St. Kitts and Nevis

BARRIER ANALYSIS AND ENABLING FRAMEWORK REPORT

ADAPTATION & MITIGATION

BARRIER ANALYSIS AND ENABLING FRAMEWORK REPORT

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Acronyms and Abbreviations

ATGS	Agricultural Transformation and Growth Strategy
AWWA	American Water Works Association
BAEF	Barrier Analysis and Enabling Frameworks
CARDI	Caribbean Agricultural Research and Development Institute
CAWASA	Caribbean Water and Sewerage Association Inc.
DMA	District Metered Areas
EV	Electric Vehicle
GCF	Green Climate Fund
GEF	Global Environment Facility
GHG	Greenhouse Gas
GOSKN	Government of St. Kitts and Nevis
GWP-C	Global Water Partnership - Caribbean
IPM	Integrated Pest Management
IWA	International Water Association
IWRM	Integrated Water Resources Management
NDC	Nationally Determined Contributions
NMT	Non-Motorised Transport
NRW	Non-Revenue Water
PRV	Pressure Reducing Valve
PV	Photovoltaic
PVC	Polyvinyl Chloride
SCADA	Supervisory Control and Data Acquisition System
SIDS	Small Island Developing States
SWG	Stakeholder Working Group
SWH	Solar Water Heating
TAP	Technology Action Plan
TNA	Technology Needs Assessment
TNC	Third National Communications Report to the UNFCCC
UNEP-CCC	United Nations Environment Program – Copenhagen Climate Centre
UNFCCC	United Nations Framework Convention on Climate Change
5Cs	Caribbean Community Climate Change Centre

Executive Summary

Background

The Federation of St. Kitts and Nevis (SKN) is highly vulnerable to climate hazards, including hurricanes, storms, and droughts. Climate change is projected to increase mean temperatures, result in sea level rise, change rainfall patterns, and increase intensity and severity of storms. These projections and impacts are well documented, and the country needs to take decisive action on climate change adaptation. As such, climate change adaptation has been the primary focus of the Federation together with other SIDS worldwide.

While contributing very little to global GHG emissions, the Federation recognizes its commitments under the Paris Agreement and has taken actions to mitigate climate change. Mitigation efforts are mainly related to advancing the use of renewable energy, improving energy efficiency, and maintaining carbon sequestration potential. The twin-island federation is simultaneously encouraging increased sustainable mobility but recognises that improvements in the power generation sector are foremost important. In addition, St. Kitts and Nevis recognises that mitigation actions identified have many co-benefits associated with human health, energy security, biodiversity conservation, employment, and economic growth, among others (GOSKN, 2022a,b).

The National Climate Change Policy (2017) provides the mandate and policy framework for climate action in St. Kitts and Nevis (GOSKN, 2017). The National Climate Change Adaptation Strategy (2018) operationalizes the National Climate Change Policy and was developed using a participatory approach, gaining input and recommendations from diverse stakeholder groups through national consultations (GOSKN, 2018). The Strategy details specific adaptation objectives and measures across eight sectors (agriculture, coastal and marine ecosystems, forest and terrestrial ecosystems, finance and banking, human health, infrastructure and physical development, tourism and water) and five cross-cutting areas (stakeholder capacity building and engagement, information management, research and monitoring, integrated adaptation and disaster risk reduction and inter-sectoral coordination) for the time period of 2018-2030.

The most recent vulnerability assessment for the Federation was completed in 2021 during the development of the St. Kitts and Nevis Third National Communication (TNC) to the UNFCCC. Specifically, Chapter 3 of the report relates to vulnerability and adaptation assessment (GOSKN, 2021a). Climate change vulnerability was explored under two categories: hazard-based vulnerability and sectoral vulnerability. The most vulnerable sectors identified were human settlements and infrastructure, human health, gender, vulnerable groups and community-based adaptation, coastal, marine resources and fisheries, water, tourism, and agriculture.

Key challenges for adaptation planning that have emerged include the lack of data management systems to support adaptation planning, the lack of resources (funding, human resources, technology), the adaptation deficits and setbacks associated with the outbreak of diseases – such as the COVID-19 pandemic, droughts, as well as major natural disasters – such as hurricane Maria and Irma in 2017 (GOSKN, 2021a). Similarly, challenges to mitigation action include lack of adequate data for modelling and decision-making, high capital costs of renewable energy technologies, suitability and availability of appropriate technologies, land availability, natural disasters, and lack of political will (GOSKN, 2022b). An important process for overcoming challenges related to both adaptation and mitigation is technology needs assessment (TNA). These barriers to technology diffusion and how to overcome these barriers through enabling frameworks is the focus of this report.

The Global Technology Needs Assessment project is funded by the Global Environment Facility (GEF) and executed by the United Nations Environment Programme (UNEP) through the UNEP-CCC (Copenhagen Climate Centre). The Global TNA is a strategic programme on technology transfer, designed to support developing countries to carry out Technology Needs Assessments within the framework of the United Nations Framework Convention on Climate Change (UNFCCC) and under the Paris Agreement. Its main aim is to avert the risks and impacts of climate change and to reduce national greenhouse gas (GHG) emissions. The fourth phase of the TNA project was initiated in October 2020 and includes seventeen countries consisting of Small Island Developing States and Least Developed Countries in Africa, Asia, the Pacific, and Latin America and the Caribbean (including the Bahamas and St. Kitts and Nevis).

The Barrier Analysis and Enabling Frameworks (BAEF) report for St. Kitts and Nevis represents the second deliverable of the three-step TNA process that seeks to identify and create climate technology pathways for implementation of the Paris Agreement. The first step of the process culminated in the TNA report for both adaptation and mitigation for prioritized sectors in St. Kitts and Nevis (Sahely, 2023). The sectors prioritized were the water and agriculture sector for adaptation and the energy and transport sector for mitigation. The prioritized technologies for each sector are summarized below.

Water Sector
1. Non-revenue water and demand management programme (including smart metering)
2. Leakage detection and repair and pressure management

Agriculture Sector
1. Integrated pest management
2. Soil moisture conservation monitoring and techniques

Energy Sector
1. Solar water heating
2. Residential scale grid-tied solar

Transport Sector
1. Hybrids and battery electric vehicles
2. Development and rehabilitation of sidewalks, cycle ways and lanes and safe cycle parking

The TNA and BAEF reports lead to the development of national Technology Action Plans (TAPs) that recommend enabling frameworks for the diffusion of nationally prioritized technologies and facilitate the identification of viable technology transfer projects with links to relevant financing sources. The TAPs systematically document practical actions necessary to reduce or remove policy, finance, and technology related barriers.

The TNA process for St. Kitts and Nevis is informed by the Second National Communication (GOSKN, 2015) and available chapters of the Third National Communication (TNC) (GOSKN, 2021a, 2022b) and the first Biennial Update Report (BUR1) (GOSKN, 2022a), the Nationally Determined Contributions (NDCs) (GOSKN, 2021c) and NDC Partnership Plan (GOSKN, 2022d), the SKN Water Utility Adaptation Plan (GOSKN, 2021b), the National Climate Change Policy (GOSKN, 2017) and Strategy (GOSKN, 2018), the St. Kitts and Nevis Agricultural Transformation and Growth Strategy (GOSKN, 2022e) and the St. Kitts and Nevis Energy Policy and Action Plan (GOSKN, 2011).

BAEF Process

The national TNA team for St. Kitts and Nevis was trained through a capacity building workshop related to barrier analysis and enabling frameworks in a workshop held in Basseterre, St. Kitts from July 12-13, 2023. Various methodologies including problem trees and market mapping were shared for the analysis of barriers and enabling measures for the prioritized climate change adaptation and mitigation technologies.

The sector working groups (SWG), continuing from the first phase of the TNA, contributed throughout the entire BAEF process. This involved a series of consultations which included interviews, online surveys and working group meetings. The names and contact information for the SWG are listed in Annex 1.

The first step included categorization of each technology according to the methodology laid out in the TNA BAEF guidance document (Nygaard and Hansen, 2015) and a broad overview of the preliminary targets for technology transfer and diffusion. Next, a long list of barriers for each adaptation and mitigation technology for each sector was compiled by the national consultant based on a thorough review of national policies, strategies, and national communications, BAEF reports from other countries, scientific literature, and consultation with stakeholders especially during the BAEF training held in July 2023. The sector working groups were initially engaged through an online survey which allowed for the determination of a short list of barriers. Following prioritization of barriers, logical framework analysis (problem and objective trees) was used to decompose the barriers into their root causes. Finally, a set of enabling measures to enhance the diffusion of each technology was identified through analysis of objective trees and in consultation with the SWGs and presented as a framework which will guide the development of the TAP which is the final step of the TNA process.

Barrier Analysis and Enabling Frameworks

The critical barriers and identified measures to overcome the barriers for each of the prioritized technologies are listed in Table ES.1.

The root causes of these barriers were analyzed using problem trees and measures identified to overcome the barriers using objectives trees which are found in Annexes II-V. The critical measures were combined to develop enabling frameworks for diffusion of the prioritized technologies.

Table ES.1: Summary of barriers and measures for each sector

Barriers	**Measures**
Water Sector	
High capital costs of advanced technologies required for apparent loss reduction (smart meters, SCADA and other data management systems) and real loss reduction (pipes, leakage detection equipment and specialized meters and valves)	• Implement procurement best practices to ensure optimal bulk purchasing along economical shipping routes • Explore bulk purchasing with water utility in Nevis and other neighboring islands • Private sector partnerships to encourage local suppliers to bring in specialized equipment on behalf of the utility • Pursue grants, loans, or investments from a wide range of source consider innovative instruments such as green bonds • Restructure water tariff to promote cost recovery and investment planning
Limited management and organizational skills to implement water loss prevention program	• Corporatization of the water utilities on both islands • Capacity building and greater access to professional development programs for managers on best practices in water loss prevention. • Short-term onboarding of consultants or experts to manage the implementation of any water loss prevention program. • Knowledge sharing and partnerships with other utilities that have successfully implemented similar programs.
Lack of political will to prioritize water loss reduction programs	• Public education and outreach including targeted public awareness campaigns to highlight the benefits of water loss prevention. • Meaningful engagement of stakeholders by allowing a variety of stakeholders to be involved in the planning process and implementation of water loss prevention strategies. • Showcasing of small-scale demonstration projects to demonstrate the effectiveness and benefits of water loss prevention, thus building political support.
Lack of specialized technicians and training for water loss reduction programs	• Provide access to technical training and certification programs (through established certification entities such as CAWASA) to provide technicians with credentials and ensure a standard level of competency. • Partner with other utilities in the Caribbean with successful water loss prevention programs to provide on-the-job training for local technicians. • Adjust renumeration of certified technicians to reflect upskilling.

Configuration of distribution systems make establishment of DMAs very difficult	• Modernizing infrastructure using a phased approach and best practices in planning and design:
	  o Upgrade the current distribution systems to allow for better scalability and to meet current standards.
	  o Implement modern piping and joining techniques that reduce the likelihood of leaks.
	  o Engage in comprehensive planning for future expansion and scalability of water distribution networks.
	  o Design distribution networks with DMAs in mind from the outset.

Ability to detect and locate smaller leaks	• Diversifying equipment suppliers:
	  o Encourage the entrance of more suppliers into the market to increase the availability of suitable leak detection technology.
	  o Consider public-private partnerships to facilitate the investment in necessary technologies (also noted in section 1.2.3.1)
	• Research and development:

Barriers	**Measures**
	◦ Collaborate with manufacturers of advanced technologies for leakage detection institutions to optimize technologies and methods for leak detection and repair that are suitable for local conditions. ◦ Monitor and evaluate the effectiveness of different strategies and technologies to continually improve the water loss reduction program.
Agricultural Sector	
Low market demand or premium for IPM-compliant products	• Develop certification programs for IPM-compliant products to promote best practices and standards and stimulate demand. Certified farmers would then be able to access branding and labelling strategies to showcase their products. • Partner with hotels, restaurants, and supermarkets to promote locally grown, IPM-compliant produce. • Strategies to promote healthy diets to help create demand for IPM-compliant produce.
Difficulty in monitoring and managing a diverse range of pests	• Invest in local laboratory facilities for pest identification and management. • Train specialized extension staff who can assist farmers with IPM strategies.
High implementation costs for IPM and soil moisture conservation strategies	• Offer subsidies, low-interest loans, or grants for the initial investment • Encourage and incentivize established farmers cooperatives to cooperate to actualize bulk purchasing and cost-sharing were applicable
Low awareness among farmers about the benefits of IPM and soil moisture conservation	• Implement comprehensive education and training programs through farmer field schools including modules on financial planning and analysis to help farmers understand the long-term cost savings and yield benefits. • Create demonstration farms where farmers can observe and learn first-hand • Use success stories and case studies to highlight the long-term benefits of IPM and soil moisture conservation • Launch targeted marketing and public awareness campaigns to educate farmers and the public about the benefits of soil moisture conservation. • Utilize local community meetings, farmer field days, and agricultural shows to spread awareness and demonstrate techniques.
Short term planning horizons that overlook long-term benefits of soil moisture conservation	• Strengthen extension services to provide ongoing support and guidance on long-term planning using both IPM and soil moisture conservation techniques. • Promote farmer-to-farmer learning and mentorship programs to facilitate the exchange of knowledge and experiences
Energy Sector	
High capital costs and lack of funding and financial incentives such as subsidies or low-interest loans (for both solar water heaters and residential grid-tied solar PV systems)	• The government can offer subsidies that reduce the upfront cost of solar water heaters and solar PV systems, making them more affordable for the average consumer. • Encouraging bulk purchasing and offering incentives for suppliers could increase competition and supply, potentially reducing costs. • Financial institutions, possibly with government backing or through public private partnerships, could provide low-interest loans specifically for solar energy investments. • Establishing green energy bonds or other innovative financing mechanisms to provide capital for residential solar projects. • Creating economies of scale by supporting community solar programs to reduce installation and equipment costs.

Barriers	**Measures**
Limited access to training and technical expertise in installation of solar technologies	• Developing and funding training programs at local educational institutions to increase the number of qualified installers and maintenance personnel. • Establish certification programs for solar technology installers to ensure quality control and customer confidence. • Increase awareness of the benefits of solar water heating and residential grid-tied solar PV systems through campaigns, workshops, and showcasing successful installations.
Inadequate legal frameworks especially absence of feed in tariffs to support adoption of residential PV systems	• Introduction of feed-in tariffs to provide long-term security and financial returns for solar PV system owners.
Grid infrastructure may not be able to handle variable output of solar PV systems	• Comprehensive modernization of the grid and associated investment is needed to make it more resilient and adaptable to distributed generation sources along with • Research and development into energy storage solutions
Transport Sector	
High capital costs and small market size of hybrids and EVs	• Introduce tax rebates, subsidies, or reduced import duties for hybrids and EVs to lower the initial purchase cost. • Partner with financial institutions to create favourable loan conditions for the purchase of hybrids and EVs. • Government and large corporations in St. Kitts and Nevis could make bulk purchases of hybrids and EVs, which would help create economies of scale and reduce unit costs. • Establish leasing programs to lower the upfront cost and risk for consumers, thereby making hybrids and EVs more financially accessible. • Educate the public on the long-term cost benefits of owning a hybrid or EV, such as lower maintenance and operational costs compared to traditional vehicles.
Lack of charging infrastructure	• Invest in charging infrastructure to alleviate range anxiety and make the operation of hybrids and EVs more convenient. This includes public charging stations and incentives for private charging stations at homes or businesses. • Develop a regulatory framework that supports the adoption of hybrids and EVs, such as mandated charging points in new building plans or reserved parking spaces for EVs with charging points. • Promote the use of renewable energy sources for electricity generation to power the charging stations such as solar car ports. • Lead by example by electrifying public transportation fleets.
High capital infrastructure costs associated with NMT	• Allocate specific funds or subsidies for the development of NMT infrastructure, such as sidewalks and cycle lanes. This could be a part of the national budget or through international grants aimed at sustainable transport projects. • Provide secure and convenient parking for bicycles to encourage cycling. This could be at transport hubs, workplaces, and commercial centres.
Space constraints / limited land area / narrow streets	• Integrate NMT into urban planning and development regulations (such as building codes) to ensure that future developments are built with sidewalks and bike lanes.

Barriers	**Measures**
	• Start with small-scale, low-cost interventions that can be gradually expanded, such as painting bike lanes on existing roads or creating shared spaces.
Cultural preference and status associated with motorized transport over NMT	• Launch campaigns to shift cultural perceptions of NMT, emphasizing the health, environmental, and economic benefits of walking and cycling. • Include education on the benefits of NMT in schools and through community outreach programs, such as the importance of physical activity for health. Encourage public figures and leaders to use NMT to help shift the status symbol from motorized to non-motorized transport. • Introduce traffic calming measures in urban areas to make walking and cycling safer and more appealing, such as speed bumps and pedestrian zones. • Develop and implement policies that specifically promote NMT, including regulations that require new developments to include NMT infrastructure. • Involve the community in the planning and development process to ensure that the NMT infrastructure meets the needs of residents and is maintained. • Organize regular car-free days to encourage walking and cycling, and to help residents experience the benefits of NMT.

The BAEF report is a crucial step towards the development of national Technology Action Plans (TAPs) that will guide the diffusion of nationally prioritized technologies in St. Kitts and Nevis. By addressing the root causes of the barriers to technology diffusion, the report sets a clear path for enhancing climate resilience and achieving sustainable development goals in the Federation.

Chapter 1 Water Sector

The first sector prioritized for the TNA process for climate change adaptation is the water sector. A more in-depth situational analysis of this sector can be found in the TNA report (Sahely, 2023). Two technologies were prioritized for the sector including: (1) Non-revenue water and demand management programme and (2) Leakage detection and repair and pressure management. The first step in the process is to classify the prioritized technologies.

This classification helps to facilitate barrier analysis by linking technologies to market characteristics and makes note of the fluidity between categories. Table 1.1 presents the categorization of the technologies for the water sector and sets the stage for identification of barriers.

Table 1.1: Categorization of technologies for the water sector

Technology type	Technology category	
1. Non-revenue water and demand management programme (including smart metering)	Non-market	Publicly provided goods
2. Leakage detection and repair and pressure management	Non-market	Publicly provided goods

In the rest of this report, to be more technically accurate and avoid confusion, the technologies will be referred to as apparent water loss management (*non-revenue water and demand management programme (including smart metering)*) and real water loss management (*leakage detection and repair and pressure management*).

1.1 Preliminary targets for technology transfer and diffusion

Worldwide, water losses are occurring at both the end user side and the utility's distribution side. It is a universal problem affecting both developed and developing countries. There are two types of water losses (Thornton et al., 2008):

1. Apparent losses – consists of water that is not physically lost but does not generate revenue because of inaccuracies in customer metering, data handling errors or any form of theft or illegal use
2. Real losses – consists of water lost from the distribution system through leaky pipes, joints and fittings and leaky reservoirs (including overflows)

St. Kitts and Nevis prioritized technologies to manage both apparent and real losses in its TNA report (Sahely, 2023). In alignment with the SKN Water Utility Adaptation Plan (GOSKN, 2021b) and the St. Kitts Water Conservation Plan of 2013 (GOSKN, 2013), the preliminary target is set at 25% reduction in apparent water losses and 25% reduction in real losses over 5 years. Table 1.2 presents targets for the scale of diffusion for each of the prioritized technologies. Figures 1.1 and 1.2 show the indicative costs for both apparent and real loss reduction programs as identified in the SKN Water Utility Adaptation Plan of 2021.

Table 1.2: Preliminary targets for diffusion of technologies for the water sector

Technology	Target
1. Non-revenue water and demand management programme (apparent water loss management)	
Updated water audit to determine level of losses	One complete audit for St. Kitts and one complete audit for Nevis
Identification and removal of illegal connections	Removal of at least 200 illegal connections
Audit of large volume users	Audit of top 100 large volume users
Updated information system for billing and customer information	New billing system installed for each water utility
Universal metering with increased installation of smart meters	Replacement of faulty meters (at least 1000) and installation of smart meters for large volume users (at least 100)
Meter accuracy analysis and testing	Installation of a meter test bench (one for SK and one for Nevis)
Public awareness and outreach programs	Comprehensive national public awareness campaign
2. Leakage detection and repair and pressure management (real water loss management)	
Procurement and training for new and emerging technologies such as ground penetrating radar, digital leak noise correlators and radio-frequency interferometers	Feasibility study to determine most suitable options for St. Kitts and Nevis Procurement of at least one of these types of equipment for each water utility Comprehensive training
Remote sensors for ongoing monitoring and analysis of leaks and pressure data using supervisory control and data acquisition system (SCADA)	Installation of new full SCADA system for St. Kitts and upgrade of system in Nevis
Regular inspection of pipes, cleaning, lubricating and exercising valves	Establishment of one dedicated crew for leakage detection and repair for each island
Establishment of district metered areas (DMAs) and installation of bulk meters and pressure reducing valves (PRVs)	Establishment of at least 40 DMAs with bulk meters and PRVs as needed (for both islands)

Programme activities (St Kitts)	Indicative cost	Duration
St Kitts – NRW 1 – Phase 1 Water Audit and Revenue Enhancement • Review progress on water audits completed as part of the St Kitts Water Conservation Plan and expand, and recommend enhancements as necessary to determine actual NRW. • Ensure requisite in-house capacity and technology to continue to conduct Water Audits as an ongoing activity (particularly for government buildings which are not billed; and other high volume users) • Assess customer information and meter data base systems • Assess metering coverage and accuracy of readings (including of government facilities) to better understand the supply / demand deficits • Develop a NRW reduction road map for apparent and real losses • Commence revenue enhancement activity • Review public awareness programme and revise as needed • Review plan to increase the use of water saving devices for household, business and government facilities through incentives and concessions and revise as needed.	**USD 400,000**	**3 years**
St Kitts – NRW 2 – Phase 2 Detailed Implementation Plans and Revenue Enhancement • Detailed implementation plans for apparent loss reduction • Detailed implementation plans for real loss reduction • Implementation of remedial work in high loss areas identified in water audit • Recommend upgrade of information systems where necessary • Continue revenue enhancement activity • Implement a public awareness programme • Trialling of incentive scheme for water saving devices	**USD 300,000**	**7 years**
St Kitts – NRW 3 – Phase 3 Implementation of NRW Reduction Plan • Implementation of apparent losses reduction programme • Implementation of real losses reduction programme • Continue public awareness programme • Rolling out incentive scheme for water saving devices	**USD 10,000,000**	**3 years**
St Kitts – NRW 4 – Information systems upgrades • Operationalise SCADA system and upgrade the systems that work with it to improve data collection, management and use in the effective and efficient collection of metering information (by expanding the use of smart meters to the entire island); and management of customer accounts, and supporting capacity development and staffing. Expanding the pilot phase of smart meters completed in 2019 would help to better quantify water loss and improve efficiency in how meters are read, and consequently improve the billing system. • Fully automate the operation of water supply equipment.	**USD 1,000,000**	**4 years**

Figure 1.1: Indicative costs of both apparent and real loss reduction programs for St. Kitts (excerpt from SKN Water Utility Adaptation Plan of 2021)

Programme activities (Nevis)	Indicative cost	Duration
Nevis – NRW 1 – Phase 1 Water Audit and Revenue Enhancement • Conduct Water Audit • Assess customer information and meter data base systems • Assess metering coverage and install meters for all water users • Assess accuracy of readings (including of government facilities) to better understand the supply / demand deficits • Reinstall meters on government premises • Develop a NRW reduction road map for apparent and real losses • Commence revenue enhancement activity • Develop a public awareness programme • Develop a plan to increase the use of water saving devices for household, business and government facilities through incentives and concessions	**USD 200,000**	**3 year**
Nevis – NRW 2 – Phase 2 Detailed Implementation Plans and Revenue Enhancement • Detailed implementation plans for apparent loss reduction • Detailed implementation plans for real loss reduction • Implementation of remedial work in high loss areas identified in water audit • Recommend upgrade of information systems where necessary • Continue revenue enhancement activity • Implement a public awareness programme • Trialling of incentive scheme for water saving devices	**USD 100,000**	**7 years**
Nevis – NRW 3 – Phase 3 Implementation of NRW Reduction Plan • Implementation of apparent losses reduction programme (Phase 1) • Implementation of real losses reduction programme (Phase 2) • Continue public awareness programme • Rolling out incentive scheme for water saving devices	**USD 1,000,000**	**3 years**
Nevis – NRW 4 – Information systems upgrades • Completion of information systems upgrade to improve data collection, management and use in the effective and efficient collection of metering information and management of customer accounts, and supporting capacity development and staffing.	**USD 300,000**	**4 years**

Figure 1.2: Indicative costs of both apparent and real loss reduction programs for Nevis (excerpt from SKN Water Utility Adaptation Plan of 2021)

1.2 Barrier analysis and possible enabling measures for apparent loss management

1.2.1 General description

In 2012, the apparent losses on the island of St. Kitts were estimated to be about 34 million imperial gallons per month (GOSKN, 2013). The non-revenue water (NRW) (real + apparent losses) was estimated to represent 53% of total volume of water input. NRW for Nevis is estimated to be between 30-35%. The first step in any water loss control program is a utility water balance (including water losses) as defined by the IWA/AWWA Water Audit methodology (GOSKN, 2013). The exercise of a top-down water audit allows a utility to identify weaknesses in terms of data quality and to take steps to improve data quality and ultimately to set performance indicators and monitor progress of any water loss control measures interventions taken. The steps in a strategy to reduce apparent water losses include continuous water accounting, identification and removal of illegal connections, audits of large-volume users, ensuring the integrity of the billing and customer information system, universal metering and public awareness and outreach. Data collected can be tracked in a Management Information System (MIS) or Customer Relations Management System (CRM) or basic billing software. Universal metering includes activities such as installation of meters for all users (including public standpipes), retrofitting of old meters, fixed interval meter reading, meter accuracy analysis and meter testing, calibration, repair, or replacement. Public awareness and outreach programs can include activities such as water bill inserts, social media education programmes and workshops (GOSKN, 2013).

Minimizing water losses in water systems has many benefits for water customers and utilities. These benefits include:

1. Improved operational efficiency
2. Lowered water system operational costs
3. Reduced potential for contamination
4. Extended life of facilities
5. Reduced potential property damage and water system liability
6. Reduced water outage events
7. Improved public health through a more regular and adequate water supply
8. Improved public relations

1.2.2 Identification of barriers

The long list of barriers for apparent water loss management presented to the SWG is included in Table 1.3. The long list was compiled by the national consultant based on a thorough review of national policies, strategies, and national communications, BAEF reports from other countries, scientific literature, and consultation with stakeholders especially during the BAEF training held in July 2023. Members of the SWG were asked to classify the barriers according to level of importance by assigning *High (H)* to critical or killer barriers which would adversely affect or prevent diffusion; *Medium (M)* to important barriers which should be monitored and *Low (L)* to those barriers deemed insignificant in the overall implementation process. For those barriers ranked High (H), the members of the SWG were asked to rank in order of importance. The top 4 were then selected for decomposition using the logical framework analysis.

Table 1.3: Classification and prioritization of barriers for apparent water loss management

Category	Barrier	Level of importance			
		HIGH	MED	LOW	RANK
Technical	Cybersecurity risks associated with data transmission and storage			X	
	Lack of compatibility between new technologies and existing infrastructure		X		
	Few local examples of implementation of technology		X		
	Reliability concerns in harsh environmental conditions		X		
Market	No local availability of advanced technologies (smart meters, information systems, meter test bench)		X		
	Rapid technological advancements making existing meters obsolete	X			7
Economic and financial	High capital costs	X			1
	High installation costs	X			6
	Lack of funding and financial incentives	X			10
	Economic uncertainty or instability			X	
	Difficulty in achieving a short -term return on investment		X		
	Importation costs and shipping costs for smart meters etc.		X		
	Bureaucratic hurdles in the local administration procurement process		X		
	Long wait times for overseas procurement		X		
	Additional expense for training staff to handle new technology			X	
Legal and regulatory	Inadequate legal frameworks including regulations to support water conservation technologies			X	
	Bureaucratic hurdles in approving new technologies			X	
	Variability in standards and specifications for smart meters across the region			X	
Institutional and organizational capacity	Lack of coordination between stakeholders, government agencies, utilities, suppliers etc.		X		
	Limited management / organization skills to implement apparent loss prevention program	X			2
	Challenges in data management and analysis		X		
	Lack of comprehensive strategy for water loss management	X			8
	Short term planning horizons that overlook long-term benefits of water loss reduction	X			5
Human skills	Challenges in installing, maintaining, and repairing sophisticated systems		X		
	Lack of specialized technicians and training	X			4

Category	Barrier	Level of importance			
		HIGH	MED	LOW	RANK
Socio-cultural	Public resistance to change, especially since the price of water is so cheap			X	
	Lack of awareness			X	
	Cultural practices that conflict with water conservation		X		
	Social inequities in accessing water			X	
	Mistrust in data accuracy and meter reading			X	
	Misconceptions and lack of knowledge about water conservation			X	
Environmental	Potential environmental impacts of new technologies and disposal of old meters			X	
	Ecological footprint of manufacturing and shipping of technologies			X	
Political and leadership	Lack of political will to prioritize water demand management	X			3
	Short-term political agendas conflicting with long-term water conservation goals	X			9
	Political instability affecting implementation of water conservation policies			X	

One (1) economic and financial and three (3) non-financial barriers were the top ranked critical barriers for apparent water loss management including:

1. High capital costs
2. Limited management and organizational skills to implement apparent loss prevention program
3. Lack of political will to prioritize water demand management
4. Lack of specialized technicians and training

1.2.2.1 Economic and financial barriers

The main economic barrier to implementation of a comprehensive program for reduction of apparent water losses identified by the SWG is high capital costs. The SKN Water Utility Adaptation Plan of 2021 outlines the costs of apparent loss reduction and provides preliminary estimate for the roll-out of a comprehensive plan for both apparent and real loss reduction. The first steps in apparent loss reduction (including overall audit, specialized audits of large users, retrofitting of meters etc.) is estimated to cost approximately USD 1,000,000 (phases 1 and 2 shown in Figures 1.1 and 1.2). Full implementation of apparent loss reduction especially with the installation of smart meters could amount to more than 3,300,000 USD (assumed to be approximately 30% of phase 3 shown in Figures 1.1 and 1.2) (GOSKN, 2021b). For comparison purposes, the total capital budget from government revenue allocated to the water utility in St. Kitts in 2024 was estimated at just over 5 M USD (GOSKN 2023a). This demonstrates the high capital outlays that are required to allow for comprehensive apparent water loss reduction.

Annex II details the problem trees for the critical economic and financial barrier to apparent loss management which was high capital costs. The main root causes to the core problem of high capital costs of advanced technologies for apparent loss reduction are not unique to St. Kitts and Nevis and would be encountered by most small island developing states that do not have local manufacturing of specialized equipment. In addition, since the equipment is only required by the water utility there are no local suppliers. The high cost of the equipment is further exacerbated by high importation costs mainly due to shipping of equipment from the USA or Europe to the Caribbean. Generally, the smaller islands would benefit from equipment manufactured in Trinidad and Tobago (or other larger islands) but in the case of conventional or smart meters, these are generally not manufactured anywhere in the Caribbean. Since the water utilities are owned by the government in St. Kitts and Nevis, most local taxes and tariffs are waived and so do not contribute directly to the high cost. The problem tree for this barrier is shown in Figure 1.3 for illustrative purposes (but is also included in Annex II along with all the other problem trees).

1.2.2.2 Non-financial barriers

The main non-financial barriers to implementation of an apparent loss reduction program identified by the SWG are, limited management skills to implement apparent loss prevention programs, lack of political will to prioritize water demand management and lack of specialized technicians and training.

Annex II details the problem trees for these non-financial barriers to uncover the root causes of the barriers. The root causes to limited management skills are limited access to current knowledge and training for managers in best practices in water loss prevention along with inadequate budget and human resources allocated to water loss prevention. The root causes to lack of specialized technicians are lack of opportunities for training and professional development for technicians. As it relates to lack of political will, the root causes identified include limited public awareness of the benefit of effective water loss prevention, limited resources allocated to water loss prevention (where benefits are more long term and not as tangible) and even lobbying by influential stakeholders that may be negatively impacted by an effective water loss program (i.e. a new smart meter for a large user may reveal heavy water usage and increased water bill for the consumer). It should be noted that these non-financial barriers apply also to real water loss reduction programs which will be considered in section 1.3. The linkages between all the barriers will also be covered in section 1.4.

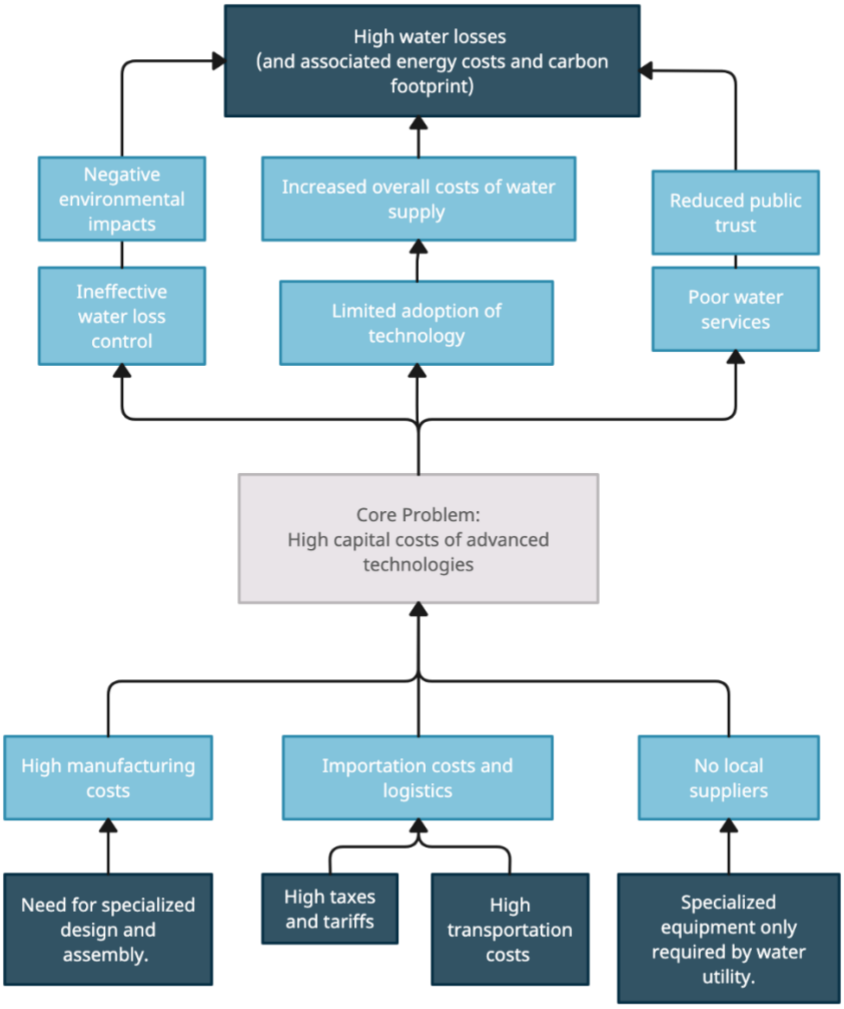


Figure 1.3: Problem tree for the main economic barrier (high capital costs) of apparent loss management

1.2.3 Identified measures

Annex II also includes objective trees which help with identifying measures that target the root causes of barriers.

1.2.3.1 Economic and financial measures

The SWG identified a few different measures to overcome the high capital costs of apparent loss management. Two measures are directly in the control of the government-owned water utility and speak to procurement best practices and trying to decrease the cost of transportation of specialized equipment. These include procurement of full container loads of goods and shipment along the most economical transportation routes. The next measure builds further on this to build partnerships with local suppliers so they can import the goods into the country. A private sector entity may have more flexibility, established transportation rates and routes and may be in a better position to optimize transportation costs than a government water utility. This would have to encompass duty-free exemptions for equipment brought in for the local water utility. Another possibility would be to negotiate with large suppliers of specialized equipment as a group of Caribbean water utilities through entities like the Caribbean Water and Sewerage Association Inc. (CAWASA) to create more opportunities for cost savings. Furthermore, the government of St. Kitts and Nevis could engage in regional cooperation with other island states to share costs and knowledge, to enable technology transfer and to lobby for the establishment of local manufacturing capabilities within the region. The objective tree for this barrier is shown in Figure 1.4 for illustrative purposes (but is also included in Annex II along with all the other objective trees).

