsibility for safeguarding water resources. By implementing these strategies, stakeholders can address interference with existing water resources for boreholes as drought intervention for domestic water supply, mitigating negative impacts, promoting sustainable water management practices, and safeguarding the integrity of aquatic ecosystems and hydrological processes.
8.0 Local Governance and Coordination	Addressing local governance and coordination for boreholes as drought intervention for domestic

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Barrier	**Measures**
Weak local governance structures, lack of coordination among stakeholders, and unclear responsibilities may impede effective borehole implementation.	water supply involves establishing robust institutional frameworks, fostering collaboration among stakeholders, and empowering local authorities to effectively plan, implement, and manage borehole projects. Here are some ways to tackle this challenge: **8.1 Multi-Stakeholder Platforms:** ✓ Establish multi-stakeholder platforms or water governance committees at the local level, comprising representatives from government agencies, community organizations, civil society groups, water user associations, and other relevant stakeholders. ✓ Facilitate regular meetings, consultations, and participatory decision-making processes that engage diverse stakeholders in dialogue, information sharing, and joint problem-solving related to borehole development, ensuring inclusivity, transparency, and accountability in decision-making. **8.2 Integrated Water Resource Management (IWRM):** ✓ Adopt an integrated water resource management (IWRM) approach that considers the interconnectedness of surface water and groundwater systems, as well as the social, economic, and environmental dimensions of water management, in local planning and decision-making processes. ✓ Promote collaboration across sectors, jurisdictions, and scales to coordinate water management efforts, share data and information, and implement coordinated strategies that address water

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	challenges holistically while maximizing synergies and minimizing trade-offs. **8.3 Local Water Committees and User Groups** ✓ Establish local water committees, water user associations, or community-based organizations that represent the interests of borehole users, landowners, and water stakeholders in planning, implementing, and managing water supply interventions at the community level. ✓ Empower local water committees with decision-making authority, technical expertise, and financial resources to oversee borehole projects, allocate water resources, and resolve conflicts through participatory processes that prioritize community needs and preferences. **8.4 Capacity Building and Training** ✓ Provide capacity building, training, and technical assistance to local authorities, water managers, and community leaders in water governance, institutional development, and project management skills, enhancing their capacity to plan, implement, and monitor borehole interventions effectively. ✓ Offer training programs on borehole maintenance, operation, and water quality management to water user groups, borehole operators, and community members, building local skills and knowledge to ensure the long-term sustainability of water supply infrastructure. **8.5 Policy and Regulatory Support**

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Barrier	**Measures**
	✓ Develop supportive policy frameworks, regulatory guidelines, and institutional mandates that clarify roles, responsibilities, and decision-making processes for borehole development, operation, and management at the local level. ✓ Streamline permitting procedures, licensing requirements, and administrative processes for borehole projects, ensuring that regulatory barriers do not impede timely implementation and delivery of water services to communities in need. **8.6 Information Sharing and Communication** ✓ Establish mechanisms for information sharing, communication, and public outreach that engage local stakeholders in borehole planning, monitoring, and management processes, promoting awareness, transparency, and accountability in water governance. ✓ Use participatory communication tools, community meetings, and outreach campaigns to disseminate information about borehole projects, water rights, user responsibilities, and governance structures, empowering communities to participate in decision-making and hold authorities accountable. **8.7 Conflict Resolution and Mediation** ✓ Develop conflict resolution mechanisms, mediation processes, and dispute resolution procedures to address conflicts over water allocation, access rights, and borehole management,

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Barrier	**Measures**
	providing avenues for resolving disputes and reaching mutually acceptable agreements. ✓ Train local mediators, facilitators, and conflict resolution practitioners in negotiation skills, consensus-building techniques, and alternative dispute resolution methods to help parties find win-win solutions to water-related conflicts and build social cohesion within communities. **8.8 Adaptive Management and Learning** ✓ Adopt adaptive management approaches that allow for flexibility, learning, and continuous improvement in water governance practices, enabling stakeholders to respond effectively to changing hydrological conditions, emerging challenges, and community needs. ✓ Foster a culture of learning, innovation, and knowledge exchange among local stakeholders, encouraging experimentation, pilot projects, and collaborative research initiatives that generate evidence-based insights and best practices for sustainable water management in the context of borehole interventions. By implementing these strategies, stakeholders can strengthen local governance and coordination for boreholes as drought intervention for domestic water supply, enhancing community resilience, promoting equitable access to water services, and fostering sustainable water management practices at the grassroots level.