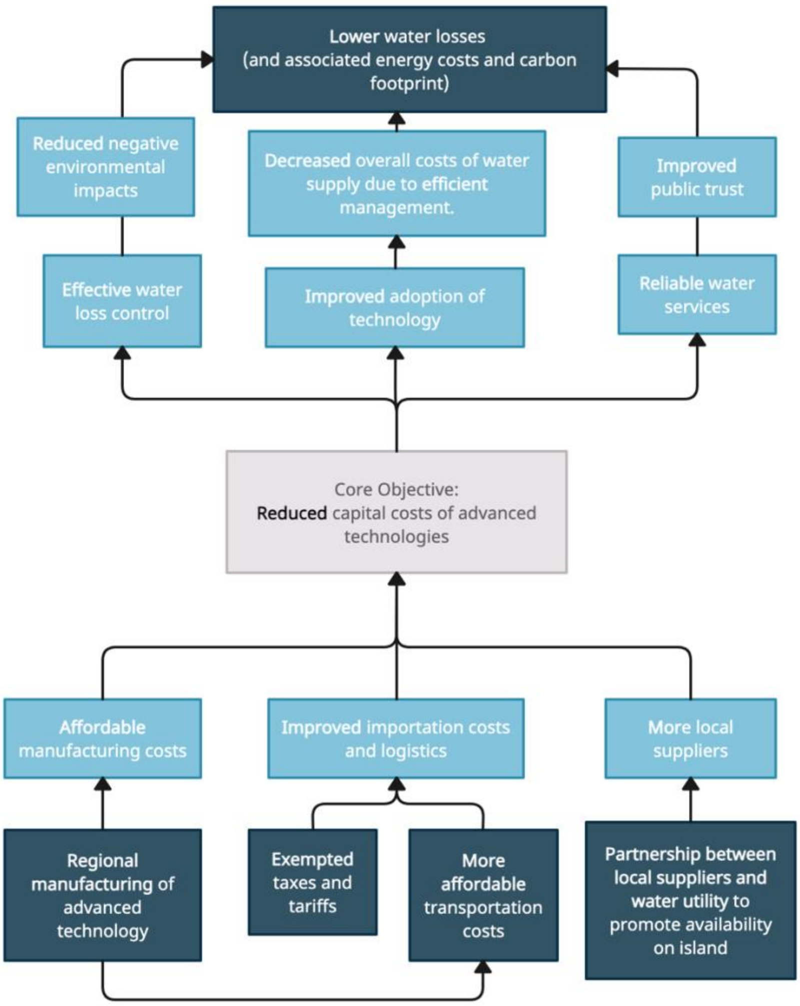


Figure 1.4: Objective tree for the main economic barrier (high capital costs) of apparent loss management

Other measures to mitigate against high capital costs include:

- Pursue grants, loans, or investments from international financial institutions, donor countries, climate funds, or public-private partnerships and consider innovative instruments like green bonds or environmental impact bonds specifically for water loss prevention investments.
- Promote incremental implementation by prioritizing the most critical and cost-effective measures first, and gradually building up the comprehensive program.
- Prioritize cost recovery with a tariff structure that reflects the cost of water loss reduction measures to ensure the sustainability of the program. The water tariff in St. Kitts has not been increased in over 20 years. Recently, the water tariff in Nevis was increased in an attempt at cost recovery. Generally, the water tariff does not cover the cost of production, less so the cost of capital improvements.

1.2.3.2 Non-financial measures

Various measures were identified to overcome non-financial barriers to apparent loss management. Many of the measures were gleaned from the objective trees and through discussion with the SWG. One major theme that emerged was the corporatization of the water utilities in both St. Kitts and Nevis such that the water utilities would no longer be departments of government, but statutory bodies still fully owned by the government. A restructuring of the utility was deemed necessary to overcome many of the barriers identified to technology diffusion. Reliable and countless experiences across the Caribbean have demonstrated that the provision of water services (utility function) works best as a separate and distinct function from the management of water resources (regulator function) (GOSKN, 2021b, 2013, K+M Advisors, 2019, GWP-C, 2011). Various examples include the National Water Commission in Jamaica and Guyana Water Inc. in Guyana. As such, the utility can adopt sound business practices, and foster good social and corporate governance in the provision of water services. Critical benefits to corporatization include but are not limited to:

1. Delivery of a better-quality service to all customers.
2. The enhancement of the national economic landscape.
3. Institutional strengthening and rebranding allowing for the enhanced development of human resources capacity that would result in greater productivity.
4. Improved efficiency in the management of our resources based on integrated water resources management (IWRM) principles.
5. Financial sustainability and flexibility to make necessary investments in water infrastructure.

Specific measures to overcome the other non-financial barriers are listed below:

- Limited management and organizational skills to implement apparent loss prevention program
    - Capacity building and greater access to professional development programs for managers on best practices in water loss prevention.
    - Short-term onboarding of consultants or experts to manage the implementation of any water loss prevention program.
    - Knowledge sharing and partnerships with other utilities that have successfully implemented similar programs.
- Lack of political will to prioritize water demand management

    - Public education and outreach including targeted public awareness campaigns to highlight the benefits of water loss prevention.
    - Meaningful engagement of stakeholders by allowing a variety of stakeholders to be involved in the planning process and implementation of water loss prevention strategies.
    - Showcasing of small-scale demonstration projects to demonstrate the effectiveness and benefits of water loss prevention, thus building political support.
- Lack of specialized technicians and training
    - Provide access to technical training and certification programs (through established certification entities such as CAWASA) to provide technicians with credentials and ensure a standard level of competency.
    - Partner with other utilities in the Caribbean with successful water loss prevention programs to provide on-the-job training for local technicians.
    - Adjust renumeration of certified technicians to reflect upskilling.

It is important to note that this analysis of barriers applies equally to implementation of real loss water reduction programs.

1.3 Barrier analysis and possible enabling measures for real loss management

1.3.1 General description

In 2012, the real losses on the island of St. Kitts were estimated to be over 37 million imperial gallons per month (GOSKN, 2013). There are two important types of interventions that can be taken to reduce real losses: (1) leakage detection and repair and (2) pressure management. Both were lumped into the same technology category during the prioritization of technologies for St. Kitts and Nevis (Sahely, 2023). Leak management methods can prevent or reduce leakage volume and leak detection technology can improve the ability of water utilities to respond quickly and repair leaks. The primary methods used for leak detection included acoustic, infrared thermography, chemical tracer, and mechanical methods. Among the acoustic methods were ground microphones, acoustic loggers on pipe fittings, and tethered in-line leak detectors. New and emerging technologies include ground penetrating radar (GPR), combined acoustic logger and leak noise correlators, digital correlators, and radio-frequency interferometers (Elliott et al. 2011). Acoustic methods have been used successfully for leak detection in metallic pipes for many years. However, their application in non-metallic piping is more challenging. The SK WSD has acoustic leakage detection equipment, but it is not widely used because of the predominance of PVC piping and the amount of time required to deploy the equipment. The Nevis Water Department does not currently have any leakage detection equipment. Repairs to pipes with holes generally involve either covering the hole from outside the pipe or inserting a smaller pipe inside the one that is leaking. The complexity and time for repairs varies widely but the knowledge and experience for repairs exists inside of both utilities in St. Kitts and Nevis. Leak detection and repair programs should include the following:

1. Update of water distribution system maps and record keeping of all inspection and repair works.
2. Use of leakage detection technology (including remote sensors) for ongoing monitoring and analysis of source, transmission, and distribution facilities. Remote sensors and monitoring software can alert operators to leaks, fluctuations in pressure, problems with equipment integrity, and other concerns; and

3. Regular inspection of pipes (and all elements of the distribution systems like meters, valves, and hydrants), and other maintenance efforts (cleaning, lubricating, exercising of valves) to improve the distribution system and prevent leaks and ruptures from occurring.

Water demand management initiatives like leakage detection and repair lead to overall improved water use efficiency, reduction in environmental impact and improved sustainability. Reducing leakages and inefficient water use reduces strain on operations, making more water available to more customers in the dry season and under drought conditions. It can also offset the need for supply side infrastructure upgrades by reducing demand growth and the impacts of climate change. As a specific example in St. Kitts, reducing leakages could bring significant energy savings (where the annual energy cost is estimated at 4.5 million XCD, 30% of operating costs). A reduction in leakage by 30% could reduce total production by 10% and energy costs by 0.5 million XCD per year (GOSKN, 2021b).

Pressure management can be defined as the practice of managing system pressures to the optimum levels of service while reducing unnecessary excess pressure and eliminating transients both of which cause distribution systems to leak (EU 2015). Years of research has shown leakage and pipe burst frequency increase with pressure thus wasting water (EU 2015, Fanner et al. 2007). The EU (2015) highlights three different levels of pressure management:

Basic

- Identify and reduce pressure transients and surges
- Achieve continuous supply (24/7 policy) even if at low pressure
- Strategic separation of transmission mains from distribution systems and zones
- Monitor pressures (inlet, critical, average), flows, bursts/leaks/repairs, complaints.
- Avoid overflows from service reservoirs; reduce outlet pressure whenever possible.

Intermediate

- Create sub-sectors (Pressure managed areas or zones)
- Reduce pressure using fixed outlet PRVs or intelligent pumping

Advanced

- Introduce time and/or flow modulation, or feedback loop from a critical node, or remote control, for valves and pumps.
- Introduce hydraulic flow modulation for valves

Both utilities in St. Kitts and Nevis practice basic level pressure management with some limited use of pressure-reducing valves (PRVs). Pressure management reduces leak flow rates and frequency of leaks thus extending infrastructure life, reducing pipe failures, conserving water, and saving money.

1.3.2 Identification of barriers

The long list of barriers for real loss management presented to the SWG is included in Table 1.4. The long list was compiled by the national consultant based on a thorough review of national policies, strategies, and national communications, BAEF reports from other countries, scientific literature, and consultation with stakeholders especially during the BAEF training held in July 2023. Members of the SWG were asked to classify the barriers according to level of importance by assigning *High (H)* to critical or killer barriers which would adversely affect or prevent diffusion; *Medium (M)* to important barriers which should be monitored and *Low (L)* to those barriers deemed insignificant in the overall implementation process. For those barriers ranked High (H), the members of the SWG were asked to rank in order of importance. The top 3 were then selected for decomposition using the logical framework analysis.

Table 1.4: Classification and prioritization of barriers for real loss management

Category	Barrier	Level of importance			
		HIGH	MED	LOW	RANK
Technical	Cybersecurity risks associated with data transmission and storage		X		
	Lack of compatibility between new technologies and existing infrastructure		X		
	Few local examples of successful implementation of real loss management		X		
	Reliability concerns for specialty valves / equipment in harsh environmental conditions		X		
	Configuration of distribution systems may make establishment of DMAs very difficult	X			1
	Reliability and ability to detect and locate smaller leaks	X			3
Market	No local availability of advanced technologies (bulk meters, leakage detection equipment, PRVs)		X		
	Rapid technological advancements making existing meters and detection equipment obsolete		X		
Economic and financial	High capital costs	X			2
	High installation costs	X			7
	Lack of funding and financial incentives	X			8
	Economic uncertainty or instability		X		
	Difficulty in achieving a short -term return on investment		X		
	Importation costs and shipping costs for smart meters etc.		X		
	Bureaucratic hurdles in the local administration procurement process		X		
	Long wait times for overseas procurement		X		
	Additional expense for training staff to handle new technology		X		
Legal and regulatory	Inadequate legal frameworks including regulations to support water conservation technologies			X	
	Bureaucratic hurdles in approving new technologies			X	
	Variability in standards and specifications for bulk meters / PRVs / leakage detection equipment across the region			X	
Institutional and organizational capacity	Lack of coordination between stakeholders, government agencies, utilities, suppliers etc.		X		
	Limited management / organization skills to implement water loss prevention program	X			6
	Challenges in data management and analysis		X		
	Resistance to change (procedural, operational etc.)		X		
	Short term planning horizons that overlook long-term benefits of real loss reduction		X		
	Lack of comprehensive strategy for water loss management	X			5

Category	Barrier	Level of importance			
		HIGH	MED	LOW	RANK
Human skills	Challenges in installing, maintaining, and repairing sophisticated systems		X		
	Lack of specialized technicians and training	X			4
Socio-cultural	Public resistance to change, especially since the price of water is so cheap		X		
	Lack of awareness			X	
	Cultural attitudes and practices that conflict with water conservation		X		
	Social inequities in accessing water			X	
	Mistrust in data accuracy and meter reading		X		
	Disruption to water supply during leak detection and repair activities		X		
Environmental	Potential environmental impacts of new technologies and disposal of old pipes			X	
	Ecological footprint of manufacturing and shipping of technologies			X	
Political and leadership	Lack of political will to prioritize water demand management		X		
	Short-term political agendas conflicting with long-term water conservation goals		X		
	Political instability affecting implementation of water conservation policies		X		

One (1) economic and financial and two (2) non-financial barriers (technical) were the top ranked critical barriers for the SWG including:

1. Configuration of distribution systems make establishment of DMAs very difficult
2. High capital costs
3. Ability to detect and locate smaller leaks

1.3.2.1 Economic and financial barriers

One of the main economic barriers to implementation of a comprehensive program for reduction of real water losses identified by the SWG is high capital costs. The SKN Water Utility Adaptation Plan of 2021 outlines the costs of real loss reduction and provides preliminary estimate for the implementation of a comprehensive plan for both apparent and real loss reduction. Full implementation of real loss reduction (including SCADA) could amount to more than 9,000,000 USD (70% of phase 3 and full amount under phase 4 shown in Figures 1.1 and 1.2). In 2024, the capital budget from government revenue allocated to the water utility in St. Kitts was estimated at just over 5 M USD (GOSKN 2023a). This demonstrates the high capital outlays that are required to allow for comprehensive real water loss reduction.

Annex II details the problem trees for the critical economic and financial barrier to apparent and real loss management which was high capital costs. During consultations, the SWG decided that the problem tree is essentially the same for both technologies (see section 1.2.2.1).

1.3.2.2 Non-financial barriers

The main non-financial barriers to implementation of a real loss reduction program identified by the SWG are technical in nature and are listed as configuration of distribution systems making establishment of DMAs very difficult and the ability of advanced technologies to detect and locate smaller leaks.

Annex II details the problem trees for these non-financial barriers to uncover the root causes of the barriers. The root causes to the complicated configuration of distribution systems are lack of planning for future scalability, predominance of old systems that no longer meet current needs and standards and lack of upgrades due to inadequate funding and challenging terrain. Ad-hoc development of distribution systems over the years has made it progressively more difficult to manage these systems. Many years of developing and operating systems reactively instead of proactively, especially in an environment where investments have not kept up with the growing needs of water utilities, make it increasingly difficult to manage old systems. Attempts to modernize such systems require solid and long-term planning with sustained financing to effectively manage water losses both apparent and real.

As to the reliability of advanced technologies to detect small leaks, the root causes identified relate to challenges of maintenance and calibration of specialized equipment due to the different kinds of pipes utilized, and few suppliers of high precision leak detection equipment suitable for the conditions found in St. Kitts and Nevis. Water utilities managing aging systems with a variety of pipe types (asbestos cement, ductile iron and increasingly PVC) make it difficult to optimize leakage detection as different types of equipment could be needed for each type of pipe.

1.3.3 Identified measures

Annex II also includes objective trees which help with identifying measures that target the root causes of barriers.

1.3.3.1 Economic and financial measures

Please see section 1.2.3.1 for a detailed discussion of the economic measures as these are generally the same for apparent and real loss reduction programs although real loss reduction programmes are generally more costly as they would generally require more substantial infrastructure upgrades such as investments in new pipes.

1.3.3.2 Non-financial measures

To overcome the non-financial barriers to real water loss reduction programs in St. Kitts and Nevis, particularly those that are technical in nature, such as the configuration of distribution systems making the establishment of District Metered Areas (DMAs) difficult and the ability of advanced technologies to detect and locate smaller leaks, a multi-faceted approach is needed with a combination of measures identified by the SWG:

- Modernizing infrastructure using a phased approach and best practices in planning and design:
  - Upgrade the current distribution systems to allow for better scalability and to meet current standards.
  - Implement modern piping and joining techniques that reduce the likelihood of leaks.
  - Engage in comprehensive planning for future expansion and scalability of water distribution networks.
  - Design distribution networks with DMAs in mind from the outset.

- Diversifying equipment suppliers:
  - Encourage the entrance of more suppliers into the market to increase the availability of suitable leak detection technology.
  - Consider public-private partnerships to facilitate the investment in necessary technologies (also noted in section 1.2.3.1)

- Capacity building and training (also noted in section 1.2.3.2):
  - Provide training for local technicians and engineers in advanced leak detection and repair methods.
  - Develop local expertise in the maintenance and operation of modern water distribution systems.

- Community engagement (also noted in section 1.2.3.2):
  - Involve the community in water loss prevention efforts, such as reporting leaks.
  - Educate residents about the importance of water conservation and the impacts of water loss.

- Research and development:
  - Collaborate with manufacturers of advanced technologies for leakage detection institutions to optimize technologies and methods for leak detection and repair that are suitable for local conditions.
  - Monitor and evaluate the effectiveness of different strategies and technologies to continually improve the water loss reduction program.

1.4 Linkages of the barriers identified

Tables 1.3 and 1.4 clearly demonstrate that both technologies share many of the same barriers with the only notable difference being some technical barriers related to the nature of the advanced technology required (smart meters for apparent loss reduction vs. leakage and detection equipment for real loss reduction). As such, only one problem tree was developed for high capital costs given that both technologies are related to water loss reduction. A comprehensive water loss reduction (apparent and real) program requires significant initial investment, which is a substantial barrier given the limited capital budget available to the water utility from government revenue.

Many of the measures identified for the non-financial barriers are cross-cutting and can be applied across both technologies. Main cross-cutting themes emerging including the need for public-private partnerships to leverage the flexibility and know-how of the private sector to optimize implementation and diffusion of the technologies. Additionally, there is a need to develop policies and update legislative acts to support and facilitate the implementation of water loss reduction measures.

The barriers for both technologies indicate a need for strategic investment in both human and capital resources, as well as a shift in political and public perception towards the value of water loss prevention. The technical and economic challenges are compounded by the small scale of the local market and the reliance on imports. Recently, the government of St. Kitts and Nevis with its delivery partner the Caribbean Community Climate Change Centre (5Cs) launched the project preparation facility (PPF) for a large water investment program with funding from the Green Climate Fund (GCF) (GCF, 2023). A major part of the over 40M USD proposed project include both apparent and real loss reduction programs. The PPF phase will allow for a more detailed feasibility study and cost benefit analysis to actualize a comprehensive water loss program for both utilities in St. Kitts and Nevis.

1.5 Enabling framework for overcoming the barriers identified for the water sector

This section details a complete framework of enabling measures for overcoming the critical barriers for diffusion of apparent and real loss reduction programs for the water sector. Along with the measures outlined in the previous sections, benefits, expected timeframe and estimated costs are including in Table 1.5. The projected costs of implementation are detailed in Figures 1.1 and 1.2 with the targets outlined in Table 1.2. Where no local data for costs exists, the SWG was consulted for their expert opinion to provide indicative costs where applicable. Further breakdown of costs and stakeholders required as implementation partners will be outlined in the next phase of the TNA – the Technology Action Plan (TAP).

Table 1.5: Enabling framework for prioritized technologies in the water sector

Barriers	Measures	Benefits	Timeframe and costs[1]
High capital costs of advanced technologies required for apparent loss reduction (smart meters, SCADA and other data management systems) and real loss reduction (pipes, leakage detection equipment and specialized meters and valves)	• Implement procurement best practices to ensure optimal bulk purchasing along economical shipping routes • Explore bulk purchasing with water utility in Nevis and other neighboring islands • Private sector partnerships to encourage local suppliers to bring in specialized equipment on behalf of the utility • Pursue grants, loans, or investments from a wide range of source consider innovative instruments such as green bonds • Restructure water tariff to promote cost recovery and investment planning	• Decreased cost of imported technologies • Improved adoption of technologies required for water loss reduction • Lower water losses • Water tariff encourages water conservation	Short to medium term
Limited management and organizational skills to implement water loss prevention program	• Corporatization of the water utilities on both islands • Capacity building and greater access to professional development programs for managers on best practices in water loss prevention. • Short-term onboarding of consultants or experts to manage the implementation of any water loss prevention program. • Knowledge sharing and partnerships with other utilities that have successfully implemented similar programs.	• Delivery of a better-quality service to all customers. • The enhancement of the national economic landscape. • Institutional strengthening and rebranding allowing for the enhanced development of human resources capacity that would result in greater productivity. • Improved efficiency in the management of our resources based on integrated water resources management (IWRM) principles. • Financial sustainability and flexibility to make necessary investments in water infrastructure.	Medium term
Lack of political will to prioritize water loss reduction programs	• Public education and outreach including targeted public awareness campaigns to highlight the benefits of water loss prevention. • Meaningful engagement of stakeholders by allowing a variety of stakeholders to be involved	• More engaged and supportive public and political directorate	Medium to long term

Barriers	Measures	Benefits	Timeframe and costs[1]
	in the planning process and implementation of water loss prevention strategies. • Showcasing of small-scale demonstration projects to demonstrate the effectiveness and benefits of water loss prevention, thus building political support.		
Lack of specialized technicians and training for water loss reduction programs	• Provide access to technical training and certification programs (through established certification entities such as CAWASA) to provide technicians with credentials and ensure a standard level of competency. • Partner with other utilities in the Caribbean with successful water loss prevention programs to provide on-the-job training for local technicians. • Adjust renumeration of certified technicians to reflect upskilling.	• Enhanced specialized skills at all levels of the water utility especially in management • Engaged and qualified workforce • More effective water loss programs • Dynamic partnerships formed with utilities on neighboring islands	Medium term

Configuration of distribution systems make establishment of DMAs very difficult	• Modernizing infrastructure using a phased approach and best practices in planning and design:
	  ○ Upgrade the current distribution systems to allow for better scalability and to meet current standards.
	  ○ Implement modern piping and joining techniques that reduce the likelihood of leaks.
	  ○ Engage in comprehensive planning for future expansion and scalability of water distribution networks.
	  ○ Design distribution networks with DMAs in mind from the outset.
		• Phased upgrades will aid in long term establishment of DMAs and more effective pressure management to decrease water losses through pipe breaks	Medium to long term

Ability to detect and locate smaller leaks	• Diversifying equipment suppliers: ○ Encourage the entrance of more suppliers into the market to increase the availability of suitable leak detection technology.	• More effective leakage detection and repair • Comprehensive water loss programs	Medium to long term

Barriers	Measures	Benefits	Timeframe and costs[1]
	○ Consider public-private partnerships to facilitate the investment in necessary technologies (also noted in section 1.2.3.1) • Research and development: ○ Collaborate with manufacturers of advanced technologies for leakage detection institutions to optimize technologies and methods for leak detection and repair that are suitable for local conditions. ○ Monitor and evaluate the effectiveness of different strategies and technologies to continually improve the water loss reduction program.		

1) Full implementation of real loss reduction (including SCADA) could amount to more than 9,000,000 USD (70% of phase 3 and full amount under phase 4 shown in Figures 1.1 and 1.2). The first steps in apparent loss reduction (including overall audit, specialized audits of large users, retrofitting of meters etc.) is estimated to cost approximately USD 1,000,000 (phases 1 and 2 shown in Figures 1.1 and 1.2). Full implementation of apparent loss reduction especially with the installation of smart meters could amount to more than 3,300,000 USD (assumed to be approximately 30% of phase 3 shown in Figures 1.1 and 1.2). The costs will be broken down by identified measure during the TAP phase.

Chapter 2 Agriculture Sector

The second sector prioritized for the TNA process for climate change adaptation is the agriculture sector. A more in-depth situational analysis of this sector can be found in the TNA report (Sahely, 2023). Two technologies were prioritized for the sector including: (1) Integrated pest management and (2) Soil moisture conservation monitoring and techniques. As with the water sector in Chapter 1, the first step in the process is to classify the prioritized technologies.

This classification helps to facilitate barrier analysis by linking technologies to market characteristics and makes note of the fluidity between categories. Table 2.1 presents the categorization of the technologies for the water sector and sets the stage for the identification of barriers.

Table 2.1: Categorization of technologies for the agriculture sector

Technology type	Technology category	
1. Integrated Pest Management	Non-market	Other non-market good
2. Soil moisture conservation monitoring and techniques	Non-market	Other non-market good

For both prioritized technologies highlighted in Table 2.1, these can be considered a non-market good as the government through its agriculture departments, would have to play a lead role in promoting the use of a wide range of practices related to soil moisture conservation which will be covered in subsequent sections and be the focus of the barrier analysis and enabling frameworks even though the sensors utilized for soil moisture monitoring would be considered a consumer good.

2.1 Preliminary targets for technology transfer and diffusion

In alignment with the St. Kitts and Nevis Agricultural Transformation and Growth Strategy (2022-2031) (GOSKN, 2022e) and the 25 by 2025 Agenda (Reduction of the food import bill by 25% by 2025) (GOSKN, 2024), the preliminary target is set at diffusion of integrated pest management on half of the active farms in St. Kitts and Nevis. Similarly, the preliminary target for diffusion of monitoring and techniques for soil moisture conservation is for half of the active farms in the Federation. Table 2.2 presents targets for the scale of diffusion for each of the prioritized technologies.

Table 2.2: Preliminary targets for diffusion of technologies for the agriculture sector

Technology	Target
1. Integrated pest management	
Installation of pest traps / pheromone traps	Recommendations in the literature vary widely and depend on the crop being planted. For general monitoring, recommendations range up to 5-10 traps per acre for high-value crops like fruits and vegetables.
Use of selective biological control agents (such as insects, microbial agents, nematodes, and viruses)	Varies greatly on the target pest, the crop type, and environmental conditions

Pest resistant cultivars	Varies on crop types and farm acreage
Organic manures	Varies on crop type, nutrient content of the manure, soil health, environmental concerns, and local regulations. Average amount per acre in IPM ranges from 2-20 tons per acre.
Farmer field school focused on IPM including traditional practices related to pest management	4-6 months farmer field school for all eligible farms in St. Kitts and Nevis depending on the average length of crop cycle.
2. Soil moisture conservation monitoring and techniques	
Soil moisture monitoring sensors (such as tensiometers, electrical resistance blocks, granular matrix sensors and time domain reflectometry)	For enhanced water management, especially in fields with greater variability or high-value crops, 2-3 sensors per acre.
Comprehensive training for farmers on soil moisture conservation measures can be categorized as biological (agroforestry and agricultural) and mechanical measures (terracing, bunding, trenching, check dams, etc.).	4-6 months farmer field school for all eligible farms in St. Kitts and Nevis depending on the average length of crop cycle.

2.2 Barrier analysis and possible enabling measures for integrated pest management

2.2.1 General description

Integrated Pest Management (IPM) is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and nontarget organisms, and the environment. The key components of an IPM approach are (Clements et al, 2011):

Crop Management: Selecting appropriate crops for local climate and soil conditions including -

- Selection of pest-resistant well adapted cultivars
- Use of legume-based crop rotations to increase soil nitrate availability thereby improving soil fertility and favorable conditions for robust plants that better face pests and diseases
- Use of cover crops
- Integration of intercropping and agro-forestry systems
- Use of crop spacing, intercropping and pruning to create conditions unfavorable to the pests

Soil Management: maintaining soil nutrition and pH levels to provide the best possible chemical, physical, and biological soil habitat for crops.

- Building a healthy soil structure
- Using longer crop rotations to enhance soil microbial populations and break disease, insect and weed cycles
- Applying organic manures to help maintain balanced pH and nutrient levels
- Reducing soil disturbance (tillage) – undisturbed soil with sufficient supply of organic matter provides a good habitat for soil fauna

- Keeping soil covered with crop residue or living plants.

Pest Management: using beneficial organisms that behave as parasitoids and predators.

- Releasing beneficial insects and providing them with a suitable habitat
- Managing plant density and structure to deter diseases
- Cultivating for weed control based on knowledge of the critical competition period
- Managing field boundaries and in-field habitats to attract beneficial insects, and trap or confuse insect pests.

IPM is not widely practiced in St. Kitts and Nevis except for some work done by CARDI related to the sweet potato weevil in 2018 (CARDI, 2018) and more recent training for extension officers in IPM in 2023 with some field work at the Tabernacle Outreach Centre (DOA, 2024b). The main pest of economic importance identified in the Director's Report for 2023 was the Cotton Leaf Hopper (DOA, 2024a). However, the report did not contain any data related to income loss due to pests for St. Kitts.

IPM contributes to climate change adaptation by providing a healthy and balanced ecosystem in which the vulnerability of plants to pests and diseases is decreased. By promoting a diversified farming system, the practice of IPM builds farmers' resilience to potential risks posed by climate change, such as damage to crop yields caused by newly emerging pests and diseases (Clements et al. 2011).

2.2.2 Identification of barriers

The long list of barriers for IPM presented to the SWG is included in Table 2.3. The long list was compiled by the national consultant based on a thorough review of national policies, strategies, and national communications, BAEF reports from other countries, scientific literature (Parsa et al. , 2024), and consultation with stakeholders especially during the BAEF training held in July 2023. Members of the SWG were asked to classify the barriers according to level of importance by assigning *High (H)* to critical or killer barriers which would adversely affect or prevent diffusion; *Medium (M)* to important barriers which should be monitored and *Low (L)* to those barriers deemed insignificant in the overall implementation process. For those barriers ranked High (H), the members of the SWG were asked to rank in order of importance. The top 4 were then selected for decomposition using the logical framework analysis.

Table 2.3: Classification and prioritization of barriers for integrated pest management

Category	Barrier	Level of importance			
		HIGH	MED	LOW	RANK
Technical	Few local examples of successful implementation of IPM		X		
	Difficulty in monitoring and managing a diverse range of pests	X			2
	Challenges in storing and distributing IPM resources		X		
Market	No local availability of supporting technologies / tools for IPM		X		
	Challenges in accessing markets for IPM-compliant products		X		
	Reliance on imports, which can be disrupted by transportation or trade issues		X		
	Low market demand or premium for IPM-compliant products	X			1
	Competition with cheaper, non-IPM products		X		
	Lack of market incentives or certification schemes for IPM products		X		
	Consumer preferences and perceptions about agricultural products		X		
Economic and financial	High implementation costs for IPM strategies, especially for advanced or imported technologies	X			3
	Lack of funding and financial incentives		X		
	Economic uncertainty or instability		X		
	Difficulty in achieving a short -term return on investment		X		
	Dependence on narrow range of agricultural products, increasing risk from pest outbreaks		X		
	Importation costs and shipping costs for IPM tools / technologies	X			5
	Additional expense for training farmers to handle new technologies / tools for IPM		X		
Legal and regulatory	Inadequate legal frameworks including regulations to support IPM		X		
	Regulatory hurdles in approving, registering, and using certain pest control products		X		
Institutional and organizational capacity	Lack of coordination between stakeholders, government agencies, farmer, suppliers etc.		X		
	Inadequate extension services to provide training and support for IPM		X		
	Short term planning horizons that overlook long-term benefits of IPM		X		
	Lack of comprehensive strategy for IPM	X			6

Category	Barrier	Level of importance			
		HIGH	MED	LOW	RANK
Human skills	Dependence on traditional farming practices that do not incorporate IPM principles	X			7
	Limited access to training and technical expertise in IPM		X		
	Need for ongoing technical support and troubleshooting		X		
	Limited access to PPE		X		
	Risks associated with handling and applying chemical pesticides		X		
Socio-cultural	Resistance to changing traditional agricultural practices		X		
	Low awareness among farmers about the benefits of IPM	X			4
	Cultural attitudes and practices that conflict with IPM		X		
	Social dynamics and community structures that influence farming practices		X		
Environmental	Limited island area, which can increase pest populations and disease transmission		X		
	Vulnerability to climate change and extreme weather events impacting pest dynamics		X		
Political and leadership	Lack of political will to prioritize IPM		X		
	Short-term political agendas conflicting with long-term pest control goals		X		
	Political instability affecting implementation of IPM policies		X		

Two (2) economic and financial and two (2) non-financial barriers (technical and socio-cultural) were the top ranked critical barriers including:

1. Low market demand or premium for IPM-compliant products
2. Difficulty in monitoring and managing a diverse range of pests
3. High implementation costs for IPM strategies
4. Low awareness among farmers about the benefits of IPM

2.2.2.1 Economic and financial barriers

The main economic barriers to implementation of a comprehensive program for IPM identified by the SWG is low market demand for IPM-compliant products and high implementation costs for IPM strategies. A study by Pretty and Bharucha (2015) provides a detailed analysis of Integrated Pest Management (IPM) projects across Asia and Africa, and found that, on average, IPM projects have led to a 40.9% increase in yields and a 30.7% reduction in pesticide use, with some crops achieving complete cessation of pesticide application. This demonstrates IPM's potential for sustainable intensification of agriculture, aligning with goals for environmental conservation, farmer health, and economic benefit. Very little data on the costs of IPM strategies can be found in the literature. This may be because IPM strategies must be specially tailored for the type of crop and pest being targeted.

Annex III details the problem trees for the critical economic and financial barriers to IPM. The root causes to low market demand for IPM-compliant products are high cost of specialized inputs required for IPM, lack of policies and extension support and no targeted marketing and public awareness campaigns. As it relates further to the overall high implementation costs of IPM, this was deconstructed even more, and root causes were found to be high importation costs and logistics related to specialized inputs required for IPM and lack of access to these tools by farmers as a result. Furthermore, lack of training programs focused on IPM lead to limited awareness about its benefits.

2.2.2.2 Non-financial barriers

The main non-financial barriers to implementation of IPM identified by the SWG are technical and socio-cultural in nature and are listed as difficulty in monitoring and managing pests and low awareness among farmers about the benefits of IPM.

Annex III details the problem trees for these non-financial barriers to uncover the root causes of the barriers. The root causes to the technical issue related to the difficulty and complexity in monitoring and managing a diverse range of pests were found to be lack of laboratory facilities able to test for various pests, lack of specialized extension staff to aid in monitoring and lack of access to specialized inputs required for effective IPM. As it relates to low awareness among farmers about IPM, the root causes identified relate to lack of extensions services and training related to IPM, limited communications and networking amongst farmers and resistance to change and adopting new techniques.

2.2.3 Identified measures

Annex III also includes objective trees which help with identifying measures that target the root causes of barriers. Overcoming the barriers to the diffusion of Integrated Pest Management (IPM) for small-scale agriculture in St. Kitts and Nevis, requires a multi-faceted approach.

2.2.3.1 Economic and financial measures

Based on the objective trees developed in Annex III, the SWG identified various measures to address the critical economic and financial barriers including:

- Stimulate Market Demand:
  - Develop certification programs for IPM-compliant products to promote best practices and standards and stimulate demand. Certified farmers would then be able to access branding and labelling strategies to showcase their products.
  - Partner with hotels, restaurants, and supermarkets to promote locally grown, IPM-compliant produce and healthy food.
  - Strategies to promote healthy diets to create more demand for IPM-compliant produce

- Reduce Implementation Costs:
  - Offer subsidies or grants for the initial investment in IPM, reducing the financial burden on farmers.
  - Encourage and incentivize established farmers cooperatives to cooperate to actualize bulk purchasing and cost-sharing where applicable for IPM inputs to lower costs.

2.2.3.2 Non-financial measures

Building on the measures identified to overcome economic and financial barriers, additional measures to overcome the critical technical and socio-cultural barriers include:

- Enhance Pest Monitoring and Management:
  - Invest in local laboratory facilities for pest identification and management.
  - Train specialized extension staff who can assist farmers with IPM strategies especially as it relates to longer crop rotation cycles, traditional practices related to pest management and data collection and analysis.
  - Develop local production of IPM inputs, such as biocontrol agents, to reduce reliance on imports.

- Increase Awareness and Training:
  - Implement comprehensive education and training programs focused on IPM benefits and techniques focused on farmer field schools.
  - Create demonstration farms where farmers can observe and learn about IPM practices first-hand.
  - Utilize farmer-to-farmer networks for sharing knowledge and experiences and to optimize collective action on IPM
  - Use success stories and case studies to highlight the long-term benefits of IPM

2.3 Barrier analysis and possible enabling measures for soil moisture conservation monitoring and techniques

2.3.1 General description

The main objective of soil moisture conservation is to minimize the amount of water lost from the soils through evaporation (water loss directly from the soil) and transpiration (water loss occurring through the plants) – or combined, the evapotranspiration. Preserving soil moisture is important means to maintain the necessary water for agricultural production and helps minimize irrigation needs of the crops. This is especially important in areas where rainwater and/or groundwater resources for irrigation are scarce or decreasing due to climate change or other causes (CTCN 2022). Even in areas where irrigation is widely practiced, soil moisture monitoring is important to ensure irrigation water is utilized efficiently.

Soil moisture conservation measures can be categorized as biological (agroforestry and agricultural) and mechanical measures (terracing, bunding, trenching, check dams, etc.). Generally, most methods used for soil quality improvement and conservation (and even for IPM), will also yield benefits to soil moisture conservation. Examples of methods for reducing excess soil moisture loss include following:

- Spreading manure or compost over the soil – this minimizes evapotranspiration and provides valuable nutrients to the soil through processes of decomposition
- Mulching – mulch is a layer of organic (or inorganic) material that is placed on the root zone of the plants. Mulching is most suited for low to medium rainfall areas, and less suited for areas with very wet conditions.
- Conservation tillage – reducing or eliminating the tillage to maintain healthy soil organic levels which increases the soils capacity to absorb and retain water.
- Crop rotation – growing different types of crops every season helps improve soil structure and thus water holding capacity.
- Green manuring – growing of plant materials with the sole purpose of adding to the soil for improved organic matter and nutrients.
- Deep tillage – suited for some areas and soils, deep tillage can help increase porosity and permeability of the soil to increase its water absorption capacity.
- Mixed cropping and interplanting - cultivating a combination of crops with different planting times and different length of growth periods.
- Contour ploughing – by ploughing the soil along the contour instead of up- and downward slopes, the velocity of runoff is reduced, creating even barriers, and more water is retained in the soils and distributed more equally across the cropland.
- Strip cropping - growing erosion permitting crops and erosion resisting crops in alternate strips.

It is important for the effectiveness of these techniques to be evaluated and measured in the field. Such data provide real-time information and the ability to adjust the irrigation regime to increase soil moisture. Various tools are available to measure soil moisture including tensiometers, electrical resistance blocks, granular matrix sensors and time domain reflectometry (Kujawski 2011).

2.3.2 Identification of barriers

The long list of barriers for soil moisture conservation monitoring and techniques is found in Table 2.4. The long list was compiled by the national consultant based on a thorough review of national policies, strategies, and national communications, BAEF reports from other countries, scientific literature, and consultation with stakeholders especially during the BAEF training held in July 2023. Members of the SWG were asked to classify the barriers according to level of importance by assigning *High (H)* to critical or killer barriers which would adversely affect or prevent diffusion; *Medium (M)* to important barriers which should be monitored and *Low (L)* to those barriers deemed insignificant in the overall implementation process. For those barriers ranked High (H), the members of the SWG were asked to rank in order of importance. The top 3 were then selected for decomposition using the logical framework analysis.

One (1) economic and financial and two (2) non-financial barriers (institutional capacity and socio-cultural) were the top ranked critical barriers for the SWG including:

1. High implementation costs for soil moisture conservation strategies
2. Short term planning horizons that overlook long-term benefits of soil moisture conservation
3. Low awareness among farmers about the benefits of soil moisture conservation

Low awareness among farmers was also identified as a barrier for IPM, as such only one problem tree was developed to cover both.

Table 2.4: Classification and prioritization of barriers for soil moisture conservation monitoring and techniques

Category	Barrier	Level of importance			
		HIGH	MED	LOW	RANK
Technical	Few local examples of successful implementation of soil moisture conservation		X		
	Dependence on traditional farming practices that do no prioritize soil moisture conservation	X			5
Market	No local availability of supporting technologies / tools for soil moisture monitoring		X		
	Reliance on imports, which can be disrupted by transportation or trade issues		X		
	Low water tariff disincentive for conserving irrigation water and monitoring soil moisture		X		
Economic and financial	High implementation costs for soil moisture conservation strategies	X			1
	Lack of funding and financial incentives		X		
	Economic uncertainty or instability		X		
	Difficulty in achieving a short -term return on investment		X		
	Dependence in accessing credit or financial support for small scale farmers		X		
	Importation costs and shipping costs for required tools / technologies		X		
	Additional expense for training farmers to handle new tools for soil moisture monitoring		X		
Legal and regulatory	Inadequate legal frameworks including regulations to support soil moisture conservation		X		
	Limited governmental capacity to provide guidance and support to soil moisture conservation		X		
Institutional and organizational capacity	Lack of coordination between stakeholders, government agencies, farmer, suppliers etc.		X		
	Inadequate extension services to provide training and support for soil moisture conservation		X		
	Limited capacity of local institutions to support and promote soil moisture conservation		X		
	Short term planning horizons that overlook long-term benefits of soil moisture conservation	X			2
Human skills	Limited access to training and technical expertise in soil moisture conservation	X			4
Socio-cultural	Resistance to changing traditional agricultural practices	X			6
	Low awareness among farmers about the benefits of soil moisture conservation	X			3
	Cultural attitudes and practices that conflict with soil moisture conservation		X		
	Social dynamics and community structures that influence farming practices		X		
Environmental	Limited island area, which can restrict the choice of soil conservation techniques			X	
	Vulnerability to climate change and extreme weather events		X		
	Saline intrusion in coastal areas impacting soil quality and moisture retention			X	
Political and leadership	Lack of political will to prioritize soil moisture conservation		X		
	Short-term political agendas conflicting with long-term soil moisture conservation goals		X		
	Political instability affecting implementation of soil moisture conservation policies		X		

2.3.2.1 Economic and financial barriers

One of the main economic barriers to implementation of comprehensive soil moisture conservation monitoring and techniques identified by the SWG is high implementation costs. Annex III details the problem tree for this critical economic and financial barrier. The root causes to the overall high implementation costs of soil moisture conservation are all inter-related and were found to be high importation costs and logistics related to specialized inputs required, lack of local suppliers and lack of training programs focused on soil moisture conservation monitoring and techniques.

2.3.2.2 Non-financial barriers

The first of two non-financial barriers to implementation of soil moisture conservation identified by the SWG is short-term planning horizons that overlook long-term benefits of soil moisture monitoring and conservation. Effective soil moisture conservation is a combination of activities that require a long-term outlook, much longer than a typical crop cycle, with a 3-to-5-year timeframe needed to realize the benefits. As it relates to low awareness among farmers about soil moisture conservation, the root causes identified relate to lack of extensions services and training, limited communications and networking amongst farmers and resistance to change and adopting new techniques.

Annex III details the problem trees for this non-financial barrier to uncover its root causes which are tied with overall lack of awareness of the important benefits of soil moisture conservation including lack of specialized extension services and training leading to resistance to change.

2.3.3 Identified measures

2.3.3.1 Economic and financial measures

Several measures can be developed to overcome the economic, financial, and non-financial barriers to the diffusion of soil moisture conservation techniques. The SWG identified various strategies to address critical economic barrier:

- Subsidies and Financial Incentives:
    - Provide subsidies or financial incentives for the adoption of soil moisture conservation techniques.
    - Offer low-interest loans or grants for purchasing necessary equipment and inputs.

- Group Purchasing and cost-sharing initiatives:
    - Encourage farmer cooperatives to take advantage of bulk buying discounts for inputs and equipment.
    - Develop cost-sharing programs where the government or NGOs share the cost of implementing soil moisture conservation strategies with farmers.

2.3.3.2 Non-financial measures

Building on the measures identified to overcome economic and financial barriers, additional measures to overcome the critical institutional capacity and socio-cultural barriers include:

- Training and demonstration projects:

  - Conduct training programs and workshops that emphasize the long-term benefits of soil moisture conservation for sustainability and resilience through farmer field schools.
  - Include modules on financial planning and analysis to help farmers understand the long-term cost savings and yield benefits.
  - Set up demonstration farms that showcase the long-term benefits of soil moisture conservation, providing a tangible example for farmers.

- Extension Services:
  - Strengthen extension services to provide ongoing support and guidance on long-term planning and soil moisture conservation techniques including data collection and analysis.

- Farmer-to-Farmer Networks:
  - Promote farmer-to-farmer learning and mentorship programs to facilitate the exchange of knowledge and experiences related to soil moisture conservation.

- Awareness Campaigns and community engagement:
  - Launch targeted marketing and public awareness campaigns to educate farmers and the public about the benefits of soil moisture conservation.
  - Utilize local community meetings, farmer field days, and agricultural shows to spread awareness and demonstrate techniques.

By addressing the barriers from multiple angles—economic, educational, and technical—the diffusion of soil moisture conservation techniques can be enhanced, leading to increased adoption rates among small-scale farmers in St. Kitts and Nevis. This holistic approach aims to reduce the initial barriers while showcasing the long-term benefits for both the farmers and the environment.

2.4 Linkages of the barriers identified

The barriers to the implementation of Integrated Pest Management (IPM) and soil moisture conservation in St. Kitts and Nevis, as identified, present an interplay of economic, financial, and non-financial challenges.

The barriers for both IPM and soil moisture conservation share common roots, notably economic and financial constraints are exacerbated by a lack of supportive policies, high costs related to importation and logistics, and the absence of localized inputs and suppliers. Non-financial barriers stem from a broader cultural and institutional resistance to adopting new technologies, compounded by short-term planning perspectives and a general lack of awareness about the benefits of these adaptation strategies.

These linkages suggest that addressing the barriers to IPM and soil moisture conservation requires a holistic approach that considers both the economic realities and the socio-cultural context of agriculture in St. Kitts and Nevis. Solutions should aim to:

- Enhance market demand for IPM-compliant and other products from farmers implementing soil moisture conservation through public awareness campaigns and targeted marketing.
- Reduce implementation costs through policy support, subsidies, or incentives for the use of specialized inputs and best practices and know-how.

- Improve access to training and extension services to raise awareness and skill levels among farmers.
- Foster a cultural shift towards long-term sustainability and resilience in the face of climate change.

Implementing such solutions will likely involve coordinated efforts between government agencies, agricultural extension services, the private sector, and farming communities to create an enabling environment for climate change adaptation technologies in agriculture.

2.5 Enabling framework for overcoming the barriers in the agriculture sector

This section details a complete framework of enabling measures for overcoming the critical barriers for diffusion of IPM and soil moisture conservation and monitoring for the agriculture sector. Along with the measures outlined in the previous sections, benefits, expected timeframe and estimated costs are including in Table 2.5 aligned with the targets outlined in Table 2.2. Where no local data for costs exists, the SWG was consulted for their expert opinion to provide indicative costs where applicable. Further breakdown of costs and stakeholders required as implementation partners will be outlined in the next phase of the TNA – the Technology Action Plan (TAP).

Table 2.5: Enabling framework for prioritized technologies in the agriculture sector

Barriers	Measures	Benefits	Timeframe and costs[1]
Low market demand or premium for IPM-compliant products	• Develop certification programs for IPM-compliant products to promote best practices and standards and stimulate demand. Certified farmers would then be able to access branding and labelling strategies to showcase their products. • Partner with hotels, restaurants, and supermarkets to promote locally grown, IPM-compliant produce. • Strategies to promote healthy diets to help create demand for IPM-compliant produce.	• Increased farmer income for those practicing IPM • Limited use of conventional pest control • Less overall negative impacts to health and the environment	Medium term AGTS activities 1.1.1, 1.3.6 USD 350,000
Difficulty in monitoring and managing a diverse range of pests	• Invest in local laboratory facilities for pest identification and management. • Train specialized extension staff who can assist farmers with IPM strategies.	• Decreased crop damage from pests • Increased yields and income for farmers • Greater food security • Limited use of conventional pest control • Less overall negative impacts to health and the environment	Medium term AGTS activities 3.2.1, 3.3.1 USD 1,250,000
High implementation costs for IPM and soil moisture conservation strategies	• Offer subsidies, low-interest loans, or grants for the initial investment • Encourage and incentivize established farmers cooperatives to cooperate to actualize bulk purchasing and cost-sharing were applicable	• Decreased crop damage from pests • More efficient use of irrigation water • Increased yields and income for farmers • Greater food security for all • Limited use of conventional pest control and conventional practices for soil conservation • Less overall negative impacts to health and the environment	Short to medium term AGTS activity 2.1.2 USD 850,000
Low awareness among farmers about the benefits of IPM and soil moisture conservation	• Implement comprehensive education and training programs through farmer field schools including modules on financial planning and analysis to help farmers understand the long-term cost savings and yield benefits.	• Enhanced specialized skills at all levels • Greater food security • Dynamic partnerships formed with farmers across the Federation	Short to medium term AGTS activity 4.1.1, 4.1.2, 4.1.3 USD 1,350,000

Barriers	**Measures**	**Benefits**	**Timeframe and costs[1]**
	• Create demonstration farms where farmers can observe and learn first-hand • Use success stories and case studies to highlight the long-term benefits of IPM and soil moisture conservation • Launch targeted marketing and public awareness campaigns to educate farmers and the public about the benefits of soil moisture conservation. • Utilize local community meetings, farmer field days, and agricultural shows to spread awareness and demonstrate techniques.	• More engaged and supportive public and political directorate	
Short term planning horizons that overlook long-term benefits of soil moisture conservation	• Strengthen extension services to provide ongoing support and guidance on long-term planning using both IPM and soil moisture conservation techniques. • Promote farmer-to-farmer learning and mentorship programs to facilitate the exchange of knowledge and experiences	• Enhanced specialized skills at all levels • Greater food security • Dynamic partnerships formed with farmers across the Federation	Medium to long term AGTS activity 4.1.3 USD 300,000

1) The St. Kitts and Nevis Agricultural Transformation and Growth Strategy (AGTS) (2022-2031) highlights indicative costs to promote climate-smart agriculture. Activities that align with the identified measures and their estimated cost over 10 years are included here. Further breakdown of costs will be done in the TAP phase.

Chapter 3 Energy Sector

One of two sectors prioritized for the TNA process for climate change mitigation is the energy sector. A more in-depth situational analysis of this sector can be found in the TNA report (Sahely, 2023). Two technologies were prioritized for the sector including: (1) Solar water heating and (2) Residential grid-tied solar. The first step in the process is to classify the prioritized technologies.

This classification helps to facilitate barrier analysis by linking technologies to market characteristics and makes note of the fluidity between categories. Table 3.1 presents the categorization of the technologies for the energy sector and sets the stage for identification of barriers.

Table 3.1: Categorization of technologies for the energy sector

Technology type	Technology category	
1. Solar water heating	Market	Consumer good
2. Residential grid-tied solar	Market	Consumer good

3.1 Preliminary targets for technology transfer and diffusion

In alignment with the mitigation chapters of the Third National Communication (TNC) (GOSKN, 2021a, 2022b) and the first Biennial Update Report (BUR1) (GOSKN, 2022a), the Nationally Determined Contributions (NDCs) (GOSKN, 2021c), NDC Partnership Plan (GOSKN, 2022d) and the SKN Energy Policy and Action Plan (GOSKN, 2011), the preliminary target for solar water heaters (residential and commercial) is 40% by 2030 of all households (total number of households approximately 25,000 in 2030). The estimated GHG emission reduction related to the implementation of solar water heaters is 5.54 ktCO_2-eq compared to the baseline (GOSKN, 2021c). The investment required for this diffusion target including feasibility studies, incentives plans, and solar water heating units was approximated at 20 M USD (GOSKN, 2021c) (15 M USD for St. Kitts and 5 M USD for Nevis).

As it relates to residential scale grid-tied PV systems, this technology was not included as part of the mitigation actions in the NDCs as the focus was utility scale PV as the Federation aims to transition to 100% renewable energy. However, the diffusion of distributed solar technologies was still included as an activity in the NDC Partnership Plan but without a definite target (GOSKN, 2022d). As such, the SWG chose a preliminary diffusion target of residential scale grid-tied PV systems in 20% of homes by 2030. Table 3.2 presents targets for the scale of diffusion for each of the prioritized technologies.

Table 3.2: Preliminary targets for diffusion of technologies for the energy sector

Technology	Target
1. Solar water heating	
Total number of solar water heaters installed by 2030	10,000 units across both islands

Survey on use and penetration of solar water heating and economic feasibility and design of incentive regime	One comprehensive study
Public education and outreach campaign	One comprehensive campaign for both islands
2. Residential scale grid-tied solar	
Total capacity of residential grid-tied PV systems by 2030	Various unit sizes (max. 100 kw) for a total of 5 MW for St. Kitts and 2 MW for Nevis.
Net metering tariff study, regulations, and incentive regime for rooftop solar developed	Net metering and incentive regime in place
Public education and outreach campaign	One comprehensive campaign for both islands

3.2 Barrier analysis and possible enabling measures for solar water heating

3.2.1 General description

Solar water heating (SWH) is a method of converting sunlight into heat for water heating using a solar thermal collector. A solar water heater comprises several key components, including solar collectors, a fluid system to move the heat from the collector to the point of usage, and a reservoir or tank for heat storage and subsequent use. The system may be used to heat water for a variety of applications, including domestic hot water, swimming pools, commercial, and industrial uses.

The basic principle behind solar water heating is simple: sunlight is captured by the solar collectors, which convert the energy into heat. This heat is then transferred to water in the storage tank via a circulating fluid in the system, which may be the water itself or a separate heat-transfer fluid in systems designed to prevent freezing or overheating.

The most common application in the Caribbean is passive solar water heating systems. These systems do not use pumps but rely on gravity and the natural tendency of water to circulate as it is heated. Solar water heating systems can significantly reduce energy costs for heating water, are environmentally friendly, and can reduce carbon dioxide emissions by displacing the use of fossil fuels. Solar water heaters are commonplace in many SIDS such as Barbados and Bermuda. There are several examples in St. Kitts and Nevis at the residential level and local suppliers are available.

3.2.2 Identification of barriers

The long list of barriers for solar water heaters presented to the SWG is included in Table 3.3. The long list was compiled by the national consultant based on a thorough review of national policies, strategies, and national communications, BAEF reports from other countries, scientific literature, and consultation with stakeholders especially during the BAEF training held in July 2023. Members of the SWG were asked to classify the barriers according to level of importance by assigning *High (H)* to critical or killer barriers which would adversely affect or prevent diffusion; *Medium (M)* to important barriers which should be monitored and *Low (L)* to those barriers deemed insignificant in the overall implementation process. For those barriers ranked High (H), the members of the SWG were asked to rank in order of importance. The top 3 were then selected for decomposition using the logical framework analysis.

Table 3.3: Classification and prioritization of barriers for solar water heating

Category	Barrier	Level of importance			
		HIGH	**MED**	**LOW**	**RANK**
Technical	Small roof space can hinder installation of solar water heaters			X	
	Harsh environment can lead to increased wear and tear and need ongoing maintenance		X		
Market	No local manufacturing of solar water heaters		X		
	Reliance on imports, which can be disrupted by transportation or trade issues		X		
	Small market size reducing the incentive for suppliers to offer competitive pricing or invest in local distribution networks	X			4
Economic and financial	High capital costs	X			1
	Lack of funding and financial incentives such as subsidies or low-interest loans	X			2
	Economic uncertainty or instability		X		
	Difficulty in achieving a short -term return on investment		X		
	Importation costs and shipping costs for solar water heaters		X		
Legal and regulatory	Inadequate legal frameworks to support adoption of solar water heaters		X		
Institutional capacity	Lack of coordination between stakeholders, government agencies, suppliers etc.		X		
	Limited governmental capacity to provide guidance for adoption of solar water heating		X		
Human skills	Limited access to training and technical expertise in installation of solar water heaters	X			3
	Need for ongoing technical support and troubleshooting		X		
Socio-cultural	Low awareness among residents and businesses about the benefits of solar water heaters		X		
	Resistance to change			X	
Environmental	Frequent cloud cover or extreme weather events can reduce effectiveness of solar water heaters		X		
Political	Lack of political will to prioritize solar water heating			X	

Two (2) economic and financial and one (1) non-financial barrier to the adoption of solar water heaters were the top ranked critical barriers including:

1. High capital costs
2. Lack of funding and financial incentives such as subsidies or low-interest loans
3. Limited access to training and technical expertise in installation of solar water heaters

3.2.2.1 Economic and financial barriers

Two of the main economic barriers to adoption of solar water heaters identified by the SWG is high capital costs and lack of funding and financial incentives. The NDC Partnership Plan (GOSKN, 2021c) outlined that the investment required to promote the adoption of solar water heaters including feasibility studies, incentives plans and units was approximated at 20 M USD (15 M USD for St. Kitts and 5 M USD for Nevis). Currently, a 50-gal solar water heating unit (manufactured in Barbados and brought in by a local supplier) costs 2,500 USD. The cost estimates provided in the partnership plan did not include any approximation of the return on investment. However, research by Headley (2000) showed a payback period of 2-3 years for St. Kitts and Nevis when replacing an electric water heater with a solar one.

Annex IV details the problem tree for these two critical economic and financial barriers which are inter-related. The root causes to the high capital costs of solar water heaters (and residential solar PV systems) are the lack of financing options, few local suppliers and overall limited awareness of the benefits of solar technologies. In looking more closely at the lack of funding and financial incentives, lack of specific policies promoting solar water heating, limited government resources and restricted fiscal space and limited overall awareness of the benefits of solar water heating are root causes which are inter-related and mutually reinforcing.

3.2.2.2 Non-financial barriers

The main non-financial barrier to adoption of solar water heating identified by the SWG is limited technical expertise in the installation and maintenance of solar water heaters.

Annex IV details the problem tree for this non-financial barrier to uncover its root causes which are tied with overall lack of awareness of the important benefits of solar water heating and more specifically to the need for skilled installation and maintenance. Furthermore, the absence of government mandate for skill development in renewable energy further reinforces this problem.

3.2.3 Identified measures

Based on the barriers outlined in the provided text for the adoption of solar water heaters in St. Kitts and Nevis, the SWG identified the measures in the following sections to overcome these barriers utilizing the objective trees found in Annex IV.

3.2.3.1 Economic and financial measures

As it related to the critical barriers of high capital costs and lack of financial incentives, the main measures highlighted are:

- Government Subsidies: The government could offer subsidies that reduce the upfront cost of solar water heaters, making them more affordable for the average consumer.
- Bulk Purchasing and Incentives for Suppliers: Encouraging bulk purchasing and offering incentives for suppliers could increase competition and supply, potentially reducing costs.

- Low-Interest Loans: Financial institutions, possibly with government backing, could provide low-interest loans specifically for solar energy investments.
- Green Bonds or Funds: The government or private sector could create green bonds or funds that focus on supporting renewable energy projects.

Costs for solar water heaters and installation in St. Kitts and Nevis are higher due to import tariffs, small market size, and transportation costs. Addressing these through tax exemptions for renewable energy products and bulk procurement would make systems more affordable.

3.2.3.2 Non-financial measures

As it related to the critical barriers of limited access to training and technical expertise, the main measures highlighted are:

- Training Programs: Partner with local educational institutions to develop training programs to increase the number of qualified installers and maintenance personnel.
- Certification Programs: Establish certification programs for solar water heater installers to ensure quality control and customer confidence.
- Public Awareness Campaigns: Increase awareness of the benefits of solar water heating through campaigns, workshops, and showcasing successful installations.

Currently, there is some work on the ground to create an enabling environment for the upskilling of technicians in St. Kitts and Nevis as they seek to enter the fields of renewable energy especially regarding solar technologies. The Clarence Fitzroy Bryant College (CFBC) in St. Kitts has partnered with Green Solutions International (GSI) to create more opportunities for upskilling (SKNIS, 2024). They have received a grant from the GEF UNDP Small Grant Program to design, implement, and operate a centre for research, innovation, and workforce training for solar and electric vehicle technologies. The initiative seeks to address the energy gap but also aims to empower local communities by providing opportunities for workforce development, job creation, and entrepreneurship in the green technology sector.

In implementing these measures, it is important for stakeholders to engage in dialogue to ensure that the solutions are feasible and effective for the local context of St. Kitts and Nevis. Collaboration between the government, local businesses, financial institutions, educational organizations, and the public can create an environment where the adoption of solar water heaters is not only technically viable but also financially attractive and well-supported.

3.3 Barrier analysis and possible enabling measures for residential grid-tied solar

3.3.1 General description

Solar photovoltaic refers to the technology of using solar cells to convert solar radiation directly into electricity. A solar cell works based on the photovoltaic effect which can be briefly summarized as sunlight striking a semiconductor and causing electrons to be excited due to energy in the sunlight (photons). Grid-connected PV systems do not require energy storage but instead use an inverter to convert electricity from direct current (DC) to alternating current (AC) and the generated electricity is then fed into the grid distribution network to consumers. Grid-connected distributed PV systems are installed on residential, commercial, or public buildings and generate electricity which is consumed by the customer and the excess is sent/sold to the grid to be consumed by other users. Most distributed systems range between 1-5 kW in power generation. Grid-tied systems are equipped with a bi-directional meter that can measure electricity flow in both directions – to and from the grid. This is essential for net metering, a billing mechanism that credits solar energy system owners for the electricity they add to the grid. The main benefits of household PV systems including enhanced energy savings, reduced dependence on fossil fuels for electricity and increased energy security.

In St. Kitts and Nevis, there are residential and commercial PV systems that have been installed but in the absence of net metering and the high initial capital investment, the diffusion of the technology has been slow.

3.3.2 Identification of barriers

The long list of barriers for residential grid-tied solar PV systems presented to the SWG is included in Table 3.4. The long list was compiled by the national consultant based on a thorough review of national policies, strategies, and national communications, BAEF reports from other countries, scientific literature, and consultation with stakeholders especially during the BAEF training held in July 2023. Members of the SWG were asked to classify the barriers according to level of importance by assigning *High (H)* to critical or killer barriers which would adversely affect or prevent diffusion; *Medium (M)* to important barriers which should be monitored and *Low (L)* to those barriers deemed insignificant in the overall implementation process. For those barriers ranked High (H), the members of the SWG were asked to rank in order of importance. The top 3 were then selected for decomposition using the logical framework analysis.

One (1) economic and financial and two (2) non-financial barriers (legal and regulatory and technical) were the top ranked critical barriers including:

1. Inadequate legal frameworks especially absence of feed in tariffs to support adoption of residential PV systems
2. High capital costs
3. Grid infrastructure may not be able to handle variable output of solar PV systems

Table 3.4: Classification and prioritization of barriers for residential grid-tied solar

		Level of importance			
Category	**Barrier**	**HIGH**	**MED**	**LOW**	**RANK**
Technical	Small roof space / land availability can hinder installation of residential PV systems		X		
	Harsh environment can lead to increased wear and tear and need ongoing maintenance		X		
	Grid infrastructure may not be able to handle variable output of solar PV systems	X			3
	High cost of energy storage solutions can be problematic where grid infrastructure is weak	X			5
Market	No local manufacturing of residential solar PV systems		X		
	Reliance on imports, which can be disrupted by transportation or trade issues		X		
	Small market size reducing the incentive for suppliers to offer competitive pricing or invest in local distribution networks	X			6
Economic and financial	High capital costs	X			2
	Lack of funding and financial incentives such as subsidies or low-interest loans	X			4
	Economic uncertainty or instability		X		
	Difficulty in achieving a short -term return on investment		X		
	Importation costs and shipping costs for residential PV systems		X		
Legal and regulatory	Inadequate legal frameworks especially absence of feed in tariffs to support adoption of residential PV systems	X			1
Institutional capacity	Lack of coordination between stakeholders, government agencies, suppliers etc.		X		
	Limited governmental capacity to provide guidance for adoption of solar PV systems		X		
Human skills	Limited access to training and technical expertise in installation of solar PV systems	X			7
	Need for ongoing technical support and troubleshooting		X		
Socio-cultural	Low awareness among residents and businesses about the benefits of solar PV systems		X		
	Resistance to change		X		
Environmental	Frequent cloud cover or extreme weather events can reduce effectiveness of solar water heaters		X		
	Aesthetic concerns		X		
Political	Lack of political will to prioritize solar PV systems		X		

3.3.2.1 Economic and financial barriers

Two of the main economic barriers to adoption of residential grid-tied solar PV systems identified by the SWG are high capital costs and lack of funding and financial incentives. Currently, in St. Kitts and Nevis, the estimated total costs are 2,000 USD per installed kW capacity which was provided by the Energy Unit of St. Kitts and Nevis based on regional and local studies.

Annex IV details the problem tree for the critical economic and financial barrier which was high capital costs (which was the same for solar water heating). The root causes to the high capital costs of residential solar PV systems are the lack of financing options, few local suppliers and overall limited awareness of the benefits of solar technologies.

3.3.2.2 Non-financial barriers

Two critical non-financial barriers to adoption of residential grid-tied solar PV systems were identified by the SWG. Annex IV details the problem trees for these non-financial barriers, which were found to be inter-related and mutually reinforcing, to uncover root causes. As it related to the inadequate legal frameworks especially lack of feed-in tariffs, the main root causes were found to be limited government resource allocation to incentives related to renewables and limited exposure to successful models of feed-in tariff implementation leading to the absence of a government mandate for supporting residential grid-tied PV systems. Closely related is the insufficient grid infrastructure to support feed-in systems, which has as its root cause a dependence on external expertise for grid improvements, inadequate planning for integration of variable renewable energy sources and lack of advanced grid management and storage technologies.

3.3.3 Identified measures

Based on the barriers outlined above for the adoption of residential grid-tied solar PV systems in St. Kitts and Nevis, the SWG identified the measures in the following sections to overcome these barriers utilizing the objective trees found in Annex IV.

3.3.4 Economic and financial measures

Various measures were identified to overcome the barriers to the adoption of residential grid-tied solar PV systems in St. Kitts and Nevis, as it relates to high capital costs:

- Introduction of feed-in tariffs to provide long-term security and financial returns for solar PV system owners.
- Establishing green energy bonds or other innovative financing mechanisms to provide capital for residential solar projects.
- Creating economies of scale by supporting community solar programs to reduce installation and equipment costs.

3.3.5 Non-financial measures

Similarly, numerous measures were identified to overcome the non-financial barriers to the adoption of residential grid-tied solar PV systems in St. Kitts and Nevis. As it relates to inadequate legal frameworks and absence of feed-in tariffs, the implementation of robust feed-in tariffs to encourage investment in residential PV systems and development of a clear regulatory framework that supports the adoption of residential solar PV, including standards for interconnection and fair compensation for distributed generation. As it relates to inadequacy of grid infrastructure, a comprehensive modernization of the grid and associated investment is needed to make it more resilient and adaptable to distributed generation sources along with research and development into energy storage solutions to mitigate the variability of solar power and ensure grid stability. Various activities were identified under the NDC Partnership Plan of 2022 which speak to investments in grid stability and efficiency. The first step includes an efficiency study on the grid (transmission and distribution systems) to understand the various inefficiencies, identify the appropriate system upgrades and costing of upgrades. Under the plan, the needed investment for the studies and subsequent upgrades could be upwards 391 M USD.

Currently, a comprehensive study including feed-in tariff assessment and regulations for net metering which is being spearheaded by the Energy Unit of the GOSKN is nearing completion and the draft report will be available for public review by mid-2024. Additionally, St. Kitts and Nevis with GCF Readiness Funds, has two other studies which will provide substantial support and data to reinforce the measures highlighted above including: (1) Transmission and distribution efficiency and vulnerability assessment and (2) Recommendations for updating the SKN building codes to integrate energy efficiency and resilience measures.

3.4 Linkages of the barriers identified

The barriers identified for the adoption of solar water heating and residential grid-tied solar PV systems in St. Kitts and Nevis are interconnected, with economic, financial, and non-financial barriers influencing each other across both technologies.

Both technologies face high capital costs and a lack of funding and financial incentives as major economic barriers. These barriers are closely linked, as the high upfront cost of solar technologies is a significant deterrent for potential adopters. The absence of financial incentives (such as subsidies or low-interest loans) exacerbates this issue by making these systems less accessible to the general population. Additionally, the specific lack of funding for feasibility studies, incentives plans, and the procurement of units directly impacts the ability to lower these capital costs through economies of scale or through the development of more cost-effective implementation strategies.

The inter-related nature of these root causes highlights the complexity of addressing the barriers to solar energy adoption in St. Kitts and Nevis. Solutions need to be multi-faceted, addressing not only the direct financial costs associated with solar technologies but also the broader ecosystem, including legal, regulatory, and infrastructural support, as well as capacity building and public awareness initiatives. The development of comprehensive policies and programs that tackle these interconnected barriers could significantly enhance the adoption of solar water heating and residential grid-tied solar PV systems in St. Kitts and Nevis.

3.5 Enabling framework for overcoming the barriers in the energy sector

This section details a complete framework of enabling measures for overcoming the critical barriers for diffusion of solar water heaters and residential grid-tied solar PV systems for the energy sector. Along with the measures outlined in the previous sections, benefits, expected timeframe and estimated costs are including in Table 3.5 aligned with the targets outlined in Table 3.2. Where no local data for costs exists, the SWG was consulted for their expert opinion to provide indicative costs where applicable. Further breakdown of costs and stakeholders required as implementation partners will be outlined in the next phase of the TNA – the Technology Action Plan (TAP).

Table 3.5: Enabling framework for prioritized technologies in the energy sector

Barriers	Measures	Benefits	Timeframe and costs[1]
High capital costs and lack of funding and financial incentives such as subsidies or low-interest loans (for both solar water heaters and residential grid-tied solar PV systems)	• The government can offer subsidies that reduce the upfront cost of solar water heaters and solar PV systems, making them more affordable for the average consumer. • Encouraging bulk purchasing and offering incentives for suppliers could increase competition and supply, potentially reducing costs. • Financial institutions, possibly with government backing or through public private partnerships, could provide low-interest loans specifically for solar energy investments. • Establishing green energy bonds or other innovative financing mechanisms to provide capital for residential solar projects. • Creating economies of scale by supporting community solar programs to reduce installation and equipment costs.	• Less reliance on fossil fuels for water heating and residential electricity use • Energy cost savings to residential consumers • Greater energy security • Decreased GHG emissions from the energy sector	Medium term If the target is 10,000 SWH units across both islands (USD 2,500 USD per unit), total estimated cost is: USD 25,000,000 For PV systems – assuming USD 2000 per kW If the target is 5 MW installed capacity, estimated cost is: USD 10,000,000
Limited access to training and technical expertise in installation of solar technologies	• Developing and funding training programs at local educational institutions to increase the number of qualified installers and maintenance personnel. • Establish certification programs for solar technology installers to ensure quality control and customer confidence. • Increase awareness of the benefits of solar water heating and residential grid-tied solar PV systems through campaigns, workshops, and showcasing successful installations.	• More specialized and empowered workforce • Diversification of jobs in renewables • Less reliance on fossil fuels for water heating and residential electricity use • Energy cost savings to residential consumers • Greater energy security • Decreased GHG emissions from the energy sector • More engaged and supportive public and political directorate	Short to medium term Undetermined cost to be further studied during the TAP phase.
Inadequate legal frameworks especially absence of feed in tariffs to support adoption of residential PV systems	• Introduction of feed-in tariffs to provide long-term security and financial returns for solar PV system owners.	• Less reliance on fossil fuels for water heating and residential electricity use • Energy cost savings to residential consumers • Greater energy security	Short to medium term Undetermined cost to be further

Barriers	Measures	Benefits	Timeframe and costs[1]
		• Decreased GHG emissions from the energy sector	studied during the TAP phase.
Grid infrastructure may not be able to handle variable output of solar PV systems	• Comprehensive modernization of the grid and associated investment is needed to make it more resilient and adaptable to distributed generation sources along with • Research and development into energy storage solutions	• Less reliance on fossil fuels for water heating and residential electricity use • Energy cost savings to residential consumers • Greater energy security • Decreased GHG emissions from the energy sector	Medium to long term NDC PP USD 391,000,000

Chapter 4 Transport sector

The second sector prioritized for the TNA process for climate change mitigation is the transport sector. A more in-depth situational analysis of this sector can be found in the TNA report (Sahely, 2023). Two technologies were prioritized for the sector including: (1) Hybrids and battery electric vehicles (EVs) and (2) Development and rehabilitation of sidewalks, cycle lanes and safe cycle parking to promote non-motorised transport (NMT). The first step in the process is to classify the prioritized technologies.

This classification helps to facilitate barrier analysis by linking technologies to market characteristics and makes note of the fluidity between categories. Table 4.1 presents the categorization of the technologies for the water sector and sets the stage for identification of barriers.

Table 4.1: Categorization of technologies for the transport sector

Technology type	Technology category	
1. Hybrids and battery electric vehicles (EVs)	Market	Consumer good
2. Development and rehabilitation of sidewalks, cycle lanes and safe cycle parking to promote non-motorised transport (NMT)	Non-market	Publicly provided good

4.1 Preliminary targets for technology transfer and diffusion

In alignment with the mitigation chapters of the Third National Communication (TNC) (GOSKN, 2021a, 2022b) and the first Biennial Update Report (BUR1) (GOSKN, 2022a) and the Nationally Determined Contributions (NDCs) and NDC Partnership Plan (GOSKN, 2021c, 2022d), the preliminary target is 4% of the total number of vehicles (split evenly between hybrids and EVs) by 2030. GHG emissions reduction would only be realized if there is a concurrent increase in renewables for power generation. As such, no estimate of GHG emissions for this target was made in the BUR1 (GOSKN, 2022a). The investment required for this diffusion target was approximated at 14.6 M USD for EVs only. No investment estimate was made for hybrids (GOSKN, 2021c). The investment required for the installation of 28 charging stations was approximated at 250,000 USD (GOSKN, 2022a).

As it relates to promotion of NMT, this technology was not included as part of the mitigation actions in the NDCs. However, a preliminary target was set for improvement in public transport to install a shift of 20% away from personal cars. The SWG proposed a similar target where promotion of NMT through the development of sidewalks, cycle lanes and safe cycle parking allows for a modal shift of 5% from personal vehicles by 2030. Table 4.2 presents targets for the scale of diffusion for each of the prioritized technologies.

Table 4.2: Preliminary targets for diffusion of technologies for the transport sector

Technology	Target
1. Hybrids and battery electric vehicles (EVs)	
Total number of hybrids and EVs by 2030	625 EVs across both islands
Total number of charging stations installed by 2030	25 level 2 charging stations 3 level 3 charging stations

Impact assessment of hybrids and EVs and impact on grid and economic feasibility and design of inventive regime	One comprehensive study
Public education and outreach campaign	One comprehensive campaign for both islands
2. Development and rehabilitation of sidewalks, cycle lanes and safe cycle parking to promote non-motorised transport (NMT)	
Construction and rehabilitation of sidewalks in Basseterre, Sandy Point and Cayon in St. Kitts and Charlestown and Market Shop, Gingerland in Nevis	2 km of sidewalk built 5 km of sidewalk rehabilitated
Safe cycle parking near to bus depots	200 slots
Allocation of cycle lanes along main sections of the island main road (along the shoulder where feasible)	5 km of cycle lanes delineated
Development of a strategy to promote NMT, survey to understand current use of NMT, development of an incentive regime to promote walking and cycling	One comprehensive strategy
Public education and outreach campaign to promote NMT	One comprehensive campaign for both islands

4.2 Barrier analysis and possible enabling measures for hybrids and battery electric vehicles

4.2.1 General description

Generally, electric vehicles use electricity to change a battery and transform that energy to mechanical energy to drive the wheels of the vehicle (CTCN 2017). There are many types of electric vehicles, these include:

- Hydrogen fuel cell vehicles
- Battery electric vehicles
- Hybrid electric vehicles

The battery electric vehicle also gets it power from the power grid, which charges a battery. The power from the battery is used to propel the vehicle. EVs produce zero tailpipe emissions, which make them an environmentally friendly alternative to traditional vehicles. The distance an EV can travel on a single charge is a key performance indicator. Advances in battery technology continue to increase these ranges, making EVs more practical for a wider range of uses.