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Barrier	**Measures**
9.0 Community Engagement and Participation Insufficient community engagement and participation in decision-making processes related to borehole projects can lead to resistance and hinder successful implementation.	Addressing community engagement and participation for boreholes as drought intervention for domestic water supply involves empowering communities, fostering inclusive decision-making processes, and promoting active involvement in all stages of project planning, implementation, and management. Here are some ways to tackle this challenge: **9.1 Community Needs Assessment** ✓ Conduct comprehensive community needs assessments and water resource surveys to understand local water challenges, preferences, and priorities, engaging community members, leaders, and stakeholders in the identification of water supply gaps, vulnerabilities, and opportunities. ✓ Use participatory methods, such as community meetings, focus group discussions, and household surveys, to gather information on water usage patterns, sources of water stress, and community aspirations for improving water access and reliability. **9.2 Stakeholder Mapping and Engagement** ✓ Map key stakeholders, including community leaders, women's groups, youth associations, local authorities, civil society organizations, and water user committees, to identify potential partners, influencers, and champions for borehole projects. ✓ Develop targeted engagement strategies that reach diverse segments of the community, ensuring representation and participation from marginalized groups, vulnerable populations, and traditionally

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Barrier	**Measures**
	underserved communities in decision-making processes. **9.3 Participatory Planning and Design** ✓ Facilitate participatory planning workshops, design charrettes, or community design sessions that empower community members to contribute their local knowledge, preferences, and expertise to the planning and design of borehole interventions. ✓ Collaborate with communities to co-create culturally appropriate, context-specific solutions that meet their water needs, respect their cultural values, and reflect their aspirations for water security and resilience. **9.4 Community-Led Implementation** ✓ Promote community-led implementation approaches that empower local residents to take ownership of borehole projects, mobilize resources, and contribute labour, materials, or in-kind support to the construction, installation, and maintenance of water supply infrastructure. ✓ Foster a sense of ownership, pride, and responsibility among community members by involving them in hands-on activities, such as site preparation, well drilling, pump installation, and water quality testing, that build technical skills and foster collective action. **9.5 Transparency and Accountability** ✓ Provide feedback to project implementers and funders. Ensure transparency and accountability in

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Barrier	**Measures**
	borehole project management by providing regular updates, progress reports, and financial disclosures to the community, keeping stakeholders informed about project milestones, expenditures, and outcomes. ✓ Establish community oversight mechanisms, such as water user committees, project steering committees, or community scorecards, that monitor project performance, track service delivery indicators. **9.6 Capacity Building and Training** ✓ Offer capacity building workshops, training sessions, and skill development programs to community members, water user groups, and local institutions on borehole operation, maintenance, water quality management, and sustainable water use practices. ✓ Provide technical assistance, mentorship, and support to community-based organizations, youth groups, and women's cooperatives to strengthen their organizational capacity, leadership skills, and institutional resilience in managing water resources. **9.7 Community Education and Awareness** ✓ Conduct community education campaigns, public awareness programs, and water literacy initiatives that raise awareness about the importance of water conservation, hygiene promotion, and safe water practices, fostering behaviour change and promoting sustainable water use behaviours.

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Barrier	**Measures**
	✓ Use culturally relevant, locally adapted communication materials, such as posters, brochures, radio broadcasts, and theater performances, to disseminate key messages about borehole operation, water management, and health and hygiene promotion. **9.8 Partnership and Collaboration** ✓ Forge partnerships and collaborations with local NGOs, government agencies, academic institutions, and private sector entities that have expertise, resources, or networks to support community-led water initiatives, leveraging complementary strengths and maximizing collective impact. ✓ Foster synergies between borehole projects and existing community development initiatives, livelihood programs, or public health interventions, integrating water supply interventions into broader poverty alleviation strategies and sustainable development agendas. By implementing these strategies, stakeholders can address community engagement and participation for boreholes as drought intervention for domestic water supply, empowering communities, building social capital, and fostering local ownership and resilience in managing water resources.
10.0 Technical Knowledge Transfer: Challenges in transferring technical knowledge about borehole operation and maintenance to local communities can	Addressing technical knowledge transfer for boreholes as drought intervention for domestic water supply involves facilitating the exchange of expertise, skills, and best practices between technical professionals, local stakeholders, and