The hybrid electric vehicle has a small internal combustion engine. This vehicle also obtains its power from the grid, but the internal combustion engine is used to recharge the battery, if needed, thus extending the range of the vehicle. This dual-system approach aims to increase fuel efficiency and reduce emissions compared to conventional gasoline or diesel-powered vehicles. The main advantages and disadvantages of the technology are listed below:

Advantages

- Reduced carbon dioxide emissions
- Greater fuel efficiency
- Lower maintenance costs compared to the combustion engine
- Opportunity to create new jobs and build new skill sets
- High public interests

Disadvantages

- Higher capital cost compared to the conventional combustion engine vehicle
- Lack of charging infrastructure (powered by renewable energy sources or even fossil fuel sources)
- Lack of local dealer support
- Concerns with battery life and replacement costs

4.2.2 Identification of barriers

The long list of barriers for hybrids and EVs presented to the SWG is included in Table 4.3. The long list was compiled by the national consultant based on a thorough review of national policies, strategies, and national communications, BAEF reports from other countries, scientific literature, and consultation with stakeholders especially during the BAEF training held in July 2023. Members of the SWG were asked to classify the barriers according to level of importance by assigning *High (H)* to critical or killer barriers which would adversely affect or prevent diffusion; *Medium (M)* to important barriers which should be monitored and *Low (L)* to those barriers deemed insignificant in the overall implementation process. For those barriers ranked High (H), the members of the SWG were asked to rank in order of importance. The top 3 were then selected for decomposition using the logical framework analysis.

Two (2) economic and financial (including market) and one (1) non-financial barrier (technical) were the top ranked critical barriers for the SWG including:

1. High capital costs
2. Lack of charging infrastructure
3. Small market size reducing the incentive for suppliers to offer competitive pricing

Table 4.3: Classification and prioritization of barriers for hybrid and EVs

Category	Barrier	Level of importance			
		HIGH	MED	LOW	RANK
Technical	Lack of charging infrastructure	X			2
	Harsh environment can lead to increased wear and tear and need ongoing maintenance		X		
	Grid infrastructure may not be able to handle increase in demand with more EVs		X		
	Limited range of vehicles (due to insufficient charging infrastructure)		X		
	Performance and battery life can be adversely affected by hot and humid climate		X		
	Long battery charging time compared to refueling of gasoline vehicle			X	
Market	No local manufacturing of hybrids and EVs		X		
	Reliance on imports, which can be disrupted by transportation or trade issues		X		
	Small market size reducing the incentive for suppliers to offer competitive pricing	X			3
	Limited availability of models		X		
Economic and financial	High capital costs	X			1
	Lack of funding and financial incentives such as subsidies or low-interest loans	X			4
	Economic uncertainty or instability		X		
	Difficulty in achieving a short -term return on investment		X		
	High importation costs and shipping costs for hybrids and EVs		X		
Legal and regulatory	Inadequate legal frameworks to support adoption of hybrids and EVs	X			5
Institutional capacity	Lack of coordination between stakeholders, government agencies, suppliers etc.		X		
	Limited governmental capacity to provide guidance for adoption of hybrids and EVs		X		
Human skills	Limited access to training and technical expertise to service hybrids and EVs	X			6
	Need for ongoing technical support and troubleshooting		X		
Socio-cultural	Low awareness among residents and businesses about the benefits of hybrids and EVs		X		
	Resistance to change		X		
Environmental	Where electricity is primarily fossil fuel generated, environmental benefits are reduced		X		
	Negative impact of improper battery disposal		X		
Political	Lack of political will to prioritize hybrids and EVs		X		

4.2.2.1 Economic and financial barriers

Two of the main economic barriers to adoption of hybrids and EVs identified by the SWG are high capital costs and small market size reducing the incentive for suppliers to offer competitive pricing. Annex V details the problem trees for the critical economic and financial barriers. The root causes to the high capital costs and small market size of hybrids and EVs are inter-related and stem ultimately from the lack of government incentives and / or financing options which stem from lack of economies of scale, limited customer base and lower purchasing power of the average consumer.

Currently, in St. Kitts and Nevis, there are no suppliers of hybrids and EVs. As with all conventional vehicles, these are not manufactured locally, and the costs are driven by market forces outside of the Caribbean. According to Slowick et al. (2022), with declining electric vehicle battery and assembly costs, shorter-range EVs of 150 to 200 miles are projected to reach price parity by 2024–2026 in the United States. The upfront cost of any vehicle imported into St. Kitts and Nevis is increased by importation and transportation costs which for vehicles is close to 50% of the market price.

4.2.2.2 Non-financial barriers

One critical non-financial barrier to adoption of hybrids and EVs identified by the SWG was lack of charging infrastructure. The problem tree for the decomposition of this non-financial barrier is found in Annex V. The main root causes are essentially the same as for the critical economic barriers in the absence of government incentives and an overall regulatory framework to promote use of EVs. Even when EVs and hybrids reach price parity, the average consumer is not likely to make a switch to EVs without a concerted effort by the government to promote such through major investments in charging infrastructure, duty free concessions and renewable energy for the generation of electricity.

4.2.3 Identified measures

Based on the barriers outlined in the provided text for the adoption of hybrids and EVs in St. Kitts and Nevis, the SWG identified the measures in the following sections to overcome these barriers utilizing the objective trees found in Annex V. Furthermore, St. Kitts and Nevis with GCF Readiness Funds, has two other studies which will provide substantial support and data to reinforce the measures highlighted below including an electric vehicle impact assessment and roadmap for the transport sector to be completed by the end of 2024.

4.2.3.1 Economic and financial measures

Various measures were identified to overcome the economic and financial barriers to the adoption of hybrids and EVs in St. Kitts and Nevis, as it relates to high capital costs and small market size:

- Government Incentives: Introduce tax rebates, subsidies, or reduced import duties for hybrids and EVs to lower the initial purchase cost. Additionally, providing incentives for local dealerships to supply these vehicles could stimulate market competition and lower prices.

- Financing Options: Partner with financial institutions to create favourable loan conditions for the purchase of hybrids and EVs. This could include lower interest rates or longer payment terms, which would make these vehicles more accessible and crowd out conventional vehicles thus achieving adequate market size.

- Bulk Purchases: Government and large corporations in St. Kitts and Nevis could make bulk purchases of hybrids and EVs, which would help create economies of scale and reduce unit costs.

- Leasing Programs: Establish leasing programs to lower the upfront cost and risk for consumers, thereby making hybrids and EVs more financially accessible.

- Public Awareness Campaigns: Educate the public on the long-term cost benefits of owning a hybrid or EV, such as lower maintenance and operational costs compared to traditional vehicles.

4.2.3.2 Non-financial measures

As it relates to the technical barrier of lack of charging infrastructure, the SWG recommended the following measures:

- Infrastructure Investment: Invest in charging infrastructure to alleviate range anxiety and make the operation of hybrids and EVs more convenient. This includes public charging stations and incentives for private charging stations at homes or businesses.

- Regulatory Framework: Develop a regulatory framework that supports the adoption of hybrids and EVs, such as mandated charging points in new building plans or reserved parking spaces for EVs with charging points.

- Renewable Energy Integration: Promote the use of renewable energy sources for electricity generation to power the charging stations such as solar car ports, making the operation of hybrids and EVs more sustainable and appealing.

- Public Transportation Electrification: Lead by example by electrifying public transportation fleets. This can provide a high-visibility model for EV adoption and normalize the use of such vehicles.

By implementing a combination of these measures, St. Kitts and Nevis can tackle the barriers to the adoption of hybrids and EVs and facilitate a transition towards a more sustainable transportation future.

4.3 Barrier analysis and possible enabling measures for promotion of non-motorised transport

4.3.1 General description

An important part of the equation in trying to reform the transportation sector is a revival of non-motorized transport (NMT), more specifically promotion of walking and cycling to move around for short distances. The key to reversing the trend towards more private vehicle use is making walking and cycling attractive, together with improving public transport. This can be done by a range of activities including construction of sidewalks and bike lanes, bike sharing programmes, urban planning, and pedestrian-oriented development. NMT is a highly cost-effective transportation strategy and brings about large health, economic and social co-benefits, particularly for the urban poor (CTCN 2016).

Specific ways to improve non-motorised transportation (CTCN 2016) are:

- Improve sidewalks, crosswalks, paths, bicycle lanes and networks.
- Public bicycle systems (automated bicycle rental systems designed to provide efficient mobility for short, utilitarian urban trips).
- Develop pedestrian oriented land use and building design.
- Increase road and path connectivity, with special non-motorised shortcuts
- Traffic calming, streetscape improvements, traffic speed reductions, vehicle restrictions and road space reallocation.
- Safety education, law enforcement and encouragement programs.
- Bicycle parking.
- Bicycle integration in transit systems (e.g. racks in metro or on bus)
- Address security concerns of pedestrians and cyclists.
- Congestion pricing
- Vehicle parking policies
- Fuel taxes

NMT is adequate for local conditions and endorsed by local experts. There are major advantages related to costs as it is generally more cost effective to develop sidewalks and cycling routes relative to the cost of other transport infrastructure. It is well suited to short to medium travel distances which are common in SIDS. The main benefits related to NMT are:

Economic benefits

- NMT, particularly cycling, is easy, flexible, cheap, and fast
- More attractive cities for tourists and residents, particularly if car-free zones are included
- Reduced travel times due to improved traffic flow
- Energy security due to lower vehicle energy use
- Greater economic inclusion

Social and environmental benefits

- Congestion reduction
- Health benefits due to exercise.
- Diverts income from car and gas expenditure to other priorities
- Improved safety
- Air quality improvement
- Noise reduction
- GHG emissions reduction

NMT features in the Urban Resilience Plan for Basseterre (GOSKN, 2023b) which identified as one of its objectives to develop a pedestrian priority avenue in historic Basseterre to be actualized with various projects including an integrated mobility study focused on multi-modal transportation.

4.3.2 Identification of barriers

The long list of barriers for promotion of NMT presented to the SWG is included in Table 4.4. The long list was compiled by the national consultant based on a thorough review of national policies, strategies, and national communications, BAEF reports from other countries, scientific literature, and consultation with stakeholders especially during the BAEF training held in July 2023. Members of the SWG were asked to classify the barriers according to level of importance by assigning *High (H)* to critical or killer barriers which would adversely affect or prevent diffusion; *Medium (M)* to important barriers which should be monitored and *Low (L)* to those barriers deemed insignificant in the overall implementation process. For those barriers ranked High (H), the members of the SWG were asked to rank in order of importance. The top 3 were then selected for decomposition using the logical framework analysis.

One (1) economic and financial barrier and two (2) non-financial barriers (technical and socio-cultural) were the top ranked critical barriers for the SWG including:

1. Space constraints / limited land area / narrow streets
2. High capital costs of NMT infrastructure (sidewalks, cycle lanes etc.)
3. Cultural preference and status associated with motorized transport over NMT

Table 4.4: Classification and prioritization of barriers for promotion of NMT

Category	Barrier	Level of importance			
		HIGH	MED	LOW	RANK
Technical	Space constraints / limited land area / narrow streets	X			1
	Ongoing maintenance of sidewalks / cycle lanes		X		
Market	No local manufacturing of bicycles			X	
	Reliance on imports for bicycles, which can be disrupted by transportation or trade issues		X		
Economic and financial	High capital costs of NMT infrastructure (sidewalks, cycle lanes etc.)	X			2
	Lack of funding and financial incentives such as subsidies or low-interest loans		X		
	Economic uncertainty or instability		X		
	High importation costs and shipping costs for construction materials / bicycles		X		
Legal and regulatory	Inadequate legal frameworks to support adoption of NMT		X		
	Lack of integrated urban planning and transport policy	X			4
Institutional capacity	Lack of coordination between stakeholders, government agencies, suppliers etc.		X		
	Limited governmental capacity to provide guidance for adoption of hybrids and EVs		X		
Human skills	Limited access to training and technical expertise to design and implement NMT infrastructure			X	
Socio-cultural	Cultural preference and status associated with motorized transport over NMT	X			3
	Low awareness among public about the benefits of NMT		X		
	Resistance to change		X		
	Perceived and actual risk of accidents due to inadequate infrastructure can deter people from cycling / walking		X		
	Lack of public participation in planning		X		
Environmental	Tropical climate and humidity make walking / cycling less appealing		X		
	Personal fitness levels and health may deter people from engaging in NMT		X		
Political	Lack of political will to prioritize NMT		X		

4.3.2.1 Economic and financial barriers

One of the main economic barriers to promotion of NMT through development of sidewalks, cycle lanes and safe cycle parking identified by the SWG are high capital costs of required infrastructure. Annex V details the problem trees for this critical economic and financial barrier. The root causes to this core barrier are overall high construction costs related mostly to the high cost of construction materials and to a lesser degree the cost of labour. Inadequate public funding and poor urban planning limit options for development of NMT infrastructure.

4.3.2.2 Non-financial barriers

Two critical non-financial barriers to the promotion of NMT identified by the SWG are limited land space and cultural preference and status associated with motorized transport. The problem trees for the decomposition of these non-financial barriers are found in Annex V. Closely related to the economic barrier analyzed in the previous section, the absence of a government policy or regulations promoting NMT, has led to a development pathway that is focused on motorized transport. As such, the increase in motorized transport is widely regarded as positive in terms of development progress. Furthermore, such long-term emphasis on motorized transportation has dominated urban planning and infrastructure development leading to less space for NMT. Concurrently, cultural preference has shifted to motorized transport and owning a vehicle has become a symbol of personal success and status further reinforcing the focus on motorized transport.

4.3.3 Identified measures

Based on the barriers outlined in the provided text for the promotion of NMT in St. Kitts and Nevis, the SWG identified the measures in the following sections to overcome these barriers utilizing the objective trees found in Annex V.

4.3.3.1 Economic and financial measures

To overcome the identified economic barriers for non-motorized transport (NMT) in St. Kitts and Nevis, the following strategies could be considered:

- Government Funding and Subsidies: Allocate specific funds or subsidies for the development of NMT infrastructure, such as sidewalks and cycle lanes. This could be a part of the national budget or through international grants aimed at sustainable transport projects.

- Incremental Development: Start with small-scale, low-cost interventions that can be gradually expanded, such as painting bike lanes on existing roads or creating shared spaces.

4.3.3.2 Non-financial measures

Building on the economic measures highlighted above, the SWG recommend the following measures to overcome the non-financial barriers identified.

- Land Use Planning: Integrate NMT into urban planning and development regulations (such as building codes) to ensure that future developments are built with sidewalks and bike lanes.

- Cultural Shift Programs: Launch campaigns to shift cultural perceptions of NMT, emphasizing the health, environmental, and economic benefits of walking and cycling.

- Education and Awareness: Include education on the benefits of NMT in schools and through community outreach programs, such as the importance of physical activity for health. Encourage public figures and leaders to use NMT to help shift the status symbol from motorized to non-motorized transport.

- Safe Parking Solutions: Provide secure and convenient parking for bicycles to encourage cycling. This could be at transport hubs, workplaces, and commercial centres.

- Traffic Calming Measures: Introduce traffic calming measures in urban areas to make walking and cycling safer and more appealing, such as speed bumps and pedestrian zones.

- Government Policy and Regulation: Develop and implement policies that specifically promote NMT, including regulations that require new developments to include NMT infrastructure.

- Community Engagement: Involve the community in the planning and development process to ensure that the NMT infrastructure meets the needs of residents and is maintained.

- Car-Free Days: Organize regular car-free days to encourage walking and cycling, and to help residents experience the benefits of NMT.

By adopting a mix of these measures, St. Kitts and Nevis can create a more conducive environment for NMT, thereby reducing the reliance on motorized transportation and promoting a healthier, more sustainable form of mobility.

4.4 Linkages of the barriers identified

The barriers to the adoption of hybrids and electric vehicles (EVs) and the promotion of non-motorized transport (NMT) in St. Kitts and Nevis, though seemingly distinct, are interlinked in several ways:

- Urban planning and infrastructure development:
    - Both the adoption of hybrids and EVs and the promotion of NMT are hindered by current urban planning and infrastructure paradigms that prioritize conventional motorized transport.
    - There is a shared need for infrastructure development—charging stations for EVs and sidewalks/cycle lanes for NMT—which requires strategic urban planning and investment.
    - Limited land space challenges the expansion of infrastructure for both hybrids/EVs and NMT, necessitating careful planning to integrate these modes of transport into the existing landscape.

- Government policy and regulation:
    - The lack of government policy or regulations supporting sustainable transport applies to both the slow adoption of hybrids/EVs and the limited facilities for NMT.
    - Without a governmental framework that promotes alternative transport modes, investment and development in these areas remain insufficient.

- Economic and financial resources:
    - High capital costs are a barrier for both technologies. Inadequate public funding affects the ability to establish both EV infrastructure and NMT pathways, as both require significant investment.
    - The small market size for hybrids/EVs and the lower demand for NMT infrastructure due to cultural preferences mean that there is little incentive to reduce costs, which perpetuates the economic barriers.

By recognizing these links, policymakers can develop more comprehensive strategies that address multiple barriers simultaneously. For example, a holistic urban development plan that includes provisions for both EV charging infrastructure and NMT can create efficiencies and promote a more integrated approach to sustainable transportation. Furthermore, public awareness campaigns and incentives can be designed to address both cultural and economic challenges, fostering a shift towards more sustainable transportation practices.

4.5 Enabling framework for overcoming the barriers in the transport sector

This section details a complete framework of enabling measures for overcoming the critical barriers for diffusion hybrids and EVs and promotion of NMT for the transport sector. Along with the measures outlined in the previous sections, benefits, expected timeframe and estimated costs are including in Table 4.5 aligned with the targets outlined in Table 4.2. Where no local data for costs exists, the SWG was consulted for their expert opinion to provide indicative costs where applicable. Further breakdown of costs and stakeholders required as implementation partners will be outlined in the next phase of the TNA – the Technology Action Plan (TAP).

Table 4.5: Enabling framework for prioritized technologies in the transport sector

Barriers	**Measures**	**Benefits**	**Timeframe and costs**
High capital costs and small market size of hybrids and EVs	• Introduce tax rebates, subsidies, or reduced import duties for hybrids and EVs to lower the initial purchase cost. • Partner with financial institutions to create favourable loan conditions for the purchase of hybrids and EVs. • Government and large corporations in St. Kitts and Nevis could make bulk purchases of hybrids and EVs, which would help create economies of scale and reduce unit costs. • Establish leasing programs to lower the upfront cost and risk for consumers, thereby making hybrids and EVs more financially accessible. • Educate the public on the long-term cost benefits of owning a hybrid or EV, such as lower maintenance and operational costs compared to traditional vehicles.	• Less reliance on fossil fuels for transportation • Transportation cost savings to consumers • Greater energy security • Decreased GHG emissions from the transport sector	Medium term NDC PP: USD 14,600,000
Lack of charging infrastructure	• Invest in charging infrastructure to alleviate range anxiety and make the operation of hybrids and EVs more convenient. This includes public charging stations and incentives for private charging stations at homes or businesses. • Develop a regulatory framework that supports the adoption of hybrids and EVs, such as mandated charging points in new building plans or reserved parking spaces for EVs with charging points. • Promote the use of renewable energy sources for electricity generation to power the charging stations such as solar car ports. • Lead by example by electrifying public transportation fleets.	• Less reliance on fossil fuels for transportation • Transportation cost savings to consumers • Greater energy security • Decreased GHG emissions from the transport sector	Medium term NDC PP: USD 250,000

Barriers	Measures	Benefits	Timeframe and costs
High capital infrastructure costs associated with NMT	• Allocate specific funds or subsidies for the development of NMT infrastructure, such as sidewalks and cycle lanes. This could be a part of the national budget or through international grants aimed at sustainable transport projects. • Provide secure and convenient parking for bicycles to encourage cycling. This could be at transport hubs, workplaces, and commercial centres.	• Less reliance on fossil fuels for transportation • Transportation cost savings to consumers • Greater energy security • Decreased GHG emissions from the transport sector • Health benefits from increased cycling and walking	Medium term Undetermined
Space constraints / limited land area / narrow streets	• Integrate NMT into urban planning and development regulations (such as building codes) to ensure that future developments are built with sidewalks and bike lanes. • Start with small-scale, low-cost interventions that can be gradually expanded, such as painting bike lanes on existing roads or creating shared spaces.	• Less reliance on fossil fuels for transportation • Transportation cost savings to consumers • Greater energy security • Decreased GHG emissions from the transport sector • Health benefits from increased cycling and walking	Short to medium term USD 1,000,000
Cultural preference and status associated with motorized transport over NMT	• Launch campaigns to shift cultural perceptions of NMT, emphasizing the health, environmental, and economic benefits of walking and cycling. • Include education on the benefits of NMT in schools and through community outreach programs, such as the importance of physical activity for health. Encourage public figures and leaders to use NMT to help shift the status symbol from motorized to non-motorized transport. • Introduce traffic calming measures in urban areas to make walking and cycling safer and more appealing, such as speed bumps and pedestrian zones.	• Less reliance on fossil fuels for transportation • Transportation cost savings to consumers • Greater energy security • Decreased GHG emissions from the transport sector • Health benefits from increased cycling and walking	Short to medium term USD 500,000

Barriers	Measures	Benefits	Timeframe and costs
	• Develop and implement policies that specifically promote NMT, including regulations that require new developments to include NMT infrastructure. • Involve the community in the planning and development process to ensure that the NMT infrastructure meets the needs of residents and is maintained. • Organize regular car-free days to encourage walking and cycling, and to help residents experience the benefits of NMT.		

Chapter 5 Summary and Conclusions

The Barrier Analysis and Enabling Framework (BAEF) Report for St. Kitts and Nevis is a comprehensive examination of the challenges and opportunities for technology diffusion in the sectors of water, agriculture, energy, and transport in the context of climate change adaptation and mitigation. The report provides a detailed analysis of the barriers to technology transfer and diffusion, identifying critical economic, technical, institutional, and socio-cultural constraints. It also proposes a set of enabling measures aimed at overcoming these barriers and facilitating the implementation of prioritized technologies.

In the water sector, the report highlights the importance of addressing both apparent and real water loss management through a combination of economic, financial, and non-financial measures. The agriculture sector analysis emphasizes the need for integrated pest management and soil moisture conservation techniques, with a focus on enhancing market demand, reducing implementation costs, and increasing farmer awareness.

The energy sector analysis underscores the potential of solar water heating and residential grid-tied solar systems, while the transport sector analysis focuses on the diffusion of hybrids, battery electric vehicles, and the promotion of non-motorized transport. Each sector's analysis is supported by a clear framework of measures to overcome the identified barriers, including technical, economic, and policy-related interventions.

One of the significant barriers to the adoption and diffusion of climate-friendly technologies in St. Kitts and Nevis and other Small Island Developing States (SIDS) is the high capital costs associated with these technologies. This economic barrier impedes the widespread implementation of the technologies prioritized in this study.

High capital costs are primarily driven by several interrelated factors. The limited market size in SIDS reduces the incentive for suppliers to offer competitive pricing or invest in local distribution networks. This results in reliance on imports, which are subject to high importation and shipping costs. Additionally, the absence of local manufacturing capabilities further exacerbates the cost issues, as all necessary equipment must be sourced from abroad, often at a significant markup.

To address this barrier, comprehensive financial strategies need to be developed. These could include government subsidies that reduce the upfront cost of technologies, encouraging bulk purchasing to leverage economies of scale, and offering incentives for suppliers to increase competition and reduce prices. Financial institutions, possibly with government backing or through public-private partnerships, could provide low-interest loans specifically for renewable energy investments. Furthermore, innovative financing mechanisms such as green energy bonds could be established to provide capital for residential solar projects.

It is also crucial to improve the overall awareness and understanding of the long-term economic benefits of adopting these technologies. Public education campaigns and stakeholder engagement can play a vital role in shifting public perception and increasing the willingness to invest in these solutions despite the high initial costs. Addressing the high capital costs through a multifaceted approach that includes financial incentives, regulatory support, and public education is essential for the successful adoption and diffusion of climate-friendly technologies in St. Kitts and Nevis. These measures can help overcome economic barriers, making sustainable technologies more accessible and promoting a greener future for the region.

The BAEF report is a crucial step towards the development of national Technology Action Plans (TAPs) that will guide the diffusion of nationally prioritized technologies in St. Kitts and Nevis. By addressing the root causes of the barriers to technology diffusion, the report sets a clear path for enhancing climate resilience and achieving sustainable development goals in the Federation.

Overall, the BAEF report for St. Kitts and Nevis serves as a valuable resource for policymakers, stakeholders, and development partners in their efforts to facilitate technology transfer and diffusion in the context of climate change adaptation and mitigation. It provides a solid foundation for the implementation of effective strategies that will contribute to the sustainable and resilient development of St. Kitts and Nevis.

List of References

CARDI. (2018). CARDI developed IPM strategy effectively controls sweet potato weevil. Accessed online on March 10, 2024 at: https://www.cardi.org/blog/cardi-developed-ipm-strategy-effectively-controls-sweet-potato-weevil/?highlight=IPM

Caribbean Development Bank (CDB). (2002). "CDB Approves US$17 Million for Geothermal Energy Development in Nevis" https://www.caribank.org/newsroom/news-and-events/cdb-approves-us17-million-geothermal-energy-development-nevis. Accessed on June 29, 2023.

Clements, R. et al (2011) Technologies for Climate Change Adaptation – Agriculture. TNA Guidebook, August 2011.

Climate Studies Group Mona (Eds.). (2020). "The State of the Caribbean Climate". Produced for the Caribbean Development Bank. http://dx.doi.org/10.13140/RG.2.2.16732.92808

Climate Technology Centre and Network (CTCN) (2022). Factsheet on soil moisture conservation techniques. Accessed on February 9, 2022 at https://www.ctc-n.org/technologies/soil-moisture-conservation-techniques

CTCN (2017) Electric Vehicles factsheet. https://www.ctc-n.org/technologies/electric-vehicles. Accessed on January 24, 2023.

CTCN (2016) Promotion of non-motorized transport. https://www.ctc-n.org/technologies/promotion-non-motorised-transport Accessed on January 23, 2023.

Daniel and Daniel Engineering Inc. (2013) St. Kitts: Water Sector Assessment, Auditing and Conservation. Water Conservation Plan for St. Kitts. OECS/USAID Reducing the Risk to Human and Natural Assets Resulting from Climate Change Project. April 2013.

DeGroot, J. (2018). Guidance for a Gender-Responsive Technology Needs Assessment. UNEP DTU Partnership.

Department of Agriculture (DOA), St. Kitts. (2024a) Director's report for 2023.

Department of Agriculture (DOA), St. Kitts. (2024b) Annual Work Plan for 2024 Crop Program.

Elliott, R. et al (2011) Technologies for Climate Change Adaptation – Water. TNA Guidebook, April 2011.

Environmental Resources Management Group (ERM) (2022) Supplemental Environmental and Social Impact Analysis. Nevis Geothermal Well Drilling Project. Accessed on January 13, 2023 at https://nia.gov.kn/documents/geothermal-energy/

European Union (EU). 2015. EU Reference Document – Good Practices on Leakage Management – Main Report. Luxembourg: Office for Official Publications of the European Communities. Accessed on February 16, 2022 at https://circabc.europa.eu/sd/a/1ddfba34-e1ce-4888-b031-6c559cb28e47/Good%20Practices%20on%20Leakage%20Management%20-%20Main%20Report_Final.pdf.

Fanner, P.V. et al. 2007. Leakage Management Technologies. American Water Works Association Research Foundation. Online at https://waterwise.org.uk/wp-content/uploads/2019/09/EPA-2007_Leakage-Management-Technologies.pdf. Accessed February 16, 2022.

Global Climate Fund (GCF) (2023). Approved Project Preparation Facility for SKN TransWater Project. Accessed online at: https://www.greenclimate.fund/document/transitioning-water-supply-st-kitts-and-nevis-low-carbon-climate-resilient-sector-skn

GOSKN. (1994). St. Kitts and Nevis Initial National Communications to the UNFCCC.

GOSKN. (2006). Adaptation Strategy in Response to the New EU Sugar Regime 2006-2013, Ministry of Sustainable Development, Government of St. Kitts and Nevis, Basseterre.

GOSKN. (2011). SKN Energy Policy and Energy Action Plan.

GOSKN. (2013). St. Kitts Water Conservation Plan. Prepared by Daniel and Daniel Engineering for the SKWSD.

GOSKN. (2015). St. Kitts and Nevis Second National Communications to the UNFCCC.

GOSKN. (2017). St. Kitts and Nevis National Climate Change Policy. November 2017.

GOSKN. (2018). National Climate Change Adaptation Strategy for St. Kitts and Nevis. October 2018.

GOSKN. (2019). Budget address 2020: Let’s keep building a stronger and safer future for St Kitts and Nevis. Presented by Dr. the Honourable Timothy Harris Prime Minister and Minister of Finance.

GOSKN. (2020a). Annual Progress Report on the Strategic Priorities of the Government of St. Kitts and Nevis: January-December 2019, Ministry of Sustainable Development, Government of St. Kitts and Nevis, Basseterre.

GOSKN. (2020b). Estimates 2021 - Fortitude During the Pandemic: Resilience, Recovery and Transformation (Vol. 2, Issue 9).

GOSKN. (2020c). The COVID-19 pandemic impact on tourism sector in St. Kitts and Nevis. Accessed on February 15, 2023 at https://www.stats.gov.kn/wp-content/uploads/2017/11/The-COVID-Impact-Tourism-2019-20-April.pdf

GOSKN. (2021a). Vulnerability and Adaptation Assessment (Chapter 3) for St. Kitts and Nevis 3rd National Communications to the UNFCCC. July 2021.

GOSKN. (2021b). Vulnerability Assessment and Water Utility Adaptation Plan for St. Kitts and Nevis. August 2021.

GOSKN. (2021c). Updated National Determined Contributions. October 2021.

GOSKN. (2021d). St. Kitts and Nevis National Gender Equality Policy and Action Plan. September 2021.

GOSKN. (2022a). Mitigation Assessment, Actions and their Effects Chapter for St. Kitts and Nevis First Biennial Report to the UNFCCC. June 2022.

GOSKN. (2022b). National Mitigation Analysis Chapter for St. Kitts and Nevis 3rd National Communications to the UNFCCC. July 2022.

GOSKN. (2022c). National Inventory Report (Year 2018) for St. Kitts and Nevis 3rd National Communications to the UNFCCC. February 2022.

GOSKN. (2022d). National Determined Contributions NDC Partnership Plan. March 2022.

GOSKN. (2022e). St. Kitts and Nevis Agricultural Transformation and Growth Strategy (2022-2031). June 2022.

GOSKN. (2023a). Budget Estimates 2024. Vol II. December 2023. Accessed online on February 28, 2024 at https://mof.gov.kn/wp-content/uploads/2023/03/2024-ESTIMATES-VOLUME-II-WEBSITE-GOV.pdf

GOSKN. (2023b). Urban Resilience Plan for Basseterre. Urban Development Unit.

GOSKN. (2024). The Journey to 2025 and Beyond. A Transformative Blueprint for a Sustainable Future. 25 by 2025 Agenda.

GWP-Caribbean. (2011). Water Utility Reform – The Jamaica Experience. Breifing Paper. Accessed online on April 10, 2024 at https://www.gwp.org/globalassets/global/gwp-c-files/water-utility-reform---the-jamaica-experience.pdf

Headley, O. (2000). Barbados Employs the Sun to Heat Water. Sustainable Energy News. No. 30, August 2000. Accessed on April 10, 2024 at https://www.inforse.org/doc/SEN30.pdf

Parsa, S. et al. (2024). Obstacles to integrated pest management adoption in developing countries. PNAS vol. 111(10). https://doi.org/10.1073/pnas.1312693111

Pretty, J.and Z. Bharucha. (2015) Integrated Pest Management for Sustainable Intensification of Agriculture in Asia and Africa. Insects 6, no. 1: 152-182. https://doi.org/10.3390/insects6010152

Kujawski, Jennifer (2011). Measuring soil moisture. Center for Agriculture, Food and the Environment. UMass Amherst. Accessed online on March 15, 2022 at https://ag.umass.edu/print/9572

K+M Advisors. (2019) Governance Position Paper on the Caribbean Water and Sanitation Sector. Accessed on April 10, 2024 at https://clmeplus.org/app/uploads/2020/04/Governance-Pos-Paper-on-the-Caribbean-Water-and-Sanitation-Sector.pdf

National Renewable Energy Laboratory (NREL) and Caribbean Centre for Renewable Energy and Energy Efficiency (CCREEE). (2022). St. Kitts and Nevis Energy Snapshot 2020. Accessed on February 27, 2023 at https://www.energy.gov/eere/articles/st-kitts-nevis-island-energy-snapshot-2020.

Nygaard, I. and Hansen, U. (2015). Overcoming Barriers to the Transfer and Diffusion of Climate Technologies: Second edition. UNEP DTU Partnership, Copenhagen.

Sahely, H.R. et al. (2010) Combining sound science, legal action and stakeholder involvement to protect a vulnerable coastal aquifer on the island of St. Kitts. World Water Week, Stockholm, Sweden. September 5-9, 2010.

Sahely, H.R. (2023) Technology Needs Assessment Report (Adaptation and Mitigation) for St. Kitts and Nevis. June, 2023.

Sealy, L. (2015). Assessment on the Adequacy of Agricultural Market Infrastructure and the Development of Recommendations for Improvement with Specific Focus on the Needs of Women and Small Farmers-St Kitts and Nevis Country Report. Prepared for the CARICOM Secretariat.

Slowick, P. et al. (2022) Assessment of light-duty electric vehicle costs and consumer benefits in the United States in the 2022-2035 time frame. International Council on Clean Transportation. Accessed on March 8, 2024, at https://theicct.org/wp-content/uploads/2022/10/ev-cost-benefits-2035-oct22.pdf

St. Kitts and Nevis Information Service (SKNIS). (2024). CFBC partners with GSI to establish and Caribbean Centre of Excellence in research, innovation and workforce training. Accessed pm March 10, 2024 at: https://www.sknis.gov.kn/2024/03/07/cfbc-partners-with-gsi-to-establish-a-caribbean-center-ofexcellence-in-research-innovation-and-workforce-training/

Thornton, J. et al. 2008. Water Loss Control, McGraw-Hill, New York. 632 p.

UNEP DTU Partnership. (2015). Determining technologies for climate change adaptation. A hands-on guidance to MCA and the identification and assessment of related criteria. May 2015.

UNEP DTU Partnership. (2021). Technology Needs Assessments – Climate Technologies in an Urban Context. 2021.

WTTC (World Travel and Tourism Council). (2021). St Kitts and Nevis 2021 Annual Research Key Highlights.

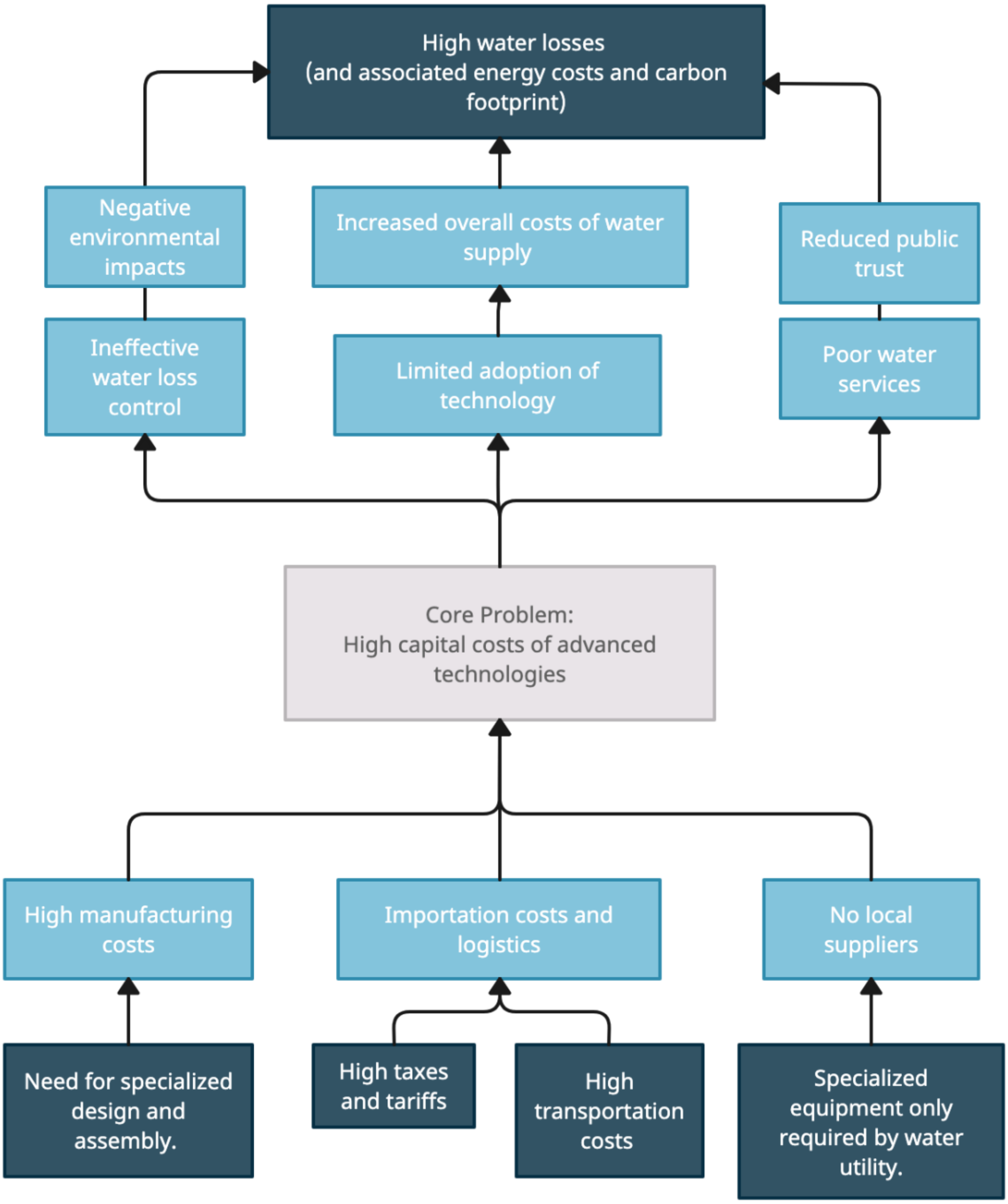
Annex I: List of Stakeholders

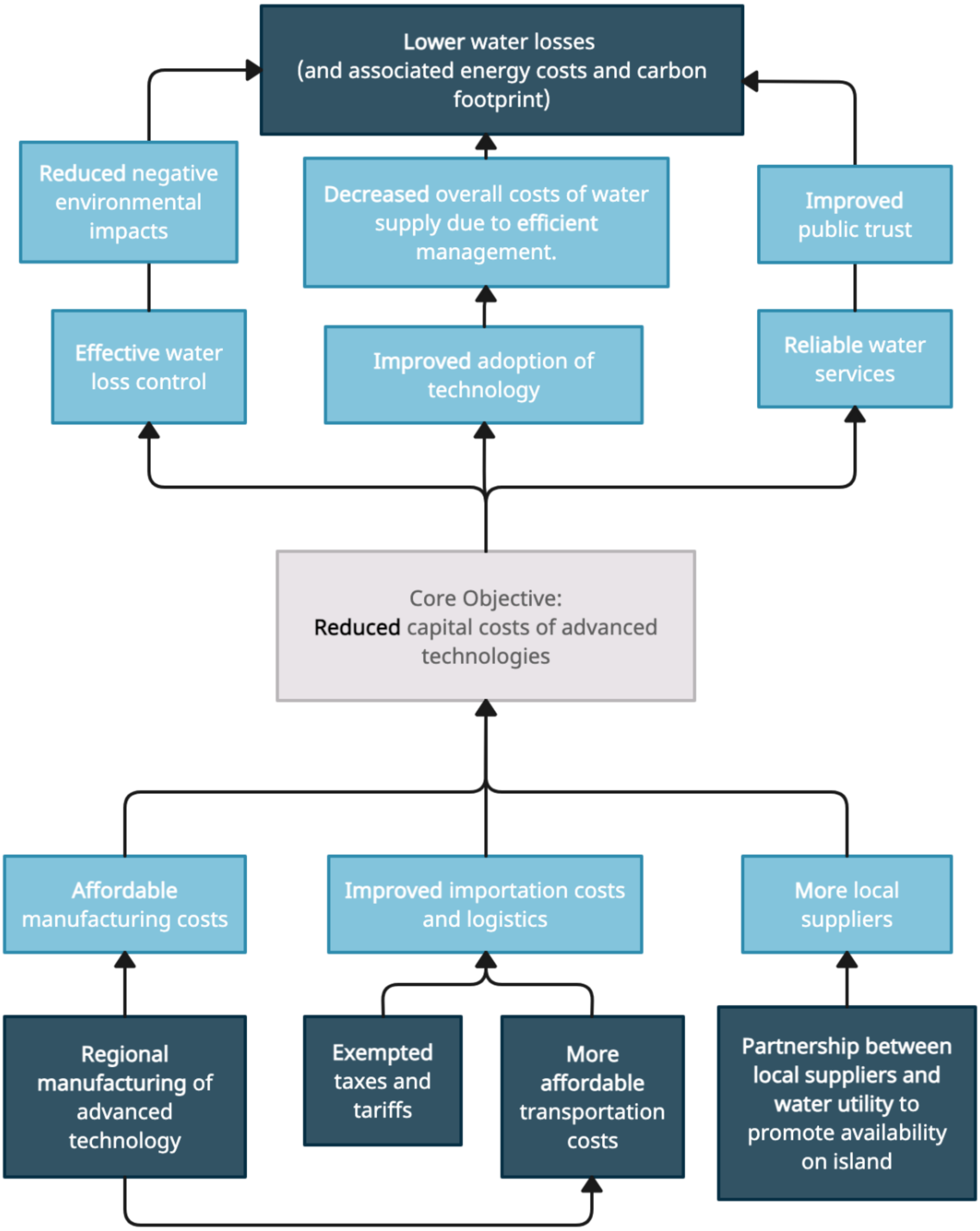
Stakeholder	Primary function	Agency Representative on the SWG Name and Email Address
Climate Action Unit Ministry of Environment, Climate Action and Constituency Empowerment	Primary focal agency for climate change action in St. Kitts and Nevis, with responsibility for compliance with the reporting requirements under the UNFCCC.	Cheryl Jeffers, Chief Technical Officer National TNA Coordinator
Water Working Group		
Integrated Water Resources Management Unit Ministry of Communications Nevis Island Administration	Responsible for the identification, upkeep, and protection of water supply sources on Nevis.	Floyd Robinson, Engineer floyd.robinson@niagovkn.com
Water Services Department Ministry of Public Infrastructure, Utilities, Posts and Urban Development	Maintains control over water production and distribution.	Cromwell Williams, Manager / Water Engineer cromwell.williams@gov.kn
Private Sector – Waterworks Solutions Inc.	Provision of services to the water sector including installation of water distribution and storage systems.	Denison Paul, Engineer wwsolutions.paul@gmail.com
Agriculture Working Group		
Nevis Department of Agriculture Ministry of Agriculture	Provides technical support that is needed to ensure that the citizens and residents of the Federation are food and nutritionally secured through various initiatives and programmes.	Quincy Bart, Quarantine Officer agriculture.dept@niagovkn.com bartquincy@gmail.com Hydeia Tyson, Extension Officer hydeiatyson18@gmail.com
Department of Agriculture Ministry of Agriculture, Fisheries and Marine Resources	Provides technical support that is needed to ensure that the citizens and residents of the Federation are food and nutritionally secured through various initiatives and programmes.	Brontie Tucker, Agronomist brontie.tucker@gov.kn

Stakeholder	Primary function	Agency Representative on the SWG Name and Email Address
Private sector – agriculture consultant	Provision of services to the agricultural sector through consultancy services.	Stephen Duggins, Consultant / Agriculture expert dugskn@gmail.com
GEF – Small Grants Programme / UNDP	GEF-SGP provides financial and technical support to community-based projects that conserve and restore the environment while enhancing well-being and livelihoods.	Ilis Watts, National Project Coordinator and Agronomist Iliswatts@unops.org
Energy and Transport Working Group		
Energy Unit Ministry of Public Infrastructure, Utilities, Posts and Urban Development	Strategic and planning unit for the energy and transport sector	Bertill Browne, Engineer bertillb@skelec.kn Denasio Frank, Engineer Denasio.frank@gov.kn
Ministry of Sustainable Development Urban Development Unit Department of Physical Planning	Strategic and planning unit for urban planning and revitalization Focal department for development control and forward planning	Rhon Boddie, Unit Head rhon.boddie@gov.kn Austin-Jay Farier, Director austin-jay.farier@gov.kn Jarid Sutton, Development Control Officer jarid.sutton@gov.kn
SKELEC	St. Kitts Electricity Company, sole electricity provider in St. Kitts	Jonathan Kelley, Engineer jkelly@skelec.kn Rhondel Phillip, Engineer rphillip@skelec.kn

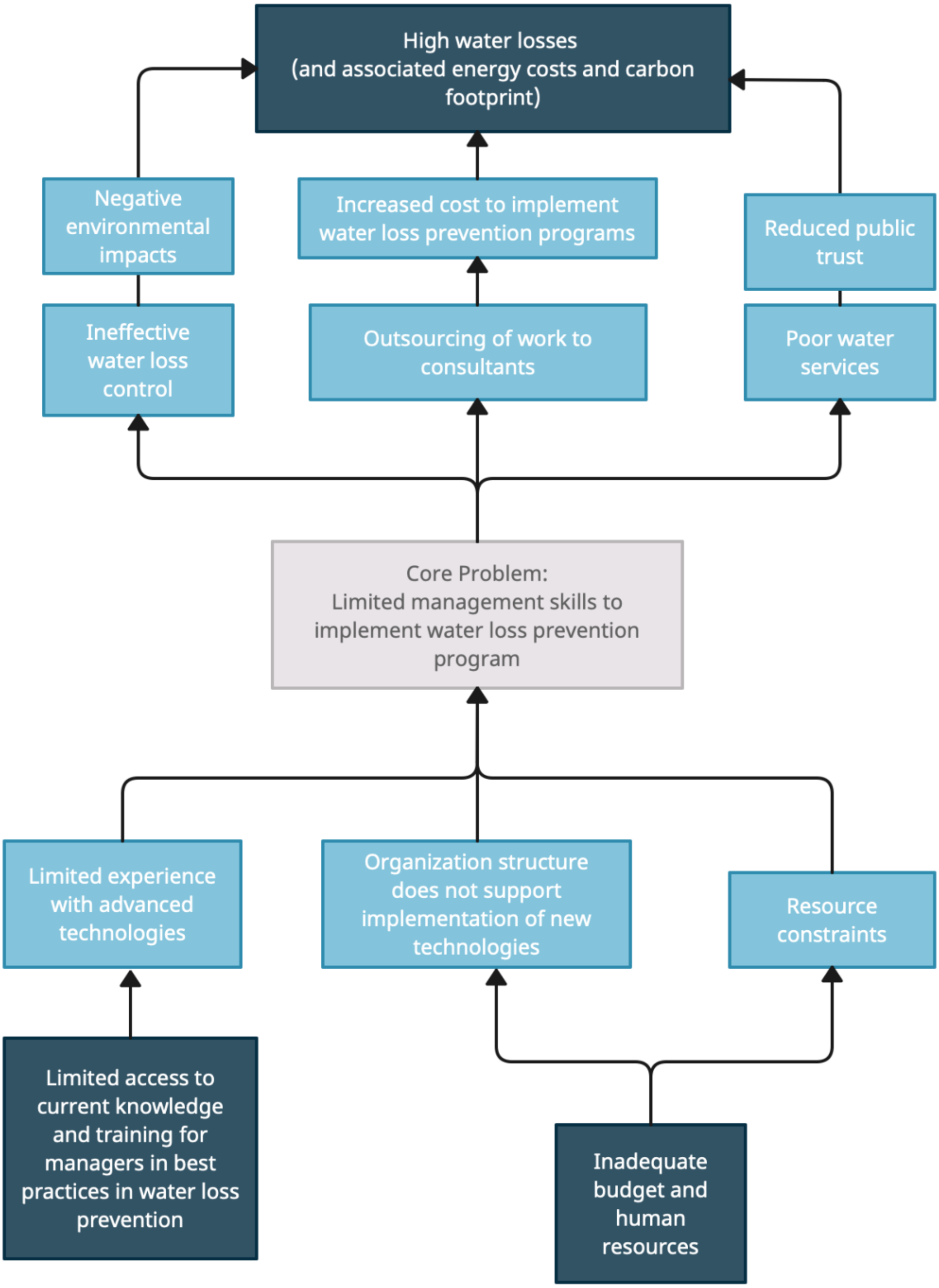
Stakeholder	Primary function	Agency Representative on the SWG Name and Email Address
NEVLEC	Nevis Electricity Company, sole electricity provider in Nevis	Ian Ward, Engineer ian.ward@nevlec.com Jervan Swanston jervan.swanston@nevlec.com Naftalie Errar, Project Manager naftalie.errar@nevlec.com
Department of Maritime Affairs	Strategic and planning unit for the maritime transport sector	Wayne Edmeade waynejrsm@gmail.com
Private Sector – New Era	Provider of RE products	Davian Trotman, Owner neweraskn@gmail.com

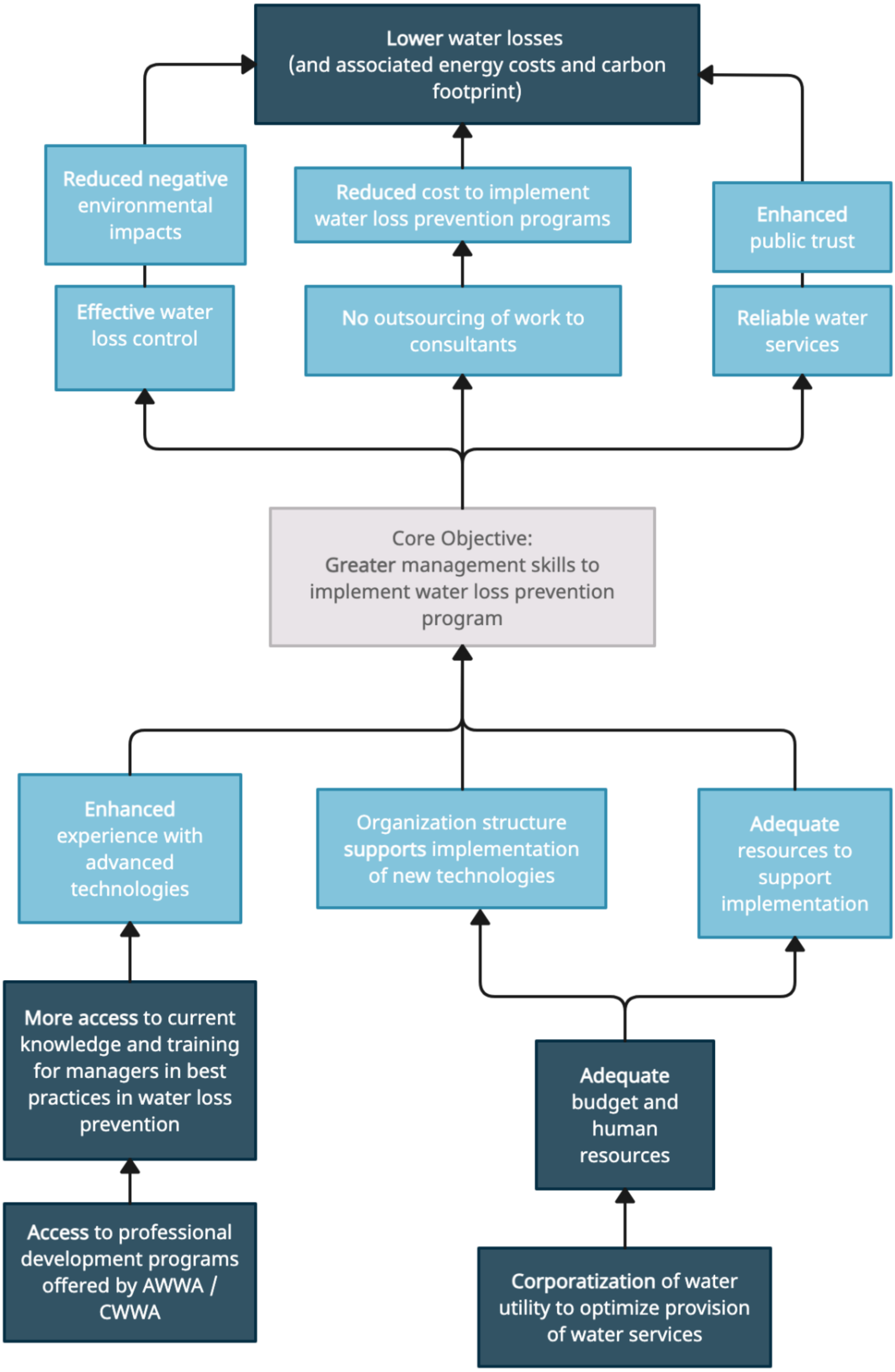
Annex II: Problem and Objective Trees – Water Sector

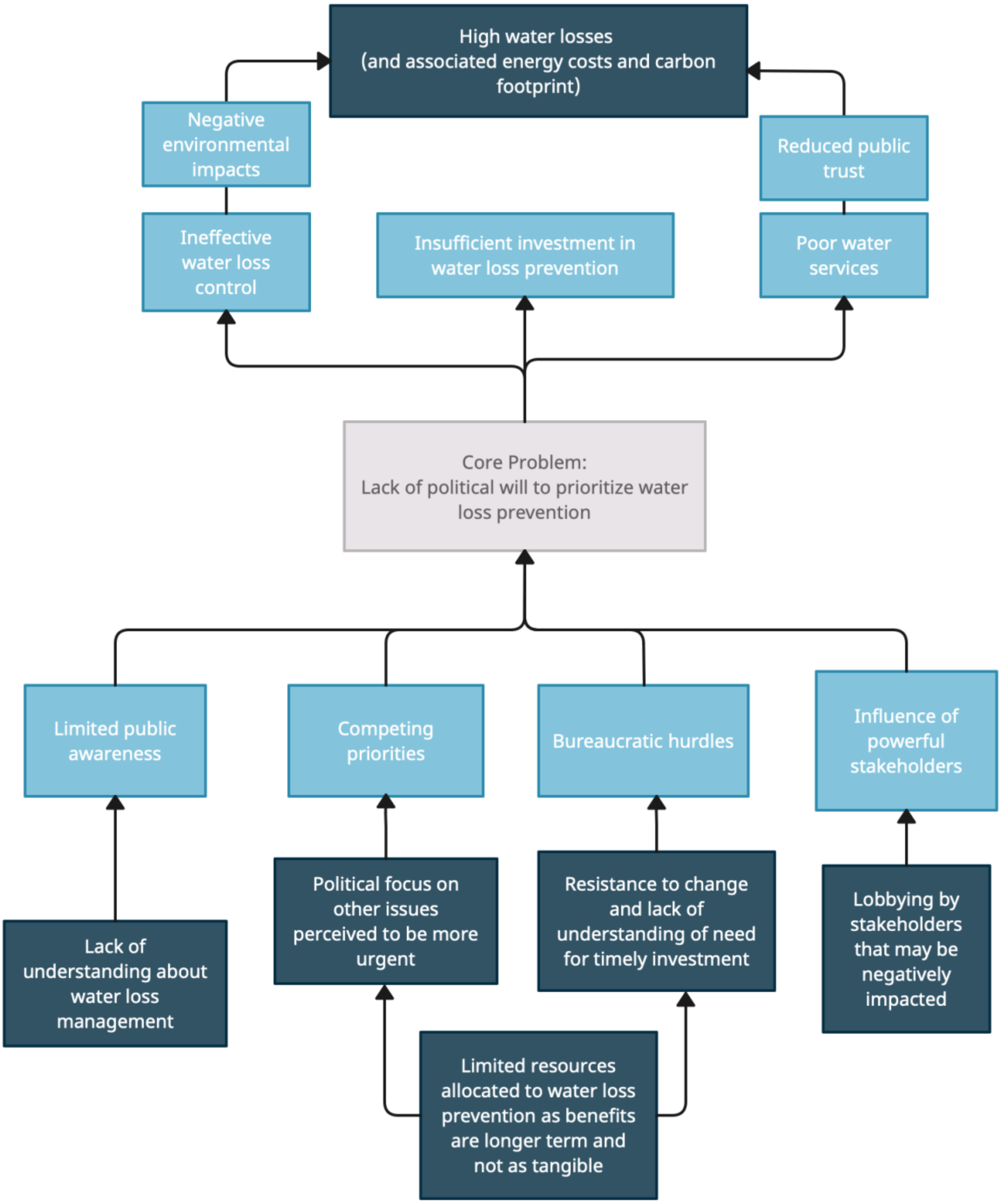


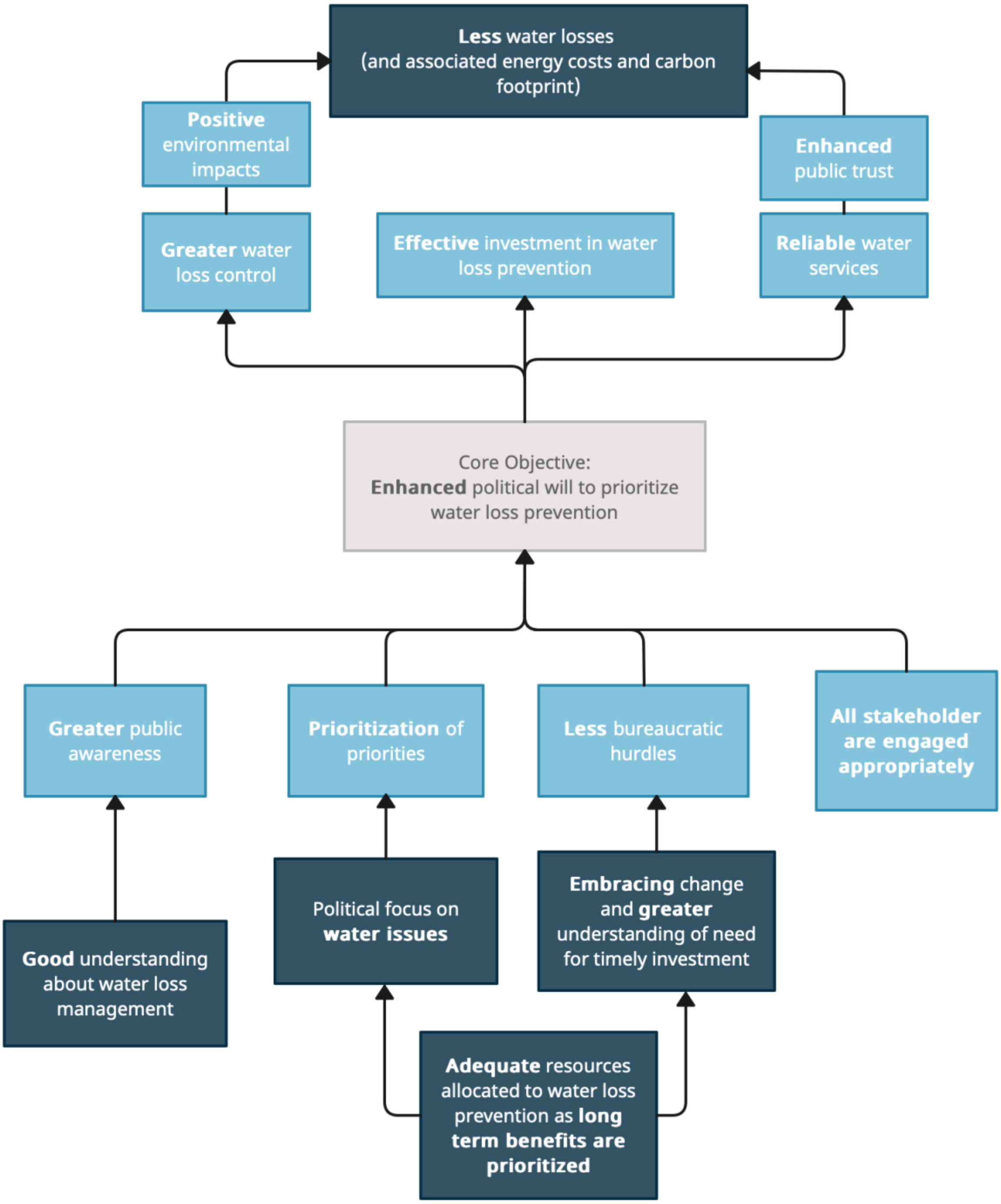


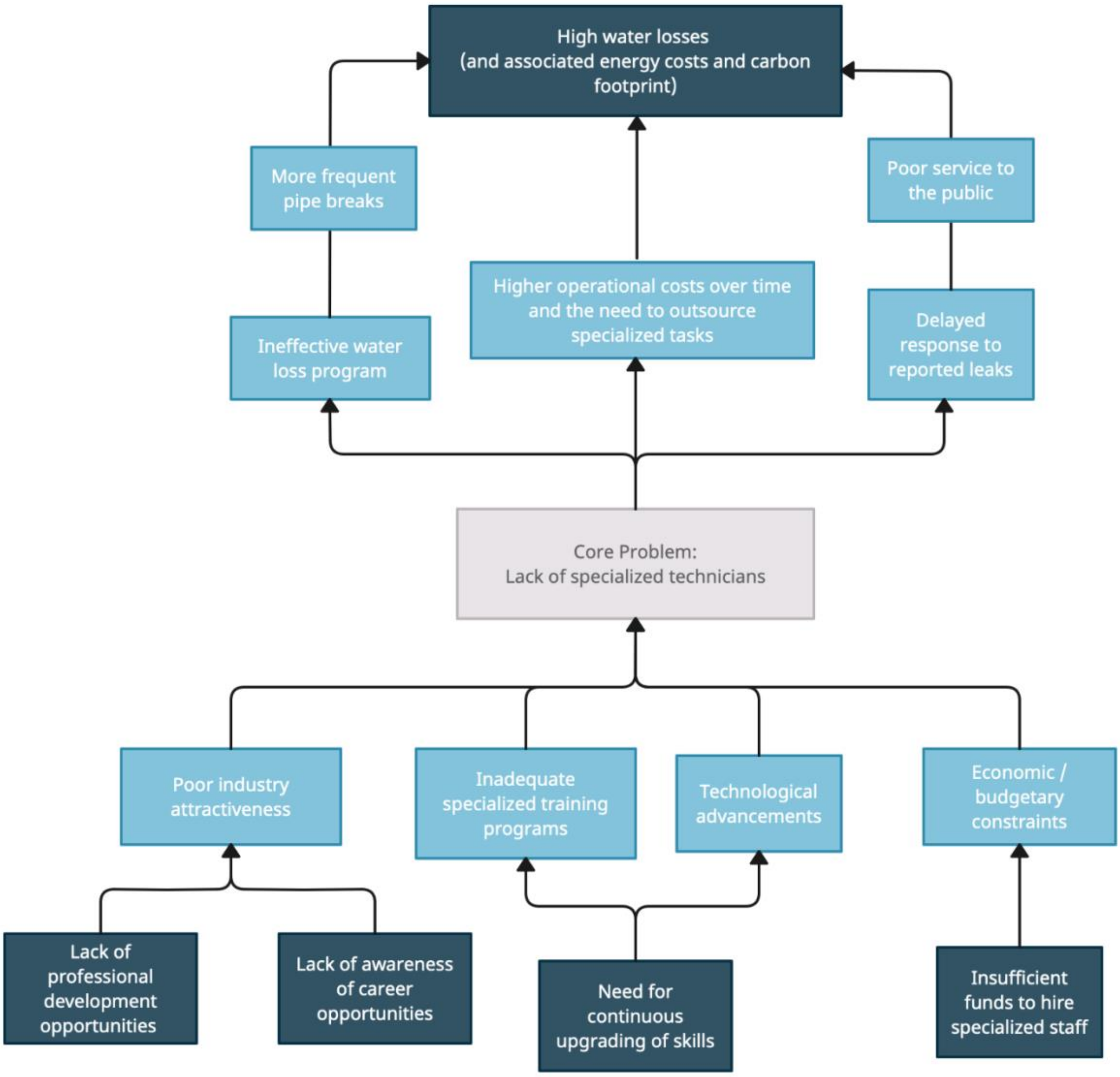
Lower water losses
(and associated energy costs and carbon footprint)
Reduced negative environmental impacts
Decreased overall costs of water supply due to efficient management.
Improved public trust
Effective water loss control
Improved adoption of technology
Reliable water services
Core Objective:
Reduced capital costs of advanced technologies
Affordable manufacturing costs
Improved importation costs and logistics
More local suppliers
Regional manufacturing of advanced technology
Exempted taxes and tariffs
More affordable transportation costs
Partnership between local suppliers and water utility to promote availability on island

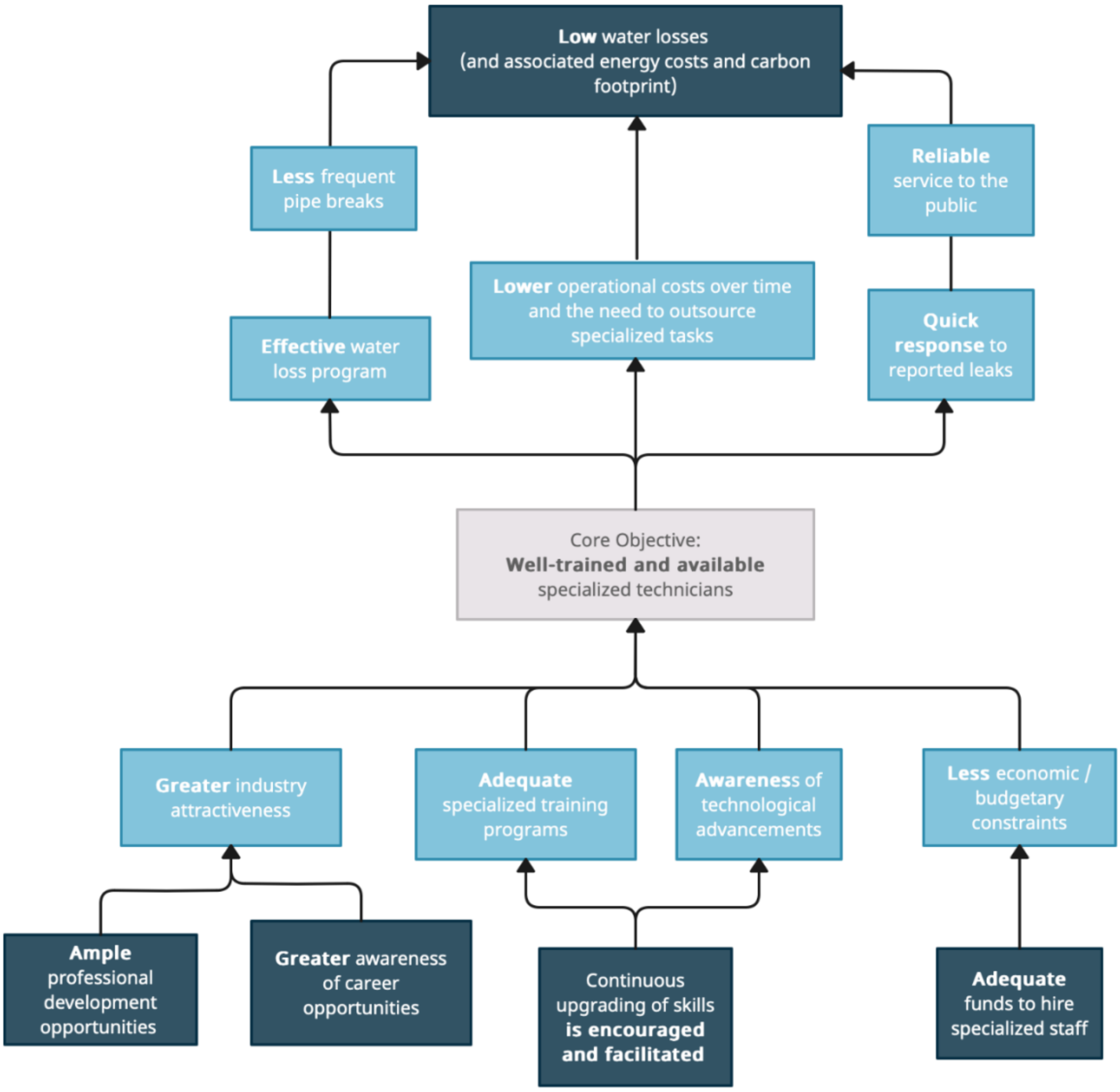

High water losses
(and associated energy costs and carbon footprint)
Negative environmental impacts
Increased cost to implement water loss prevention programs
Reduced public trust
Ineffective water loss control
Outsourcing of work to consultants
Poor water services
Core Problem:
Limited management skills to implement water loss prevention program
Limited experience with advanced technologies
Organization structure does not support implementation of new technologies
Resource constraints
Limited access to current knowledge and training for managers in best practices in water loss prevention
Inadequate budget and human resources

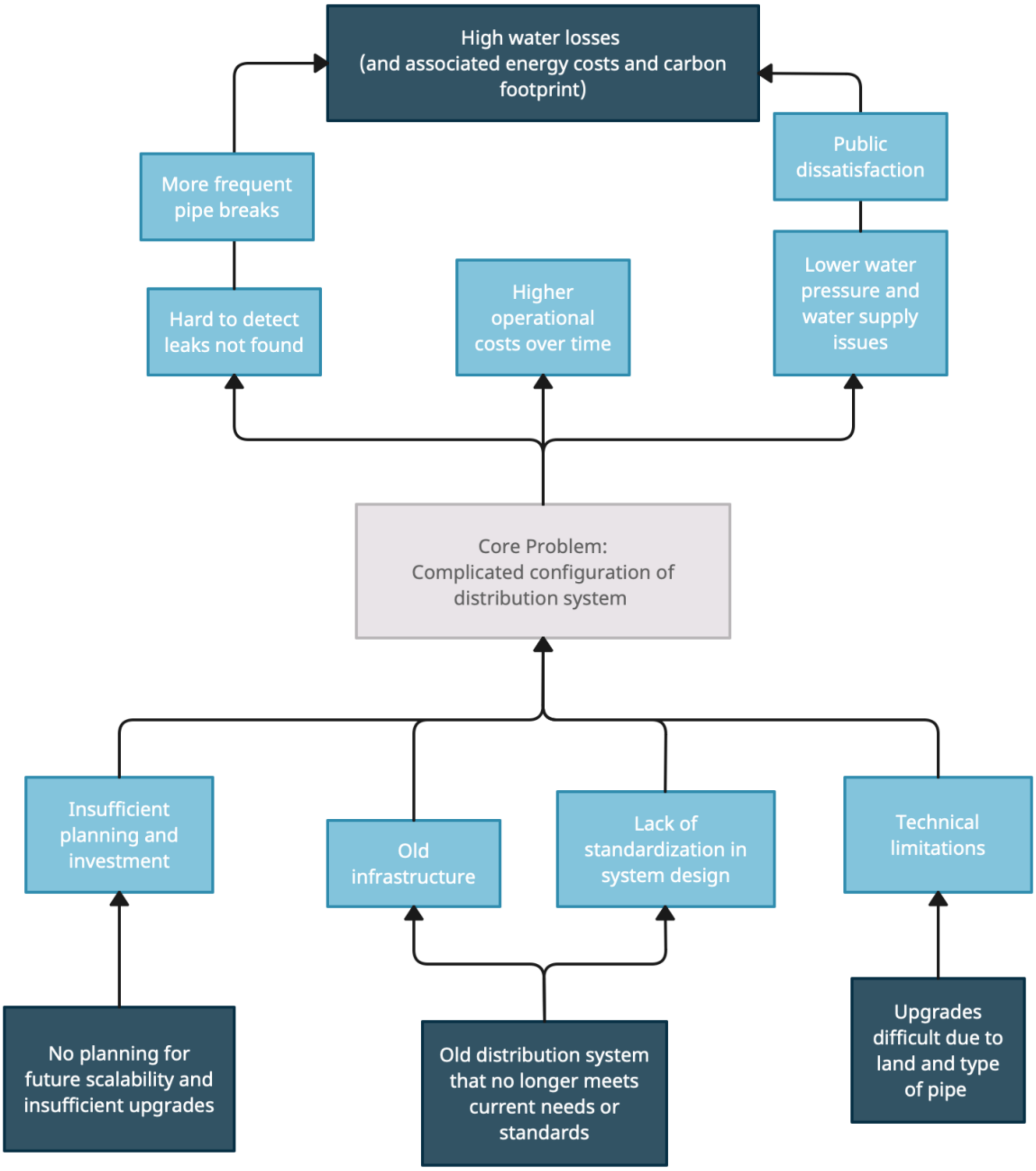

Lower water losses
(and associated energy costs and carbon footprint)
Reduced negative environmental impacts
Reduced cost to implement water loss prevention programs
Enhanced public trust
Effective water loss control
No outsourcing of work to consultants
Reliable water services
Core Objective:
Greater management skills to implement water loss prevention program
Enhanced experience with advanced technologies
Organization structure supports implementation of new technologies
Adequate resources to support implementation
More access to current knowledge and training for managers in best practices in water loss prevention
Adequate budget and human resources
Access to professional development programs offered by AWWA / CWWA
Corporatization of water utility to optimize provision of water services

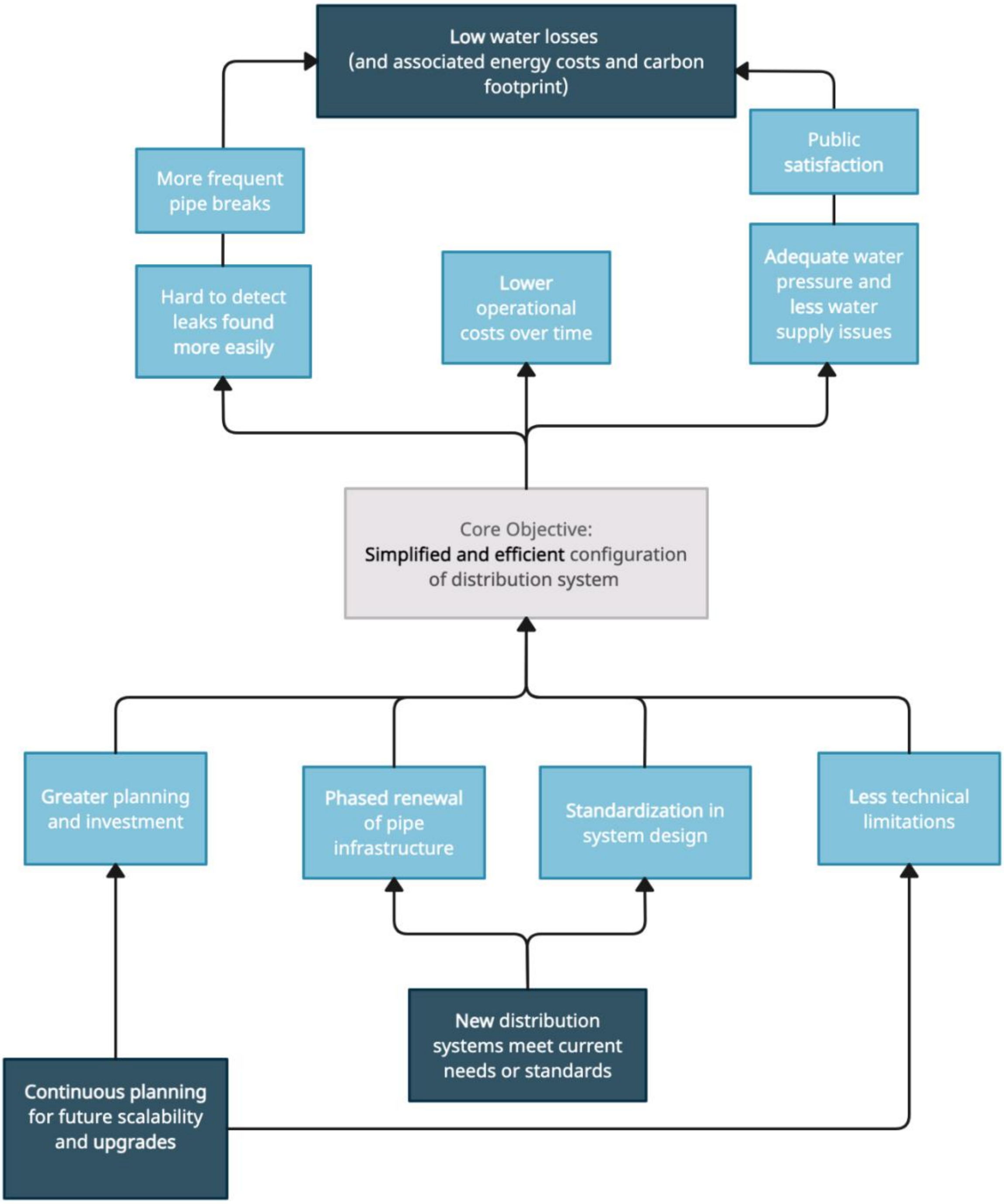

High water losses
(and associated energy costs and carbon footprint)
Negative environmental impacts
Reduced public trust
Ineffective water loss control
Insufficient investment in water loss prevention
Poor water services
Core Problem:
Lack of political will to prioritize water loss prevention
Limited public awareness
Competing priorities
Bureaucratic hurdles
Influence of powerful stakeholders
Lack of understanding about water loss management
Political focus on other issues perceived to be more urgent
Resistance to change and lack of understanding of need for timely investment
Lobbying by stakeholders that may be negatively impacted
Limited resources allocated to water loss prevention as benefits are longer term and not as tangible