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Barrier	**Measures**
impact the long-term sustainability of borehole interventions.	community members. Here are some ways to tackle this challenge: **10.1 Training Workshops and Capacity Building** ✓ Organize training workshops, seminars, and hands-on technical sessions led by qualified experts, hydrogeologists, and water engineers to impart knowledge on borehole drilling, construction, maintenance, and operation techniques. ✓ Provide capacity building programs tailored to the needs and skill levels of different stakeholders, including borehole operators, water user committees, community leaders, and local technicians, enhancing their technical competencies and confidence in managing water supply infrastructure. **10.2 Demonstration Sites and Field Visits:** ✓ Establish demonstration sites or model borehole installations where community members and local technicians can observe best practices in borehole design, construction, and maintenance firsthand, gaining practical insights and hands-on experience. ✓ Organize field visits to existing borehole projects, water supply facilities, and technical installations within the region, allowing stakeholders to learn from successful examples, exchange knowledge, and benchmark performance against industry standards. **10.3 Technical Manuals and Guidelines** ✓ Develop technical manuals, operation guides, and instructional materials that provide step-by-step guidance on

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	borehole drilling, pump installation, water quality testing, and troubleshooting procedures, serving as practical reference resources for borehole practitioners. ✓ Translate technical documents into local languages, adapt content to local contexts, and disseminate printed or digital copies to relevant stakeholders, ensuring accessibility and usability for diverse audiences with varying levels of technical expertise. **10.4 On-the-Job Training and Mentoring** ✓ Facilitate on-the-job training opportunities and mentoring programs that pair experienced professionals with apprentices, trainees, and community members, allowing them to learn technical skills through hands-on experience, guided practice, and real-world problem-solving. ✓ Foster peer-to-peer learning networks, knowledge exchange forums, and community-based apprenticeship schemes that promote skill transfer, knowledge sharing, and mutual support among borehole practitioners, building local capacity and resilience. **10.5 Technology Transfer and Adaptation** ✓ Facilitate technology transfer initiatives that introduce appropriate, affordable, and locally adaptable technologies for borehole drilling, pump selection, and water treatment, tailoring solutions to the specific needs, resources, and constraints of each community.

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Barrier	**Measures**
	✓ Promote innovation and adaptation in borehole technologies, encouraging local experimentation, testing, and customization of equipment, tools, and materials to optimize performance, durability, and cost-effectiveness in diverse hydrogeological settings. **10.6 Partnerships with Technical Institutions** ✓ Collaborate with technical institutions, vocational training centres, and engineering schools to integrate borehole management and water supply curriculum into formal education programs, vocational training courses, and continuing professional development initiatives. ✓ Establish partnerships with universities, research institutions, and international organizations to facilitate knowledge sharing, research collaboration, and technology transfer in the field of groundwater development and management. **10.7 Community-Led Research and Innovation** ✓ Encourage community-led research projects, action research initiatives, and participatory monitoring programs that empower local stakeholders to investigate water resource issues, test innovative solutions, and generate evidence-based insights for improving borehole performance and sustainability. ✓ Support community-driven innovation hubs, maker spaces, or technology incubators that provide resources, mentorship, and funding to grassroots

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Barrier	**Measures**
	innovators, entrepreneurs, and problem solvers working on water-related challenges. **10.8 Continuous Learning and Improvement** ✓ Foster a culture of continuous learning, innovation, and improvement within the borehole sector by promoting feedback loops, performance monitoring, and adaptive management practices that enable stakeholders to learn from successes, failures, and lessons learned. ✓ Establish knowledge sharing platforms, online forums, and communities of practice that facilitate ongoing dialogue, collaboration, and peer support among borehole practitioners, fostering a culture of knowledge exchange and collective problem-solving. By implementing these strategies, stakeholders can address technical knowledge transfer for boreholes as drought intervention for domestic water supply, empowering local communities, building local capacity, and enhancing the sustainability and resilience of water supply infrastructure.

Annex I: List of stakeholders involved and their contacts.

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