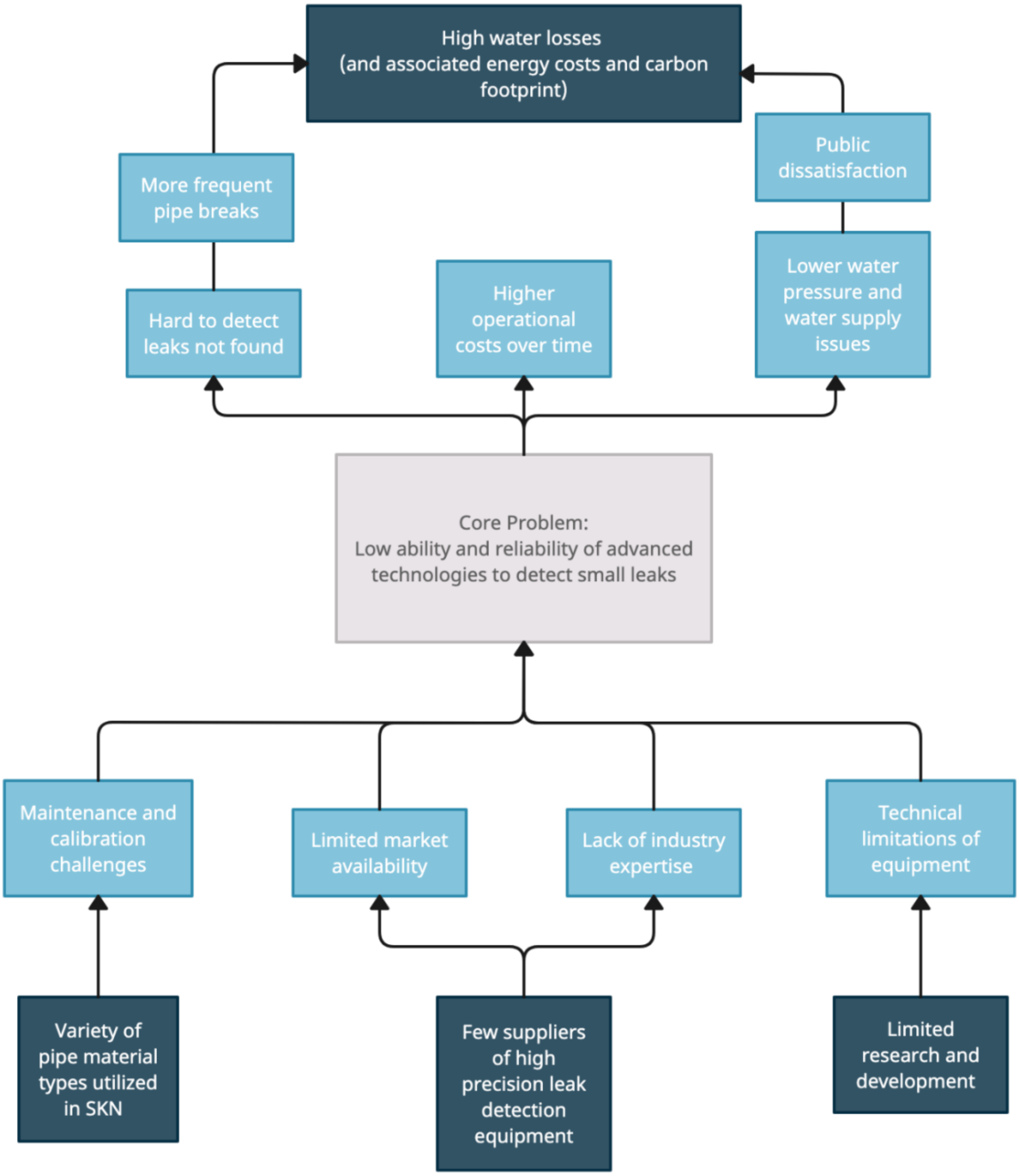

Less water losses
(and associated energy costs and carbon footprint)
Positive environmental impacts
Enhanced public trust
Greater water loss control
Effective investment in water loss prevention
Reliable water services
Core Objective:
Enhanced political will to prioritize water loss prevention
Greater public awareness
Prioritization of priorities
Less bureaucratic hurdles
All stakeholder are engaged appropriately
Good understanding about water loss management
Political focus on **water issues**
Embracing change and **greater** understanding of need for timely investment
Adequate resources allocated to water loss prevention as **long term benefits are prioritized**

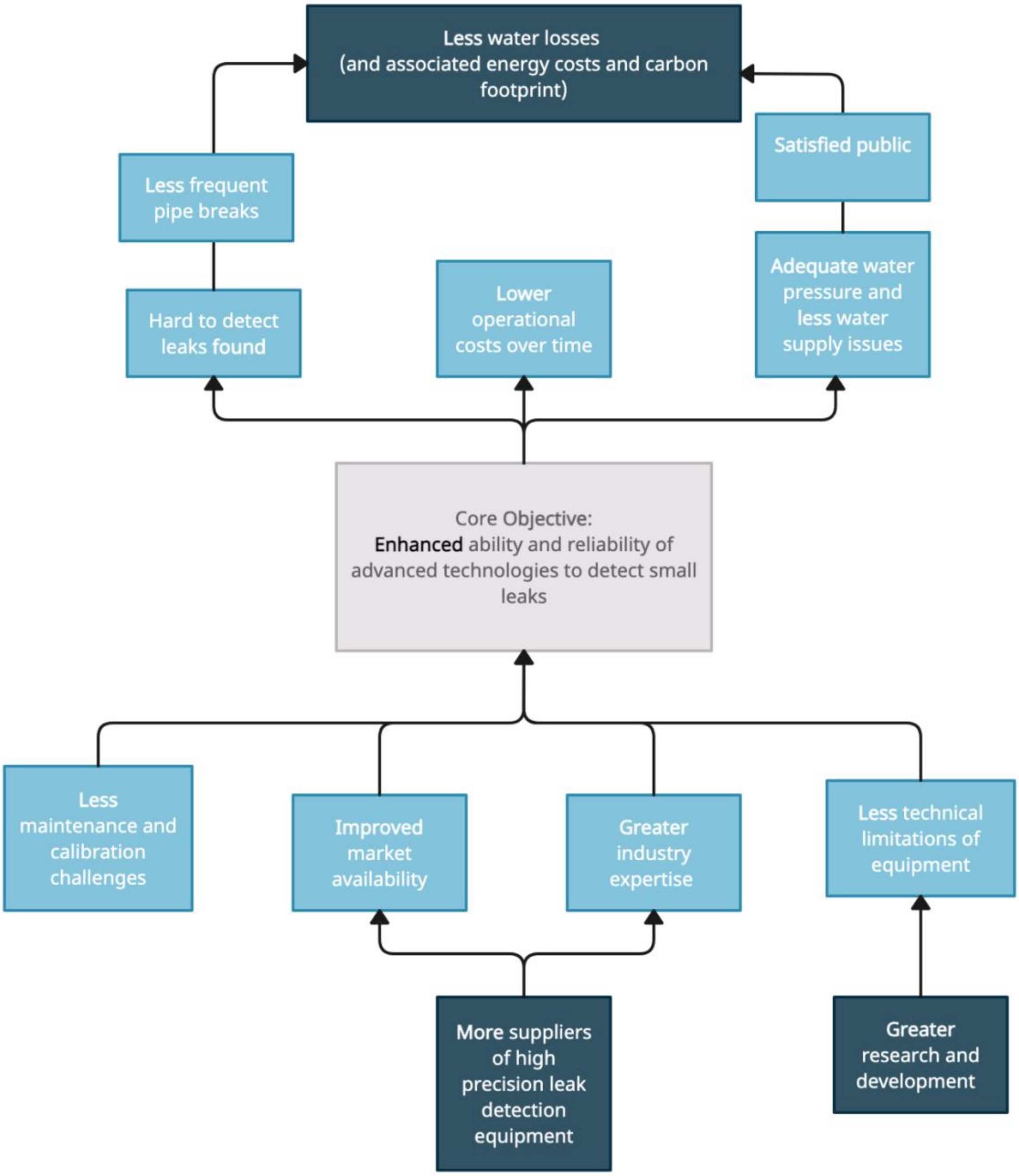

High water losses
(and associated energy costs and carbon footprint)
More frequent pipe breaks
Poor service to the public
Higher operational costs over time and the need to outsource specialized tasks
Ineffective water loss program
Delayed response to reported leaks
Core Problem:
Lack of specialized technicians
Poor industry attractiveness
Inadequate specialized training programs
Technological advancements
Economic / budgetary constraints
Lack of professional development opportunities
Lack of awareness of career opportunities
Need for continuous upgrading of skills
Insufficient funds to hire specialized staff

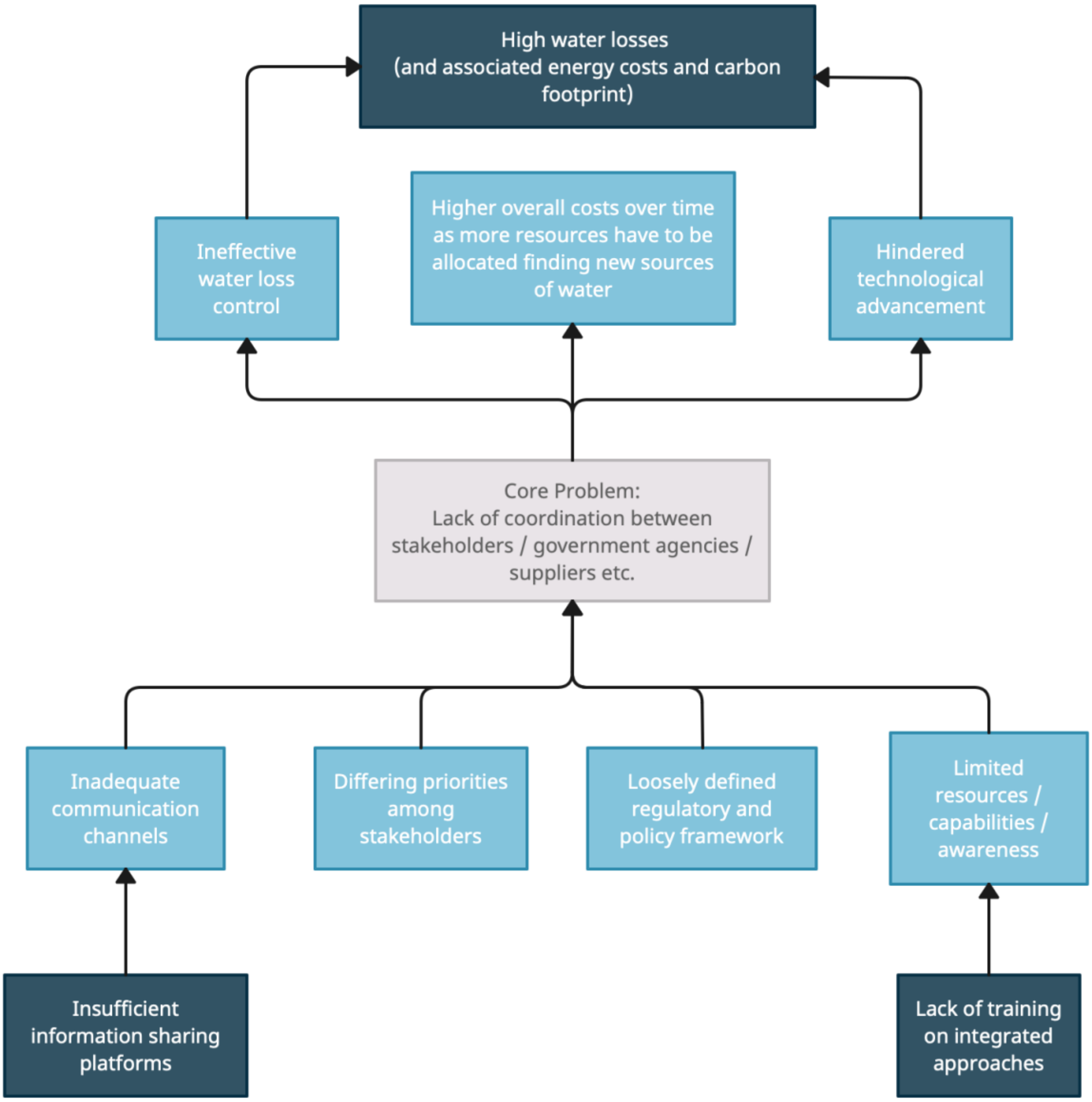

Low water losses
(and associated energy costs and carbon footprint)
Less frequent pipe breaks
Reliable service to the public
Lower operational costs over time and the need to outsource specialized tasks
Effective water loss program
Quick response to reported leaks
Core Objective:
Well-trained and available specialized technicians
Greater industry attractiveness
Adequate specialized training programs
Awareness of technological advancements
Less economic / budgetary constraints
Ample professional development opportunities
Greater awareness of career opportunities
Continuous upgrading of skills is encouraged and facilitated
Adequate funds to hire specialized staff

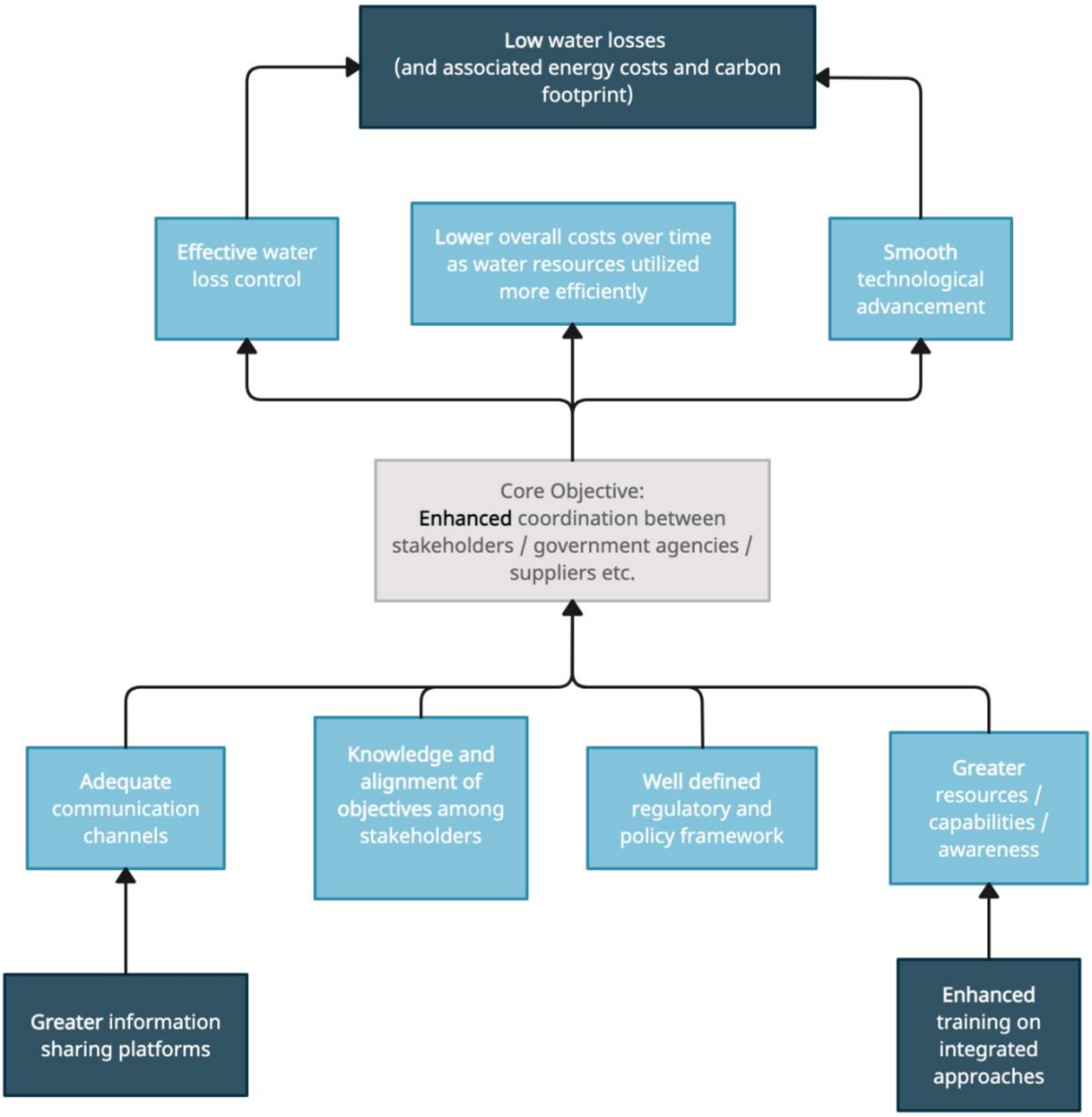

High water losses
(and associated energy costs and carbon footprint)
More frequent pipe breaks
Public dissatisfaction
Hard to detect leaks not found
Higher operational costs over time
Lower water pressure and water supply issues
Core Problem:
Complicated configuration of distribution system
Insufficient planning and investment
Old infrastructure
Lack of standardization in system design
Technical limitations
No planning for future scalability and insufficient upgrades
Old distribution system that no longer meets current needs or standards
Upgrades difficult due to land and type of pipe


Low water losses
(and associated energy costs and carbon footprint)
More frequent pipe breaks
Public satisfaction
Hard to detect leaks found more easily
Lower operational costs over time
Adequate water pressure and less water supply issues
Core Objective:
Simplified and efficient configuration of distribution system
Greater planning and investment
Phased renewal of pipe infrastructure
Standardization in system design
Less technical limitations
New distribution systems meet current needs or standards
Continuous planning for future scalability and upgrades

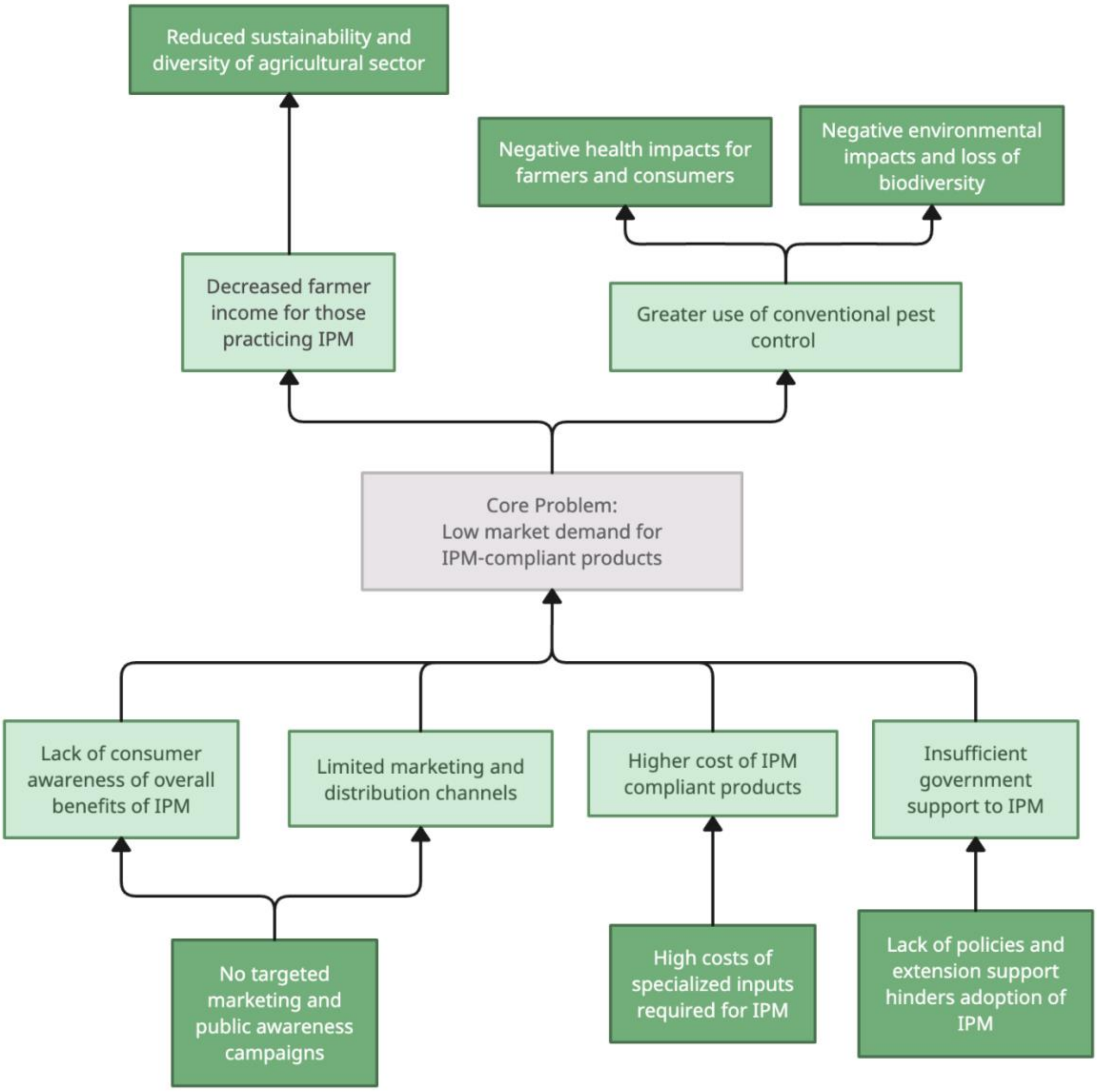

High water losses
(and associated energy costs and carbon footprint)
More frequent pipe breaks
Public dissatisfaction
Hard to detect leaks not found
Higher operational costs over time
Lower water pressure and water supply issues
Core Problem:
Low ability and reliability of advanced technologies to detect small leaks
Maintenance and calibration challenges
Limited market availability
Lack of industry expertise
Technical limitations of equipment
Variety of pipe material types utilized in SKN
Few suppliers of high precision leak detection equipment
Limited research and development

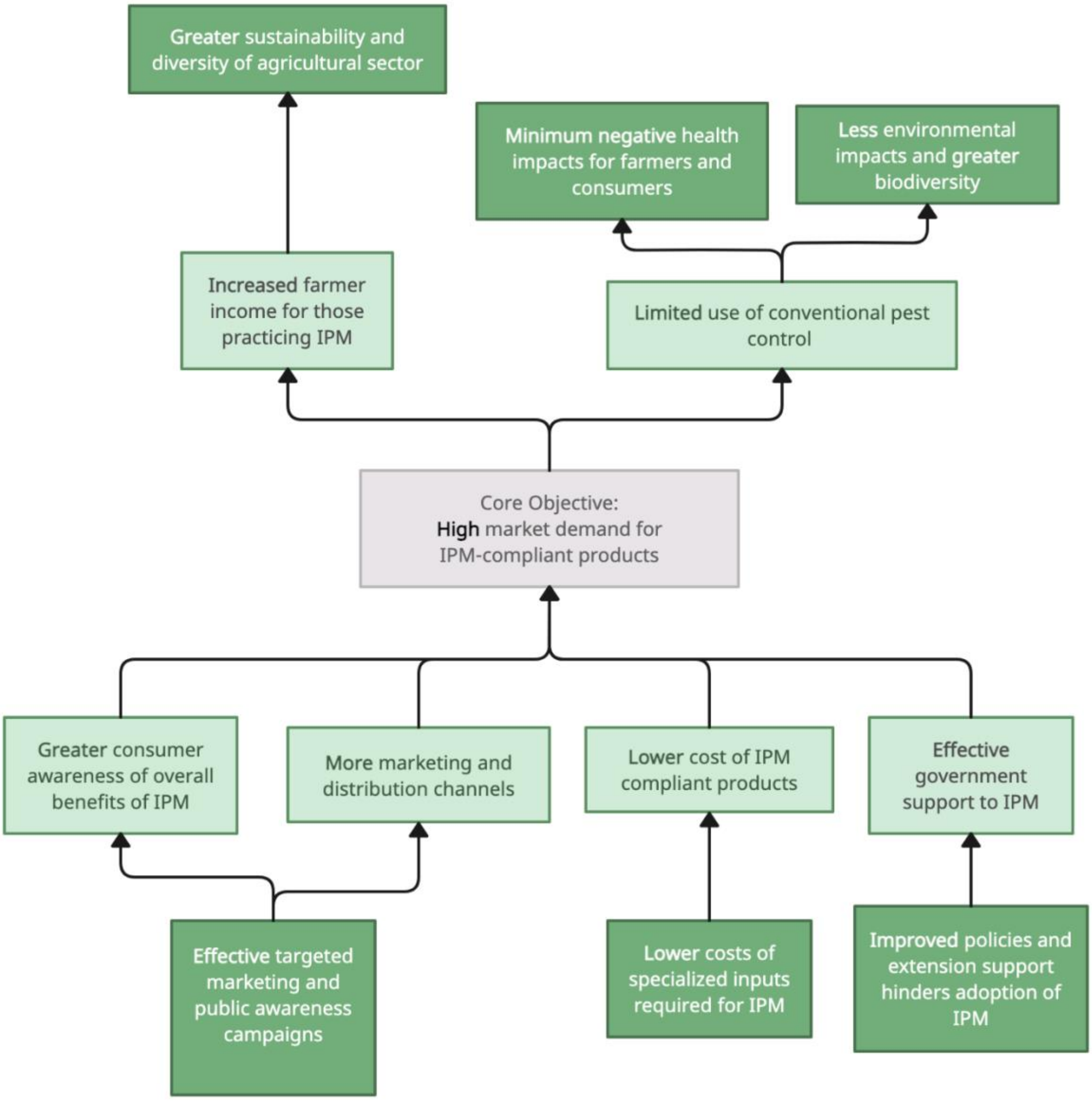

Less water losses
(and associated energy costs and carbon footprint)
Less frequent pipe breaks
Satisfied public
Hard to detect leaks found
Lower operational costs over time
Adequate water pressure and less water supply issues
Core Objective:
Enhanced ability and reliability of advanced technologies to detect small leaks
Less maintenance and calibration challenges
Improved market availability
Greater industry expertise
Less technical limitations of equipment
More suppliers of high precision leak detection equipment
Greater research and development

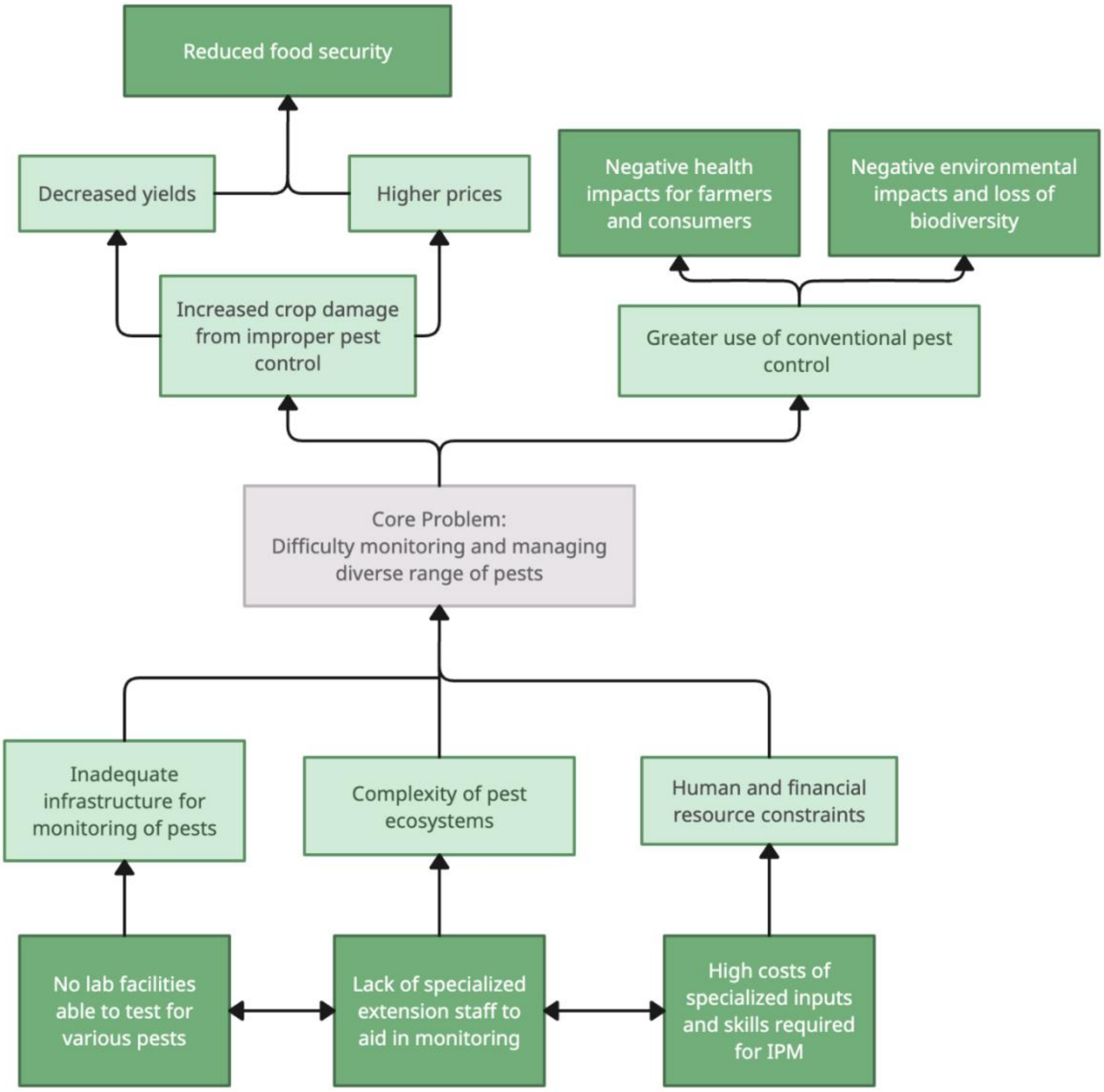

High water losses
(and associated energy costs and carbon footprint)
Ineffective water loss control
Higher overall costs over time as more resources have to be allocated finding new sources of water
Hindered technological advancement
Core Problem:
Lack of coordination between stakeholders / government agencies / suppliers etc.
Inadequate communication channels
Differing priorities among stakeholders
Loosely defined regulatory and policy framework
Limited resources / capabilities / awareness
Insufficient information sharing platforms
Lack of training on integrated approaches


Low water losses
(and associated energy costs and carbon footprint)
Effective water loss control
Lower overall costs over time as water resources utilized more efficiently
Smooth technological advancement
Core Objective:
Enhanced coordination between stakeholders / government agencies / suppliers etc.
Adequate communication channels
Knowledge and alignment of objectives among stakeholders
Well defined regulatory and policy framework
Greater resources / capabilities / awareness
Greater information sharing platforms
Enhanced training on integrated approaches

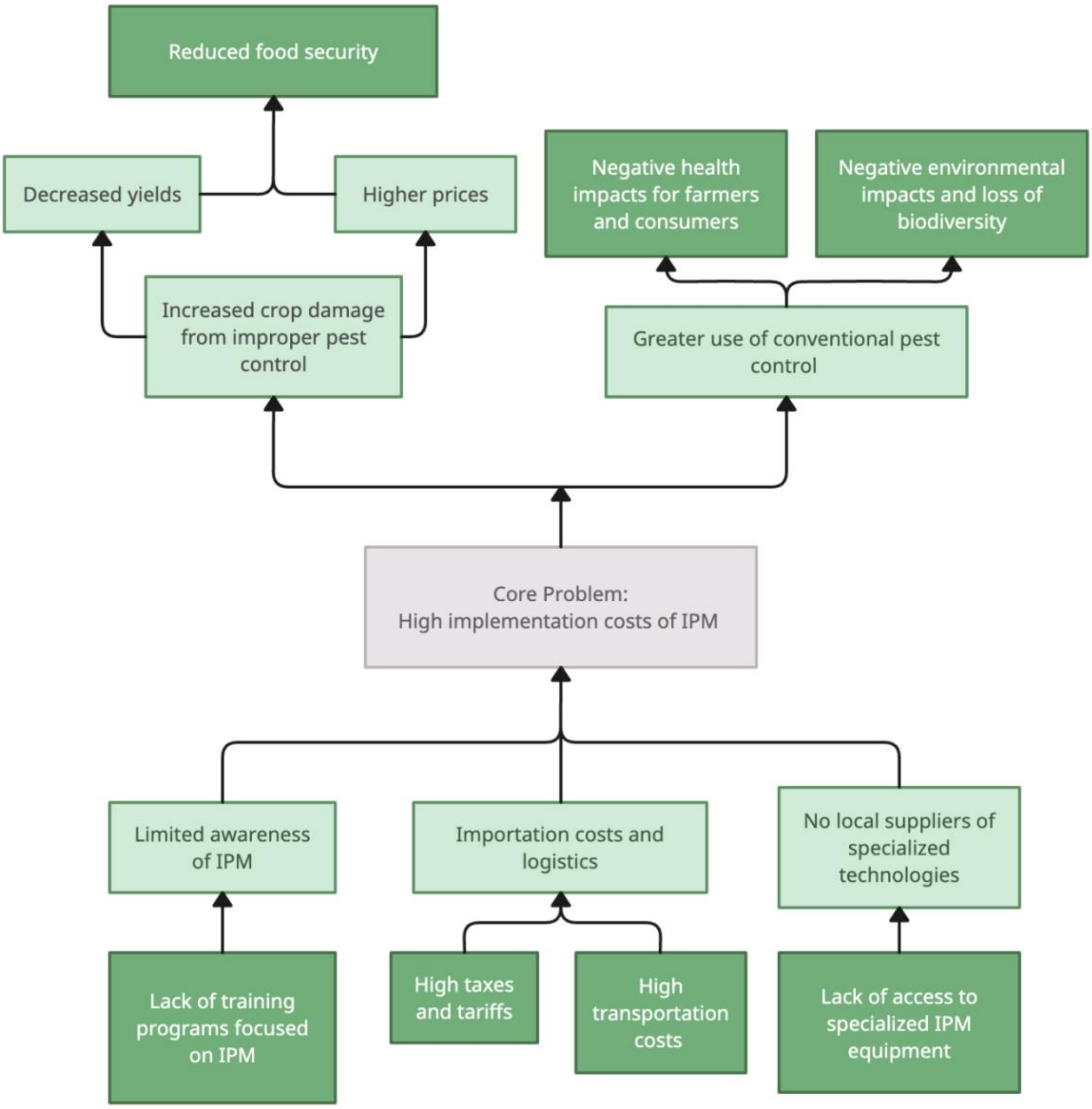
Annex III: Problem and Objective Trees – Agriculture Sector

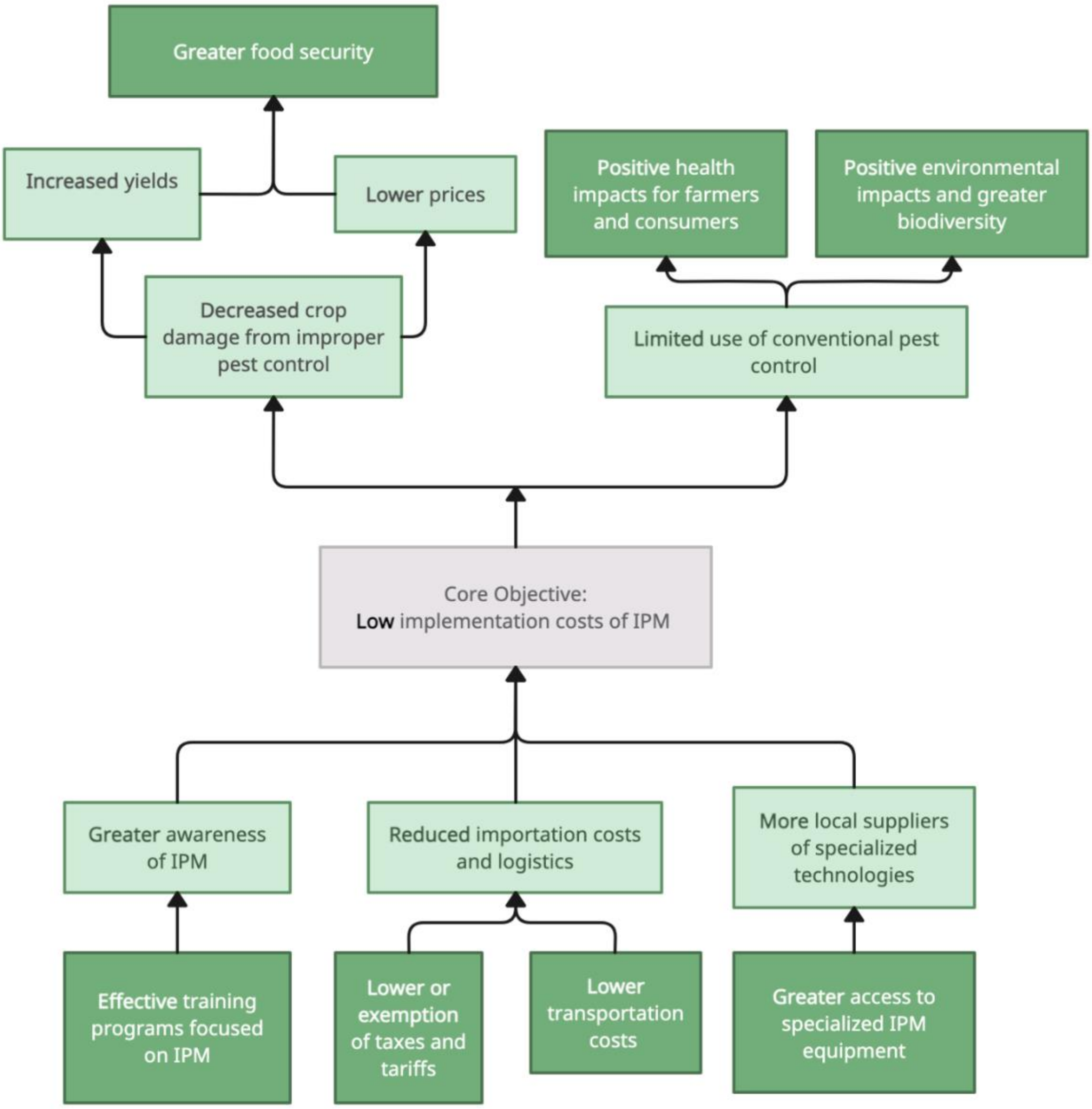


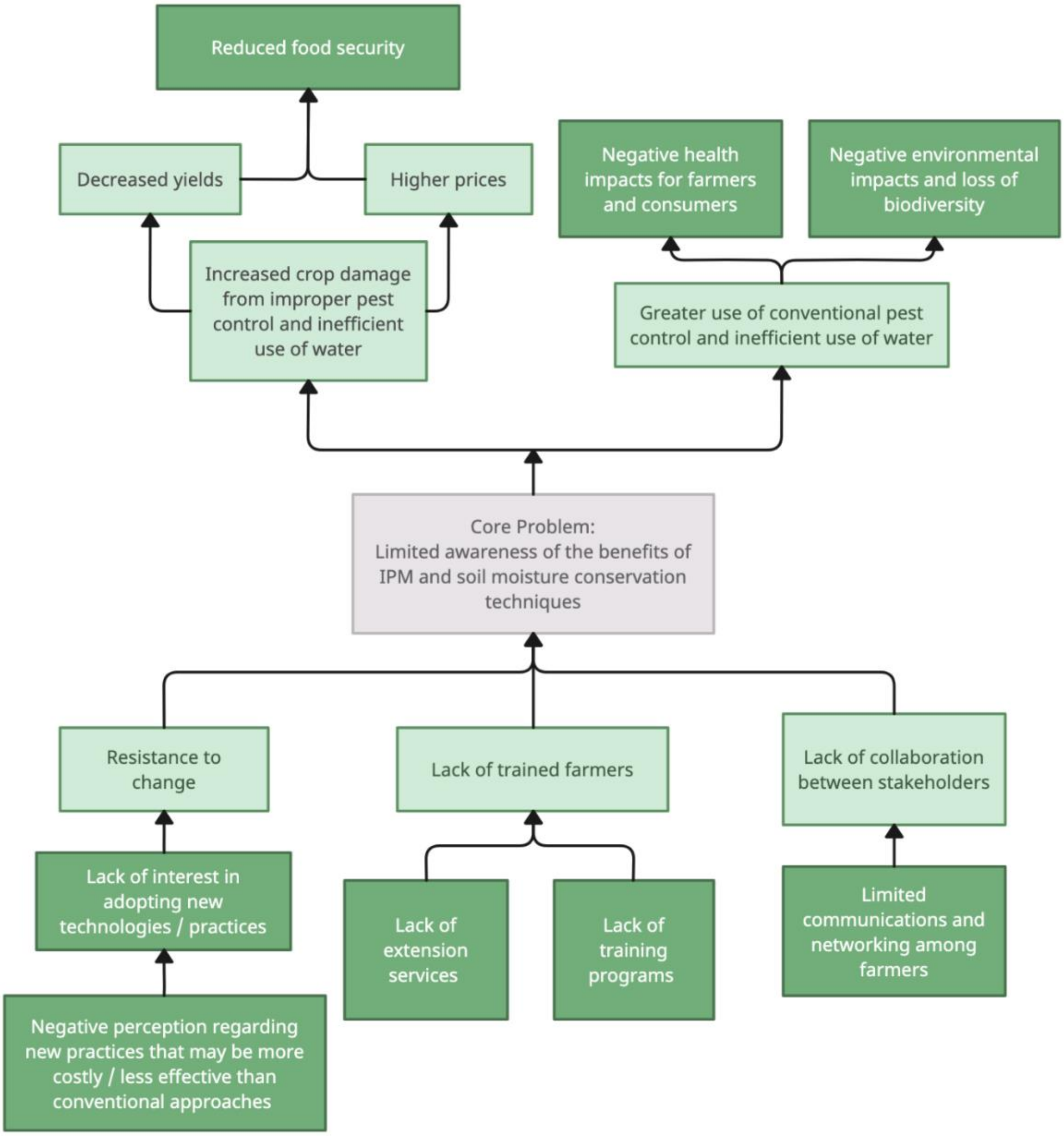

Greater sustainability and diversity of agricultural sector
Minimum negative health impacts for farmers and consumers
Less environmental impacts and greater biodiversity
Increased farmer income for those practicing IPM
Limited use of conventional pest control
Core Objective:
High market demand for IPM-compliant products
Greater consumer awareness of overall benefits of IPM
More marketing and distribution channels
Lower cost of IPM compliant products
Effective government support to IPM
Effective targeted marketing and public awareness campaigns
Lower costs of specialized inputs required for IPM
Improved policies and extension support hinders adoption of IPM

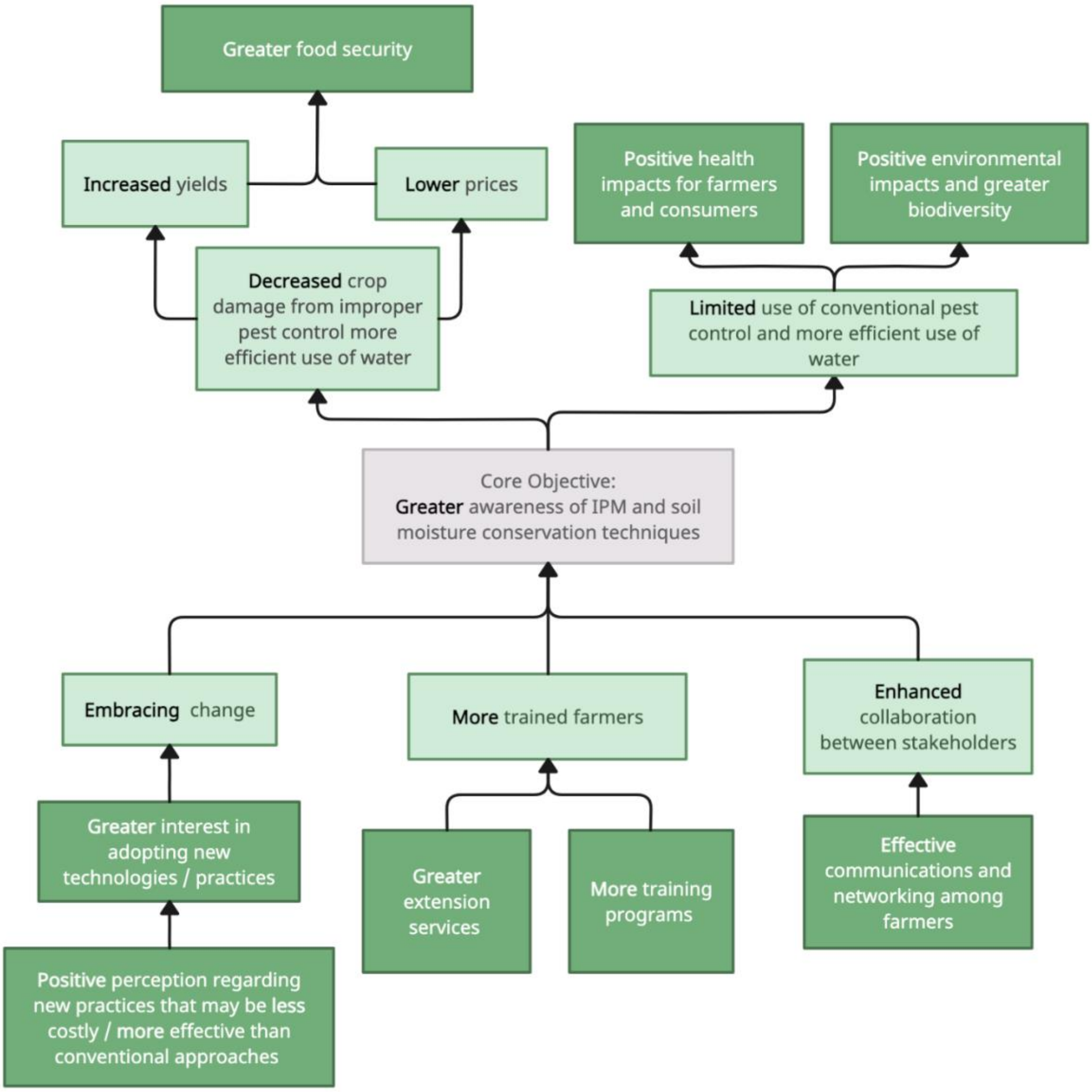

Reduced food security
Decreased yields
Higher prices
Negative health impacts for farmers and consumers
Negative environmental impacts and loss of biodiversity
Increased crop damage from improper pest control
Greater use of conventional pest control
Core Problem:
Difficulty monitoring and managing diverse range of pests
Inadequate infrastructure for monitoring of pests
Complexity of pest ecosystems
Human and financial resource constraints
No lab facilities able to test for various pests
Lack of specialized extension staff to aid in monitoring
High costs of specialized inputs and skills required for IPM

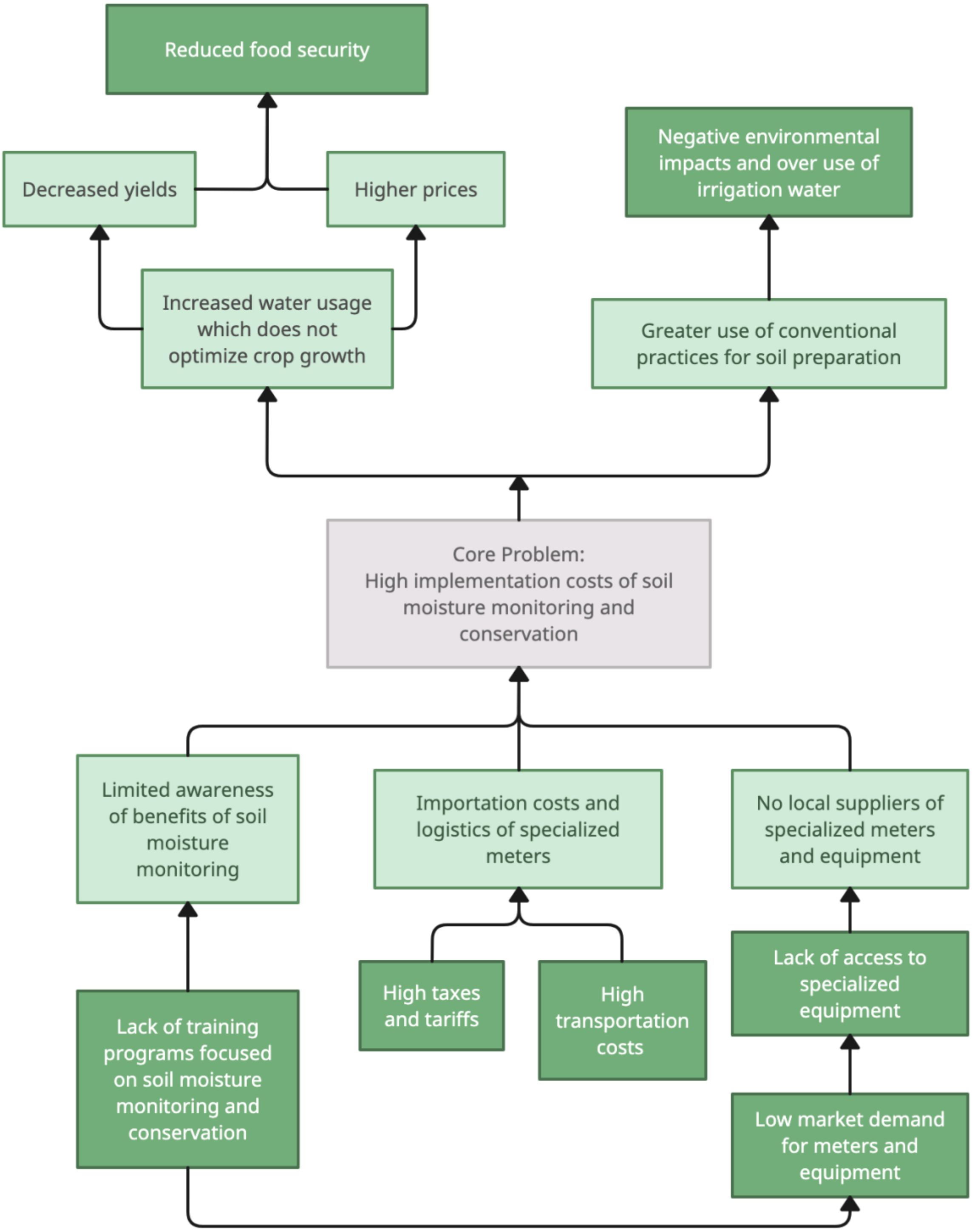

Greater food security
Increased yields
Lower prices
Positive health impacts for farmers and consumers
Positive environmental impacts and greater biodiversity
Decreased crop damage from improper pest control
Limited use of conventional pest control
Core Objective:
Effective monitoring and managing diverse range of pests
Enhanced infrastructure for monitoring of pests
Complexity of pest ecosystems
Effective allocation of human and financial resource
Greater ability to test for various pests
More specialized extension staff to aid in monitoring
Lower costs of specialized inputs and greater skills required for IPM

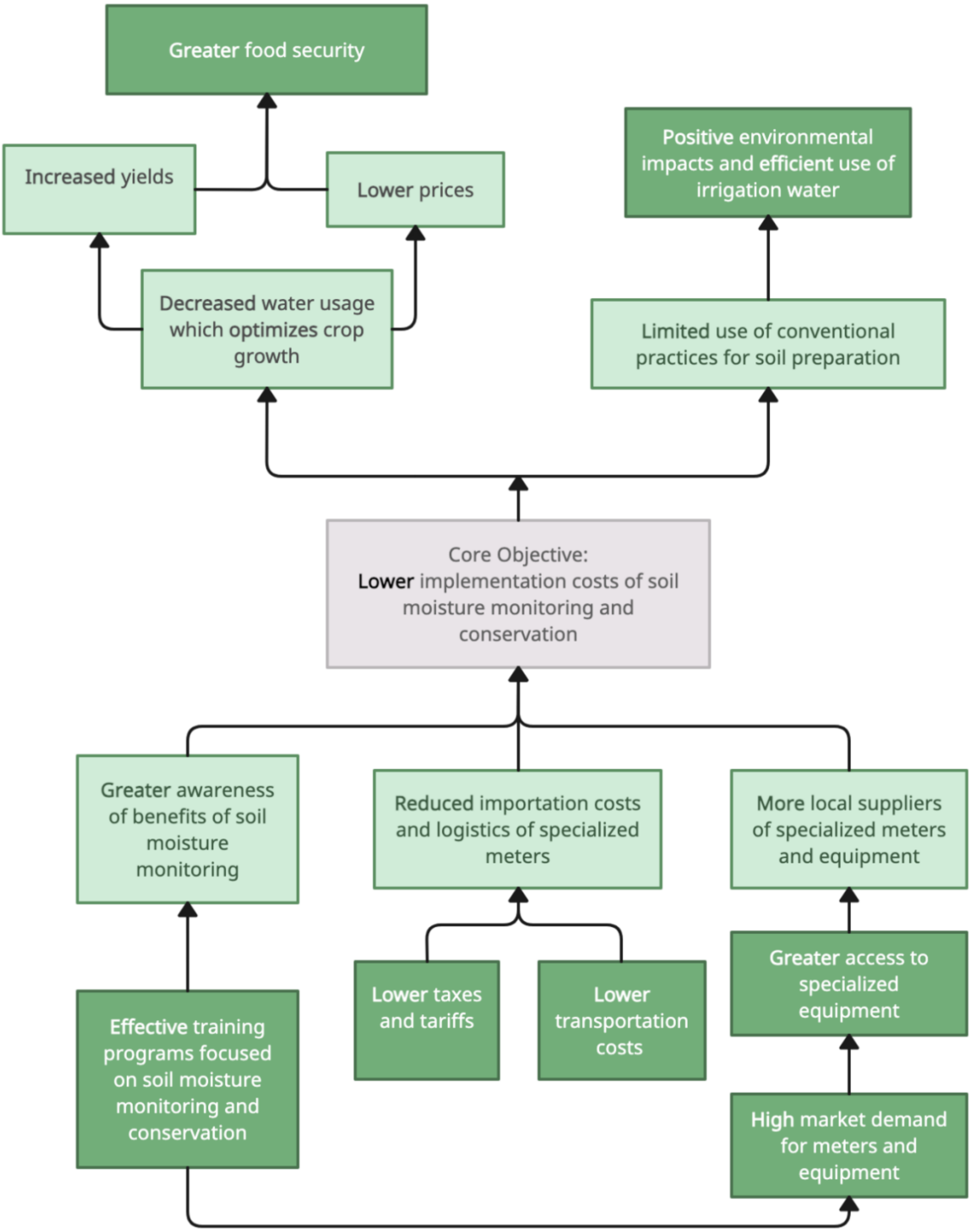

Reduced food security
Decreased yields
Higher prices
Negative health impacts for farmers and consumers
Negative environmental impacts and loss of biodiversity
Increased crop damage from improper pest control
Greater use of conventional pest control
Core Problem:
High implementation costs of IPM
Limited awareness of IPM
Importation costs and logistics
No local suppliers of specialized technologies
Lack of training programs focused on IPM
High taxes and tariffs
High transportation costs
Lack of access to specialized IPM equipment

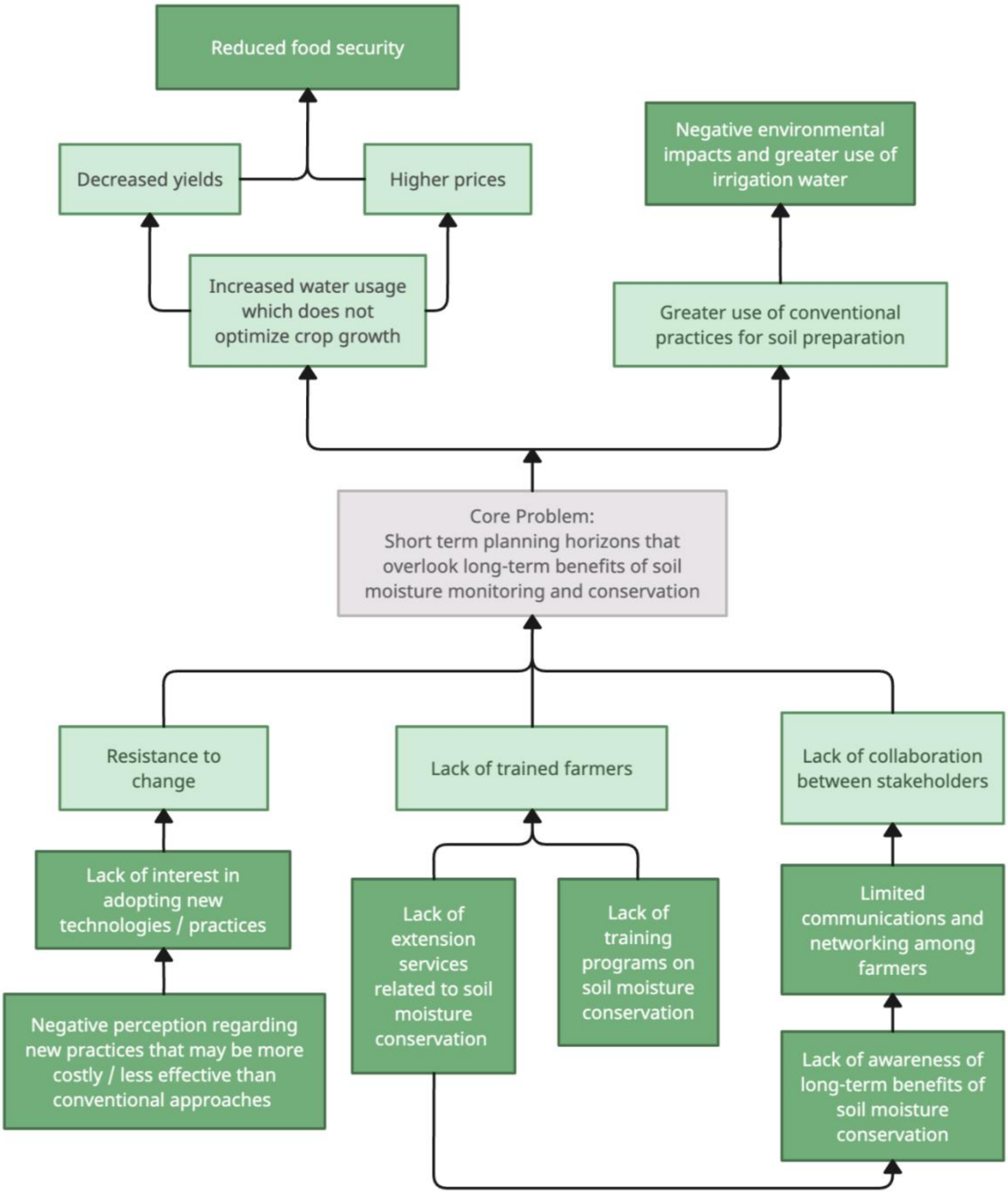

Greater food security
Increased yields
Lower prices
Positive health impacts for farmers and consumers
Positive environmental impacts and greater biodiversity
Decreased crop damage from improper pest control
Limited use of conventional pest control
Core Objective:
Low implementation costs of IPM
Greater awareness of IPM
Reduced importation costs and logistics
More local suppliers of specialized technologies
Effective training programs focused on IPM
Lower or exemption of taxes and tariffs
Lower transportation costs
Greater access to specialized IPM equipment

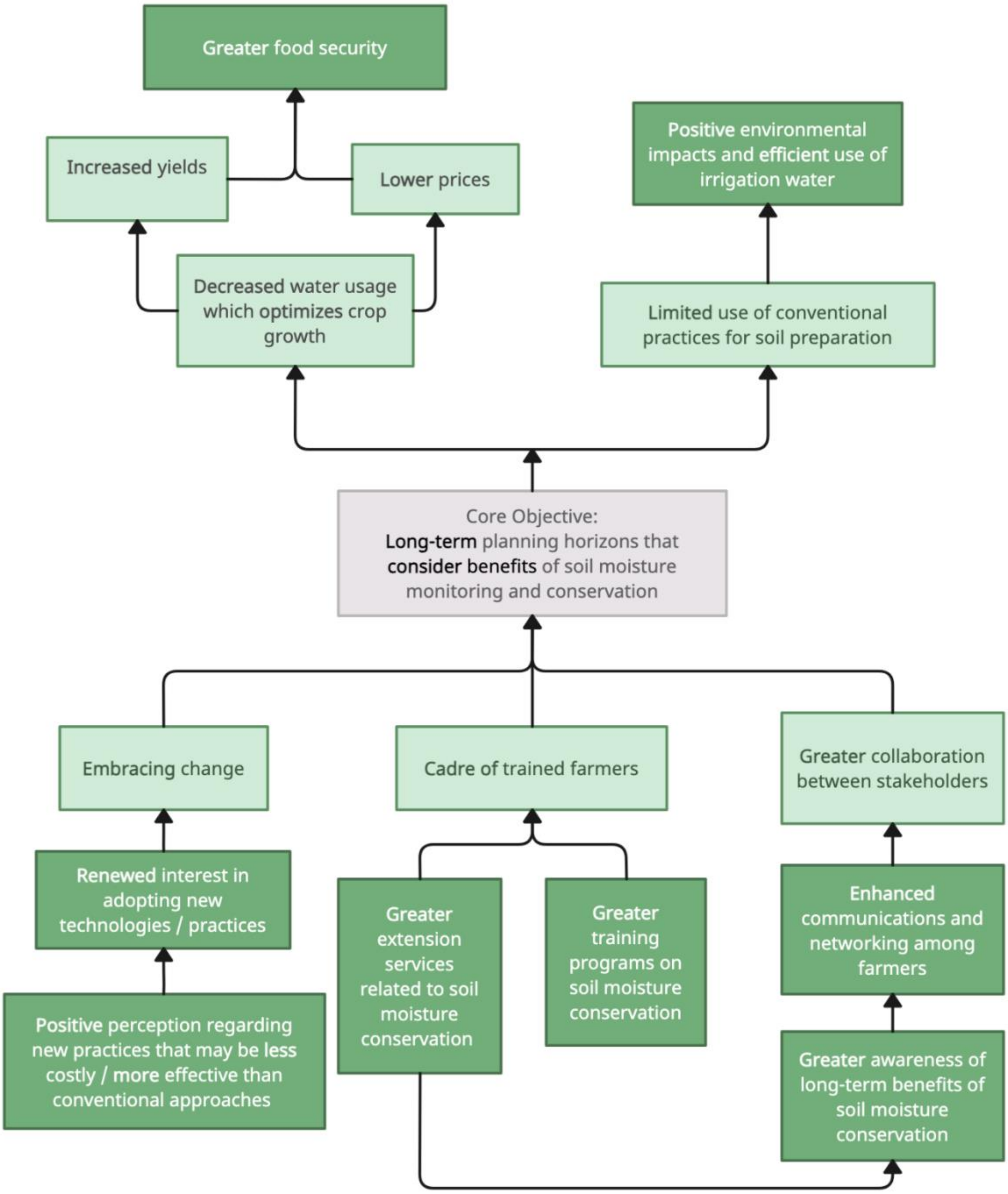

Reduced food security
Decreased yields
Higher prices
Negative health impacts for farmers and consumers
Negative environmental impacts and loss of biodiversity
Increased crop damage from improper pest control and inefficient use of water
Greater use of conventional pest control and inefficient use of water
Core Problem:
Limited awareness of the benefits of IPM and soil moisture conservation techniques
Resistance to change
Lack of trained farmers
Lack of collaboration between stakeholders
Lack of interest in adopting new technologies / practices
Lack of extension services
Lack of training programs
Limited communications and networking among farmers
Negative perception regarding new practices that may be more costly / less effective than conventional approaches


Greater food security
Increased yields
Lower prices
Positive health impacts for farmers and consumers
Positive environmental impacts and greater biodiversity
Decreased crop damage from improper pest control more efficient use of water
Limited use of conventional pest control and more efficient use of water
Core Objective:
Greater awareness of IPM and soil moisture conservation techniques
Embracing change
More trained farmers
Enhanced collaboration between stakeholders
Greater interest in adopting new technologies / practices
Greater extension services
More training programs
Effective communications and networking among farmers
Positive perception regarding new practices that may be less costly / more effective than conventional approaches

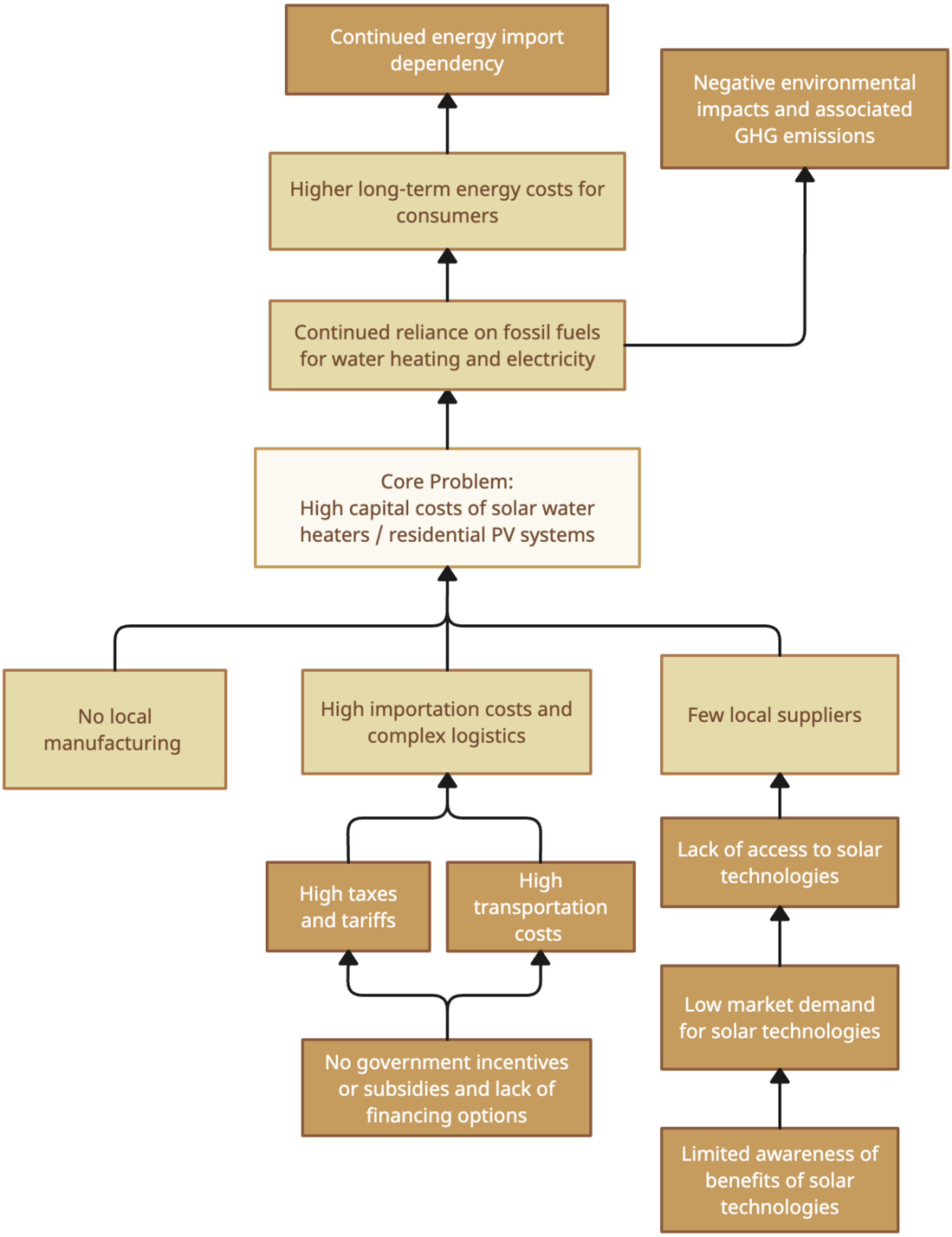

Reduced food security
Decreased yields
Higher prices
Negative environmental impacts and over use of irrigation water
Increased water usage which does not optimize crop growth
Greater use of conventional practices for soil preparation
Core Problem:
High implementation costs of soil moisture monitoring and conservation
Limited awareness of benefits of soil moisture monitoring
Importation costs and logistics of specialized meters
No local suppliers of specialized meters and equipment
High taxes and tariffs
High transportation costs
Lack of access to specialized equipment
Lack of training programs focused on soil moisture monitoring and conservation
Low market demand for meters and equipment

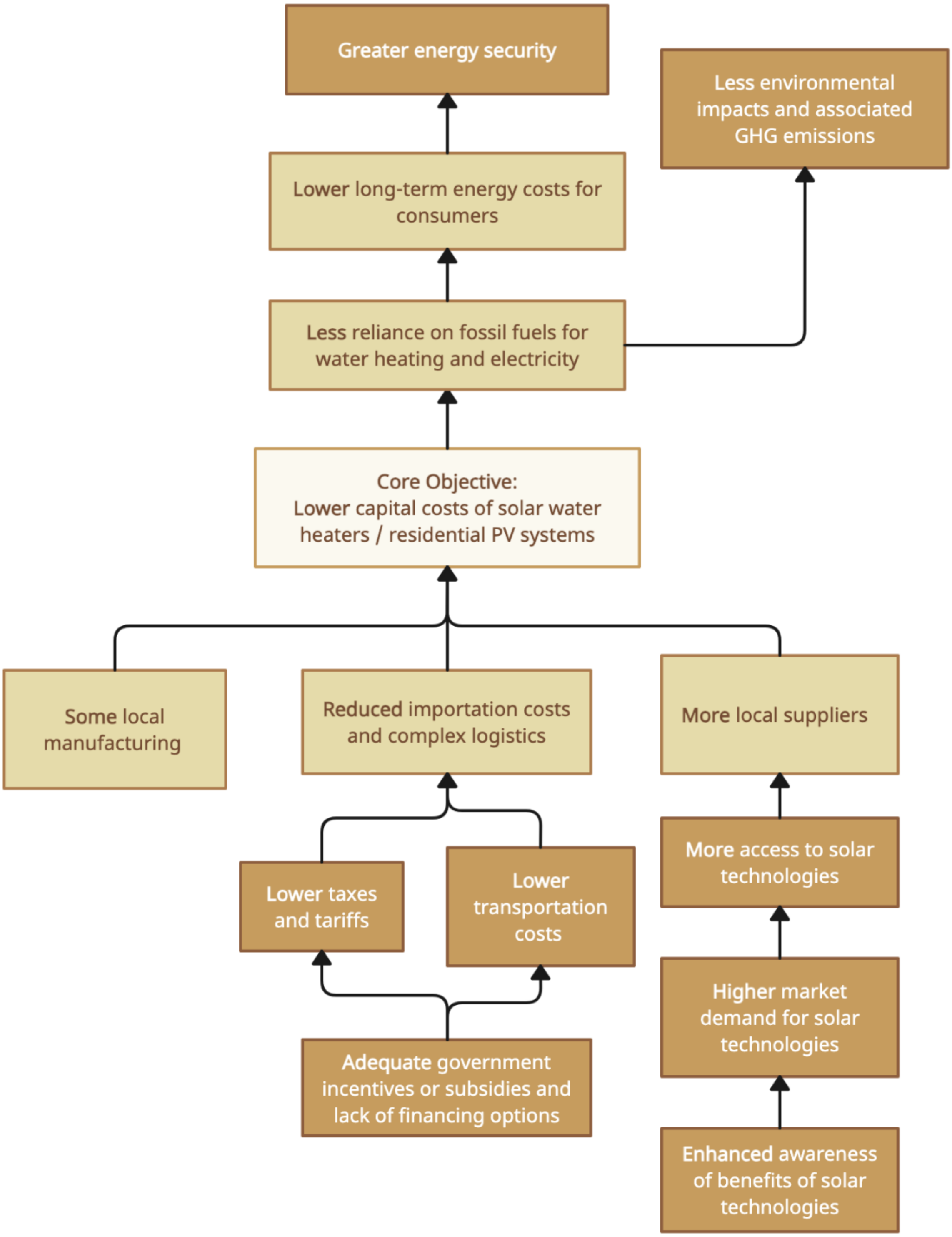

Greater food security
Increased yields
Lower prices
Positive environmental impacts and efficient use of irrigation water
Decreased water usage which optimizes crop growth
Limited use of conventional practices for soil preparation
Core Objective:
Lower implementation costs of soil moisture monitoring and conservation
Greater awareness of benefits of soil moisture monitoring
Reduced importation costs and logistics of specialized meters
More local suppliers of specialized meters and equipment
Greater access to specialized equipment
Lower taxes and tariffs
Lower transportation costs
Effective training programs focused on soil moisture monitoring and conservation
High market demand for meters and equipment

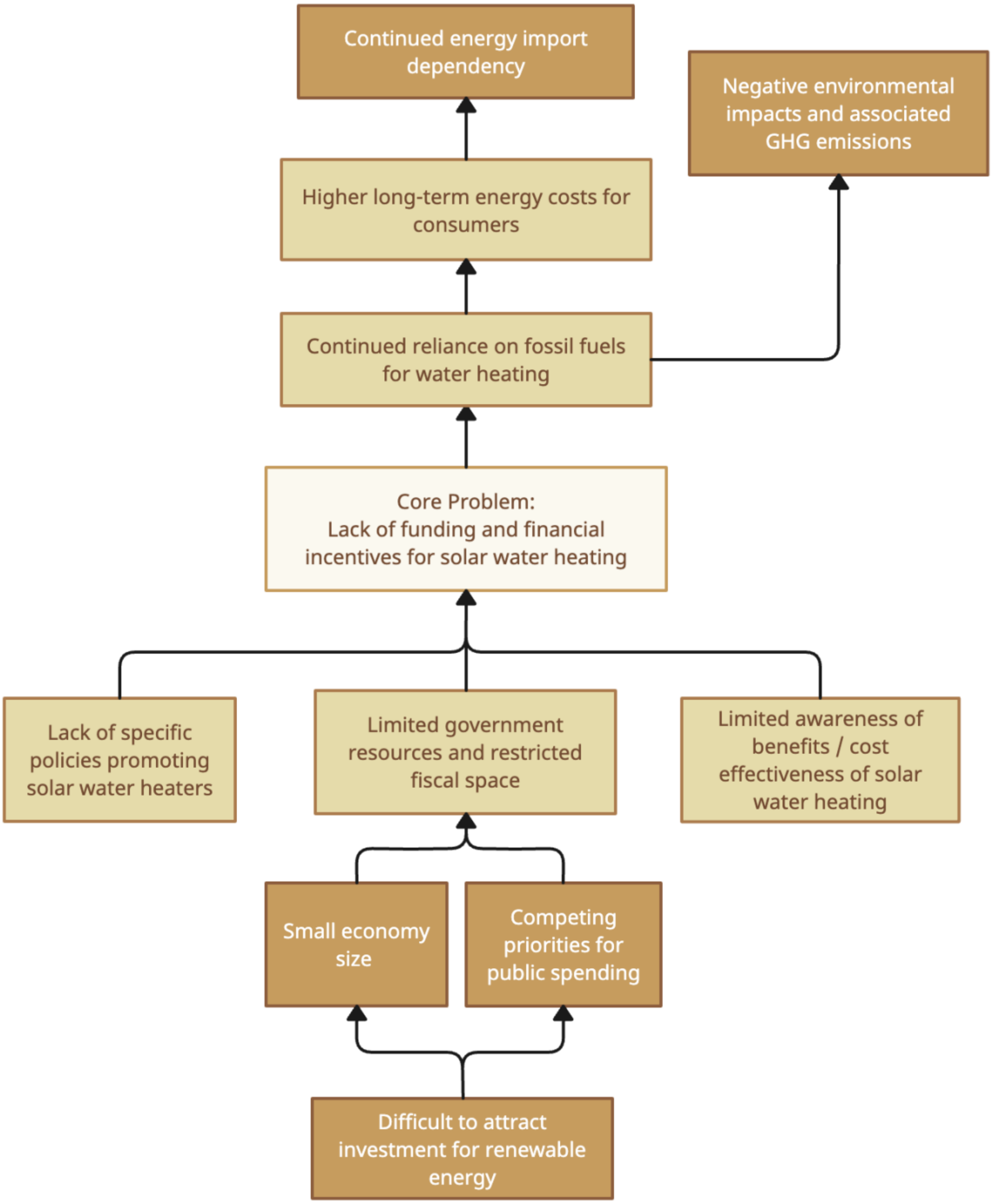

Reduced food security
Decreased yields
Higher prices
Negative environmental impacts and greater use of irrigation water
Increased water usage which does not optimize crop growth
Greater use of conventional practices for soil preparation
Core Problem:
Short term planning horizons that overlook long-term benefits of soil moisture monitoring and conservation
Resistance to change
Lack of trained farmers
Lack of collaboration between stakeholders
Lack of interest in adopting new technologies / practices
Negative perception regarding new practices that may be more costly / less effective than conventional approaches
Lack of extension services related to soil moisture conservation
Lack of training programs on soil moisture conservation
Limited communications and networking among farmers
Lack of awareness of long-term benefits of soil moisture conservation

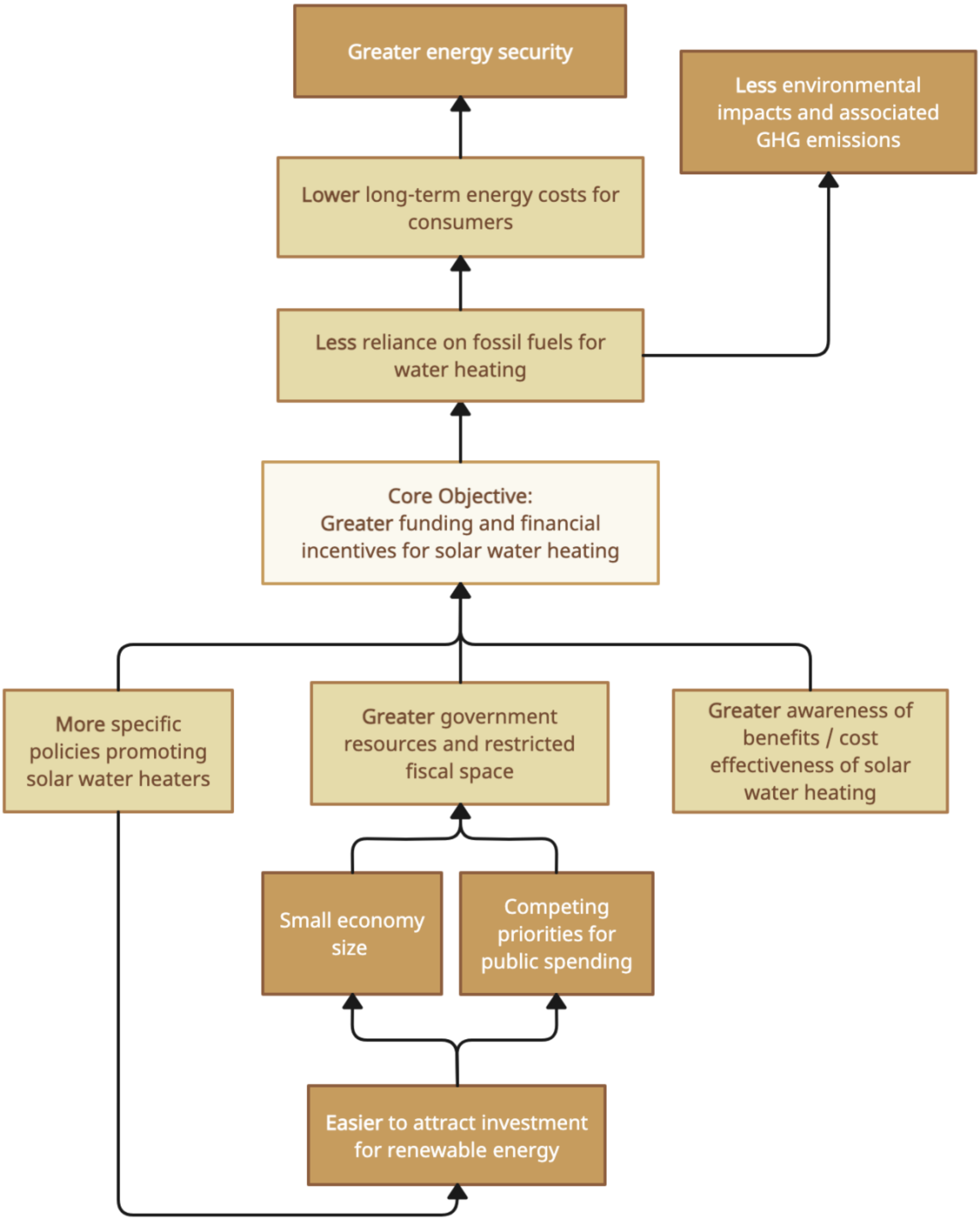

Greater food security
Increased yields
Lower prices
Positive environmental impacts and efficient use of irrigation water
Decreased water usage which optimizes crop growth
Limited use of conventional practices for soil preparation
Core Objective:
Long-term planning horizons that consider benefits of soil moisture monitoring and conservation
Embracing change
Cadre of trained farmers
Greater collaboration between stakeholders
Renewed interest in adopting new technologies / practices
Greater extension services related to soil moisture conservation
Greater training programs on soil moisture conservation
Enhanced communications and networking among farmers
Positive perception regarding new practices that may be less costly / more effective than conventional approaches
Greater awareness of long-term benefits of soil moisture conservation

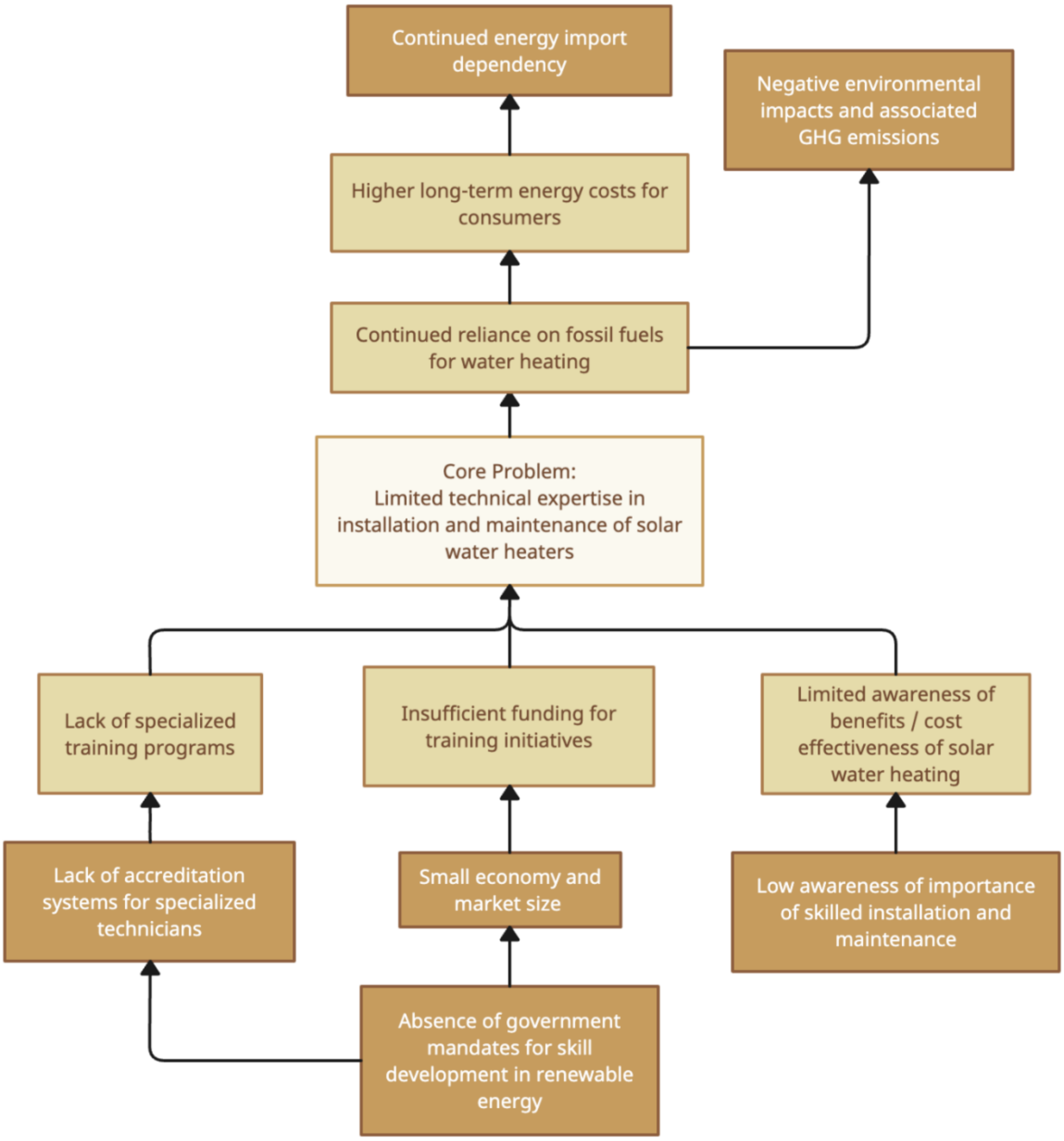
Annex IV: Problem and Objective Trees – Energy Sector



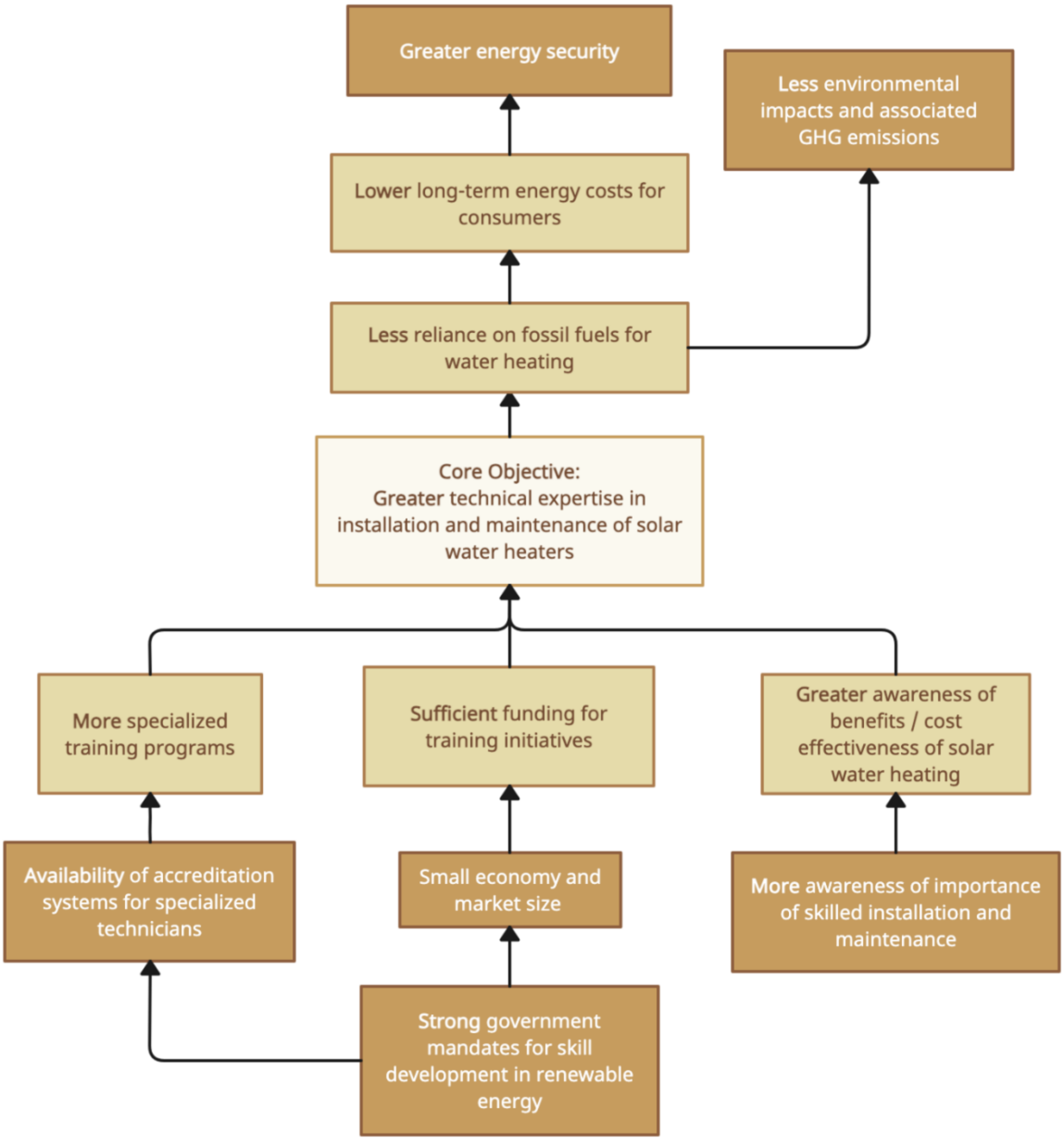

Greater energy security
Less environmental impacts and associated GHG emissions
Lower long-term energy costs for consumers
Less reliance on fossil fuels for water heating and electricity
Core Objective:
Lower capital costs of solar water heaters / residential PV systems
Some local manufacturing
Reduced importation costs and complex logistics
More local suppliers
Lower taxes and tariffs
Lower transportation costs
More access to solar technologies
Higher market demand for solar technologies
Adequate government incentives or subsidies and lack of financing options
Enhanced awareness of benefits of solar technologies

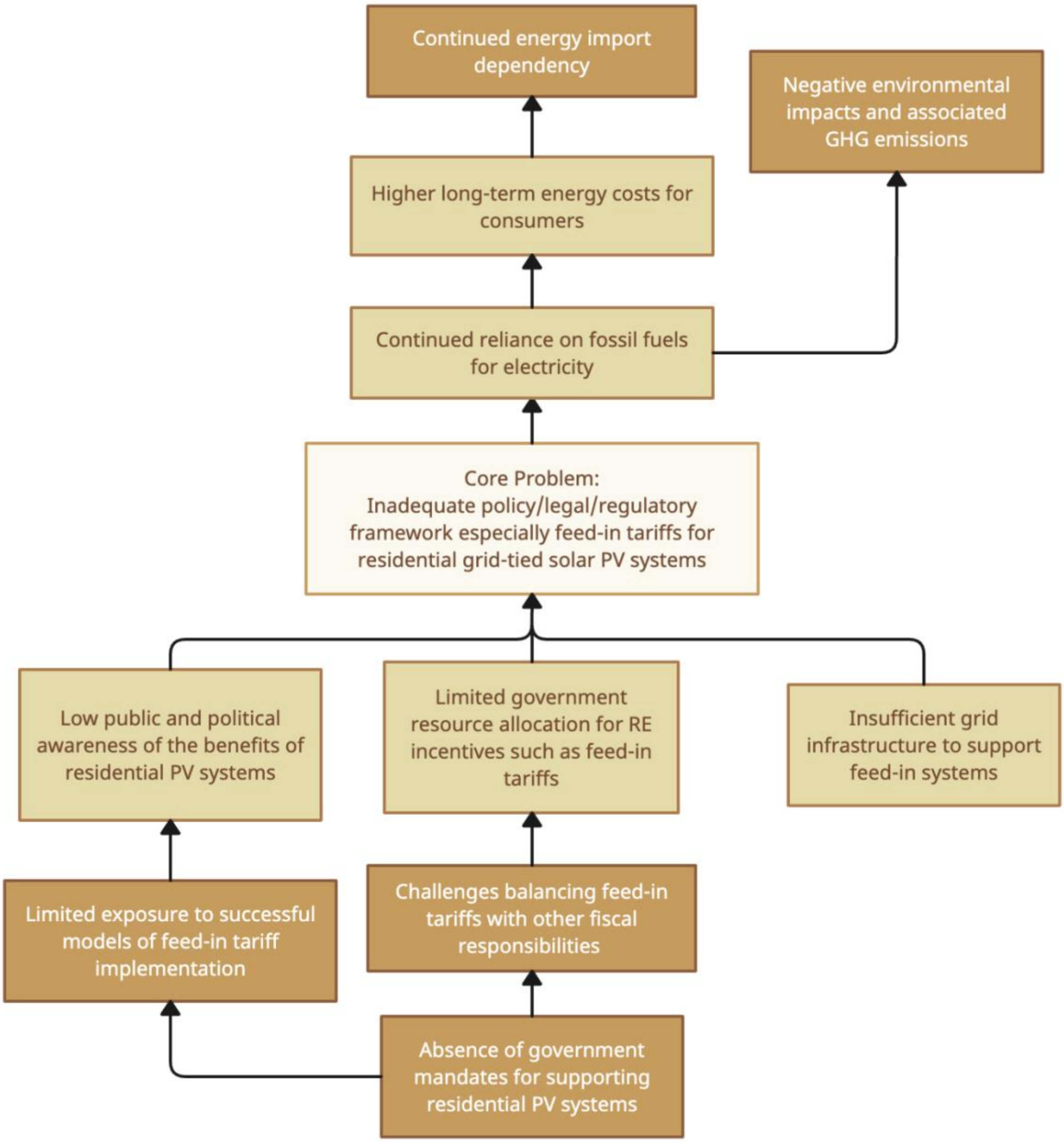

Continued energy import dependency
Negative environmental impacts and associated GHG emissions
Higher long-term energy costs for consumers
Continued reliance on fossil fuels for water heating
Core Problem:
Lack of funding and financial incentives for solar water heating
Lack of specific policies promoting solar water heaters
Limited government resources and restricted fiscal space
Limited awareness of benefits / cost effectiveness of solar water heating
Small economy size
Competing priorities for public spending
Difficult to attract investment for renewable energy

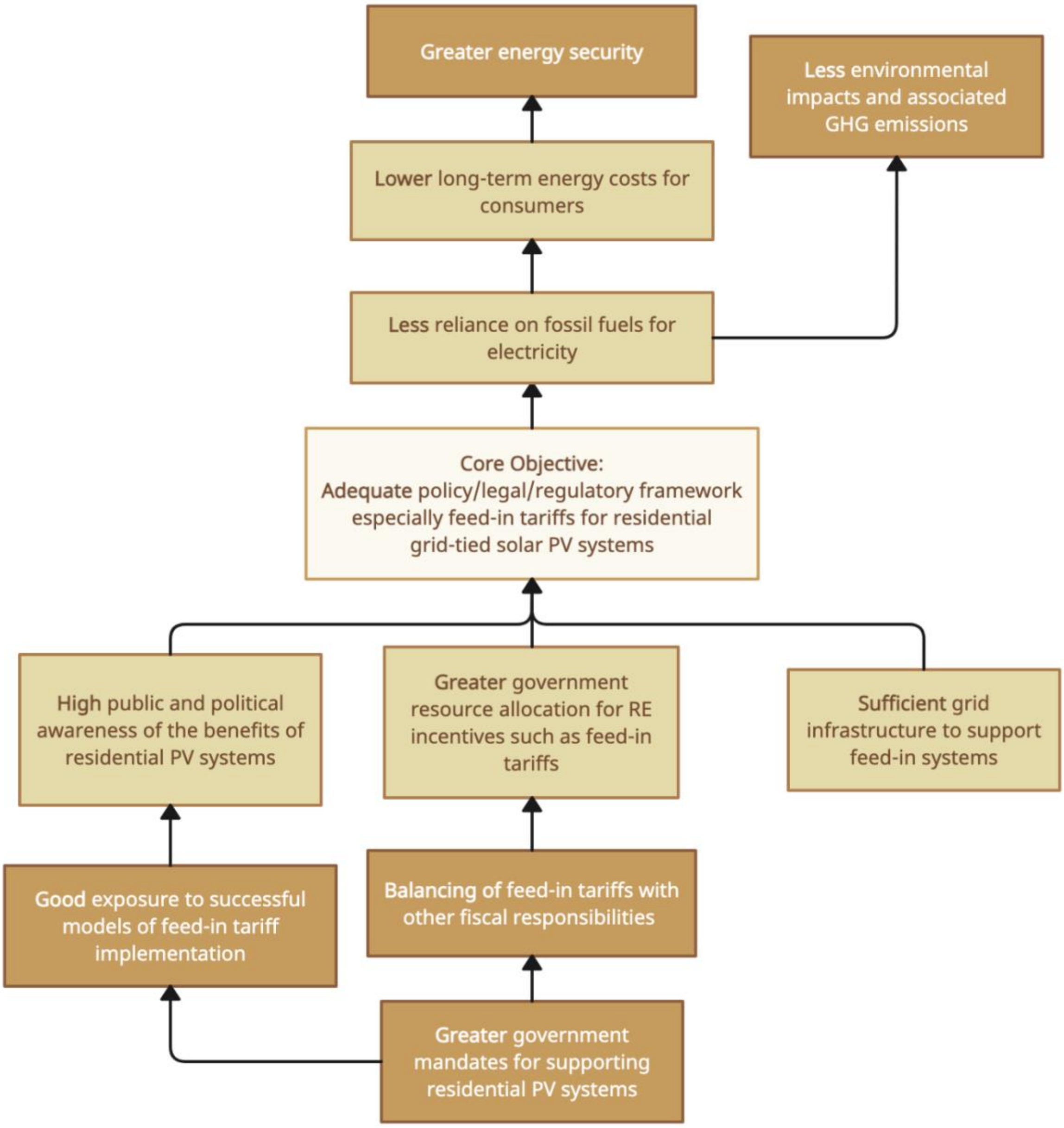

Greater energy security
Less environmental impacts and associated GHG emissions
Lower long-term energy costs for consumers
Less reliance on fossil fuels for water heating
Core Objective:
Greater funding and financial incentives for solar water heating
More specific policies promoting solar water heaters
Greater government resources and restricted fiscal space
Greater awareness of benefits / cost effectiveness of solar water heating
Small economy size
Competing priorities for public spending
Easier to attract investment for renewable energy

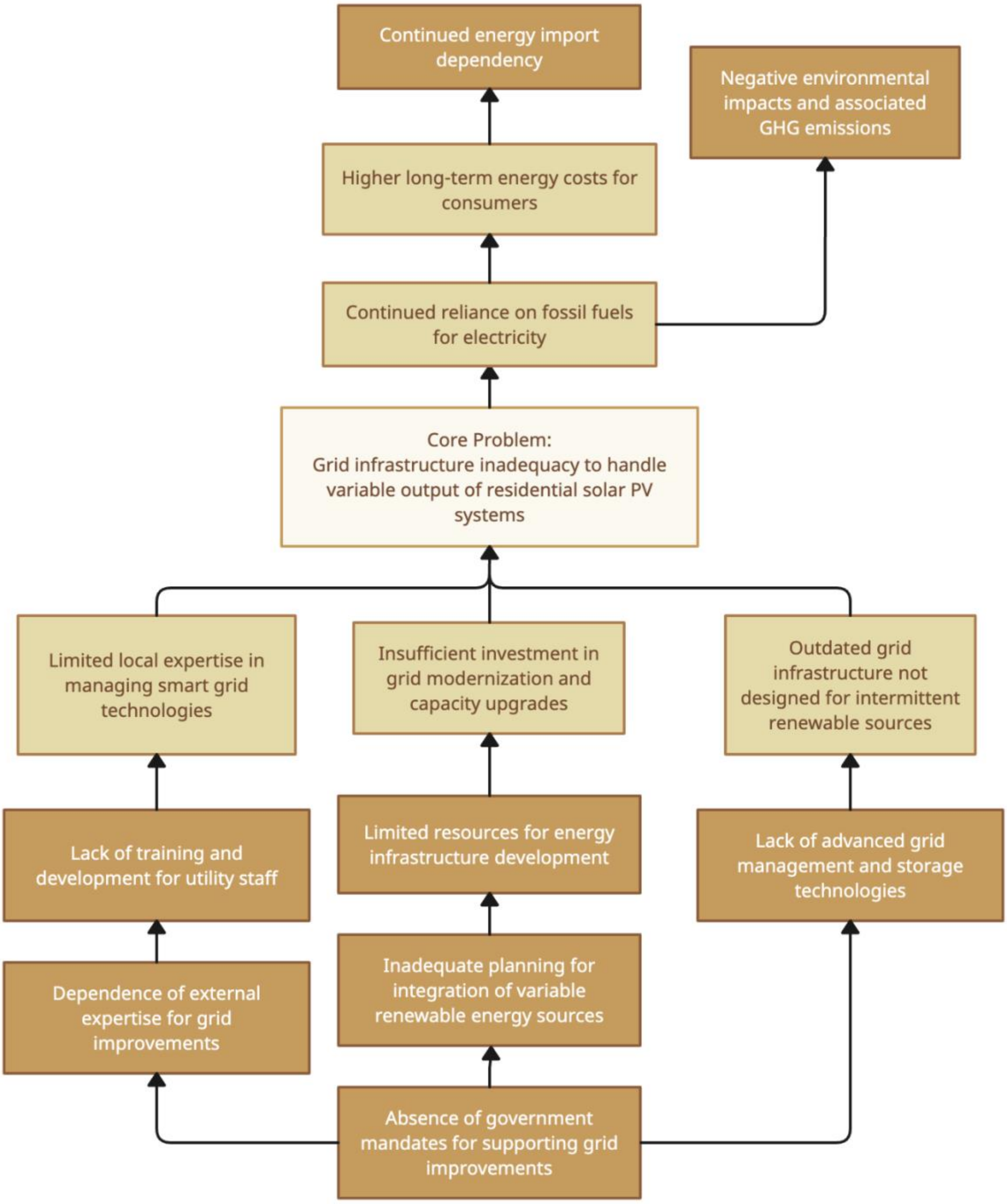


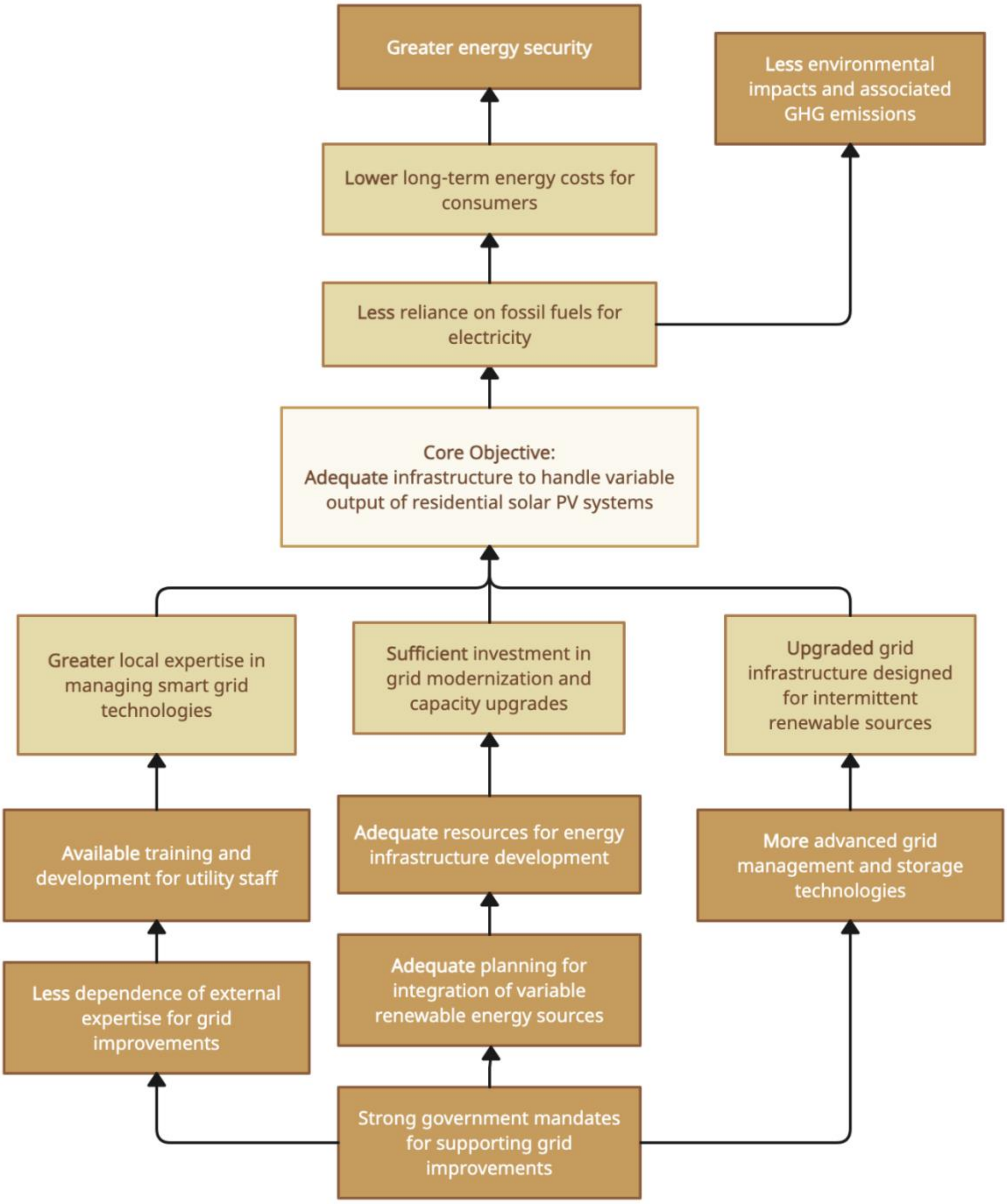
Continued energy import dependency
Negative environmental impacts and associated GHG emissions
Higher long-term energy costs for consumers
Continued reliance on fossil fuels for water heating
Core Problem:
Limited technical expertise in installation and maintenance of solar water heaters
Lack of specialized training programs
Insufficient funding for training initiatives
Limited awareness of benefits / cost effectiveness of solar water heating
Lack of accreditation systems for specialized technicians
Small economy and market size
Low awareness of importance of skilled installation and maintenance
Absence of government mandates for skill development in renewable energy


Greater energy security
Less environmental impacts and associated GHG emissions
Lower long-term energy costs for consumers
Less reliance on fossil fuels for water heating
Core Objective:
Greater technical expertise in installation and maintenance of solar water heaters
More specialized training programs
Sufficient funding for training initiatives
Greater awareness of benefits / cost effectiveness of solar water heating
Availability of accreditation systems for specialized technicians
Small economy and market size
More awareness of importance of skilled installation and maintenance
Strong government mandates for skill development in renewable energy

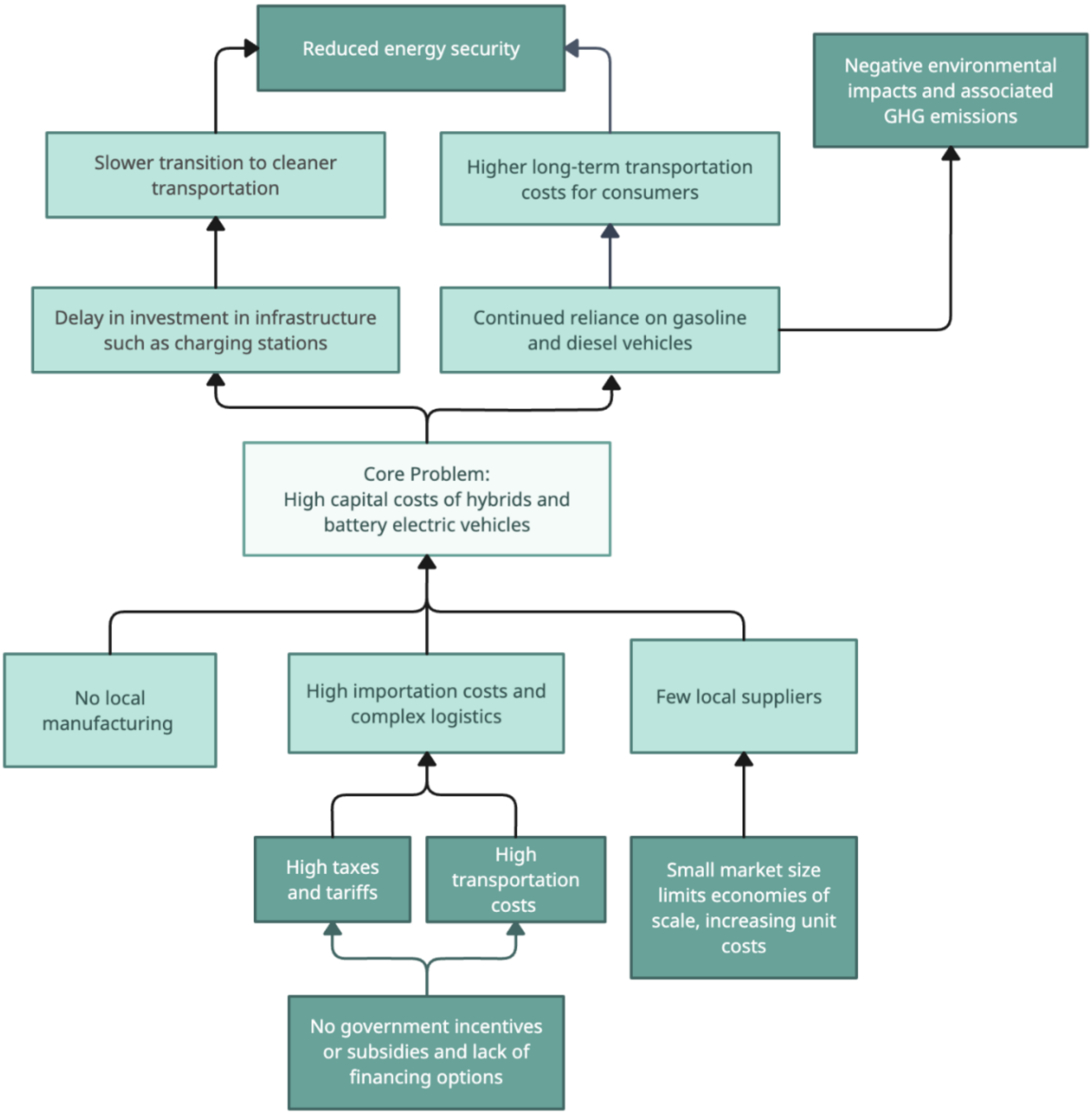

Continued energy import dependency
Negative environmental impacts and associated GHG emissions
Higher long-term energy costs for consumers
Continued reliance on fossil fuels for electricity
Core Problem: Inadequate policy/legal/regulatory framework especially feed-in tariffs for residential grid-tied solar PV systems
Low public and political awareness of the benefits of residential PV systems
Limited government resource allocation for RE incentives such as feed-in tariffs
Insufficient grid infrastructure to support feed-in systems
Limited exposure to successful models of feed-in tariff implementation
Challenges balancing feed-in tariffs with other fiscal responsibilities
Absence of government mandates for supporting residential PV systems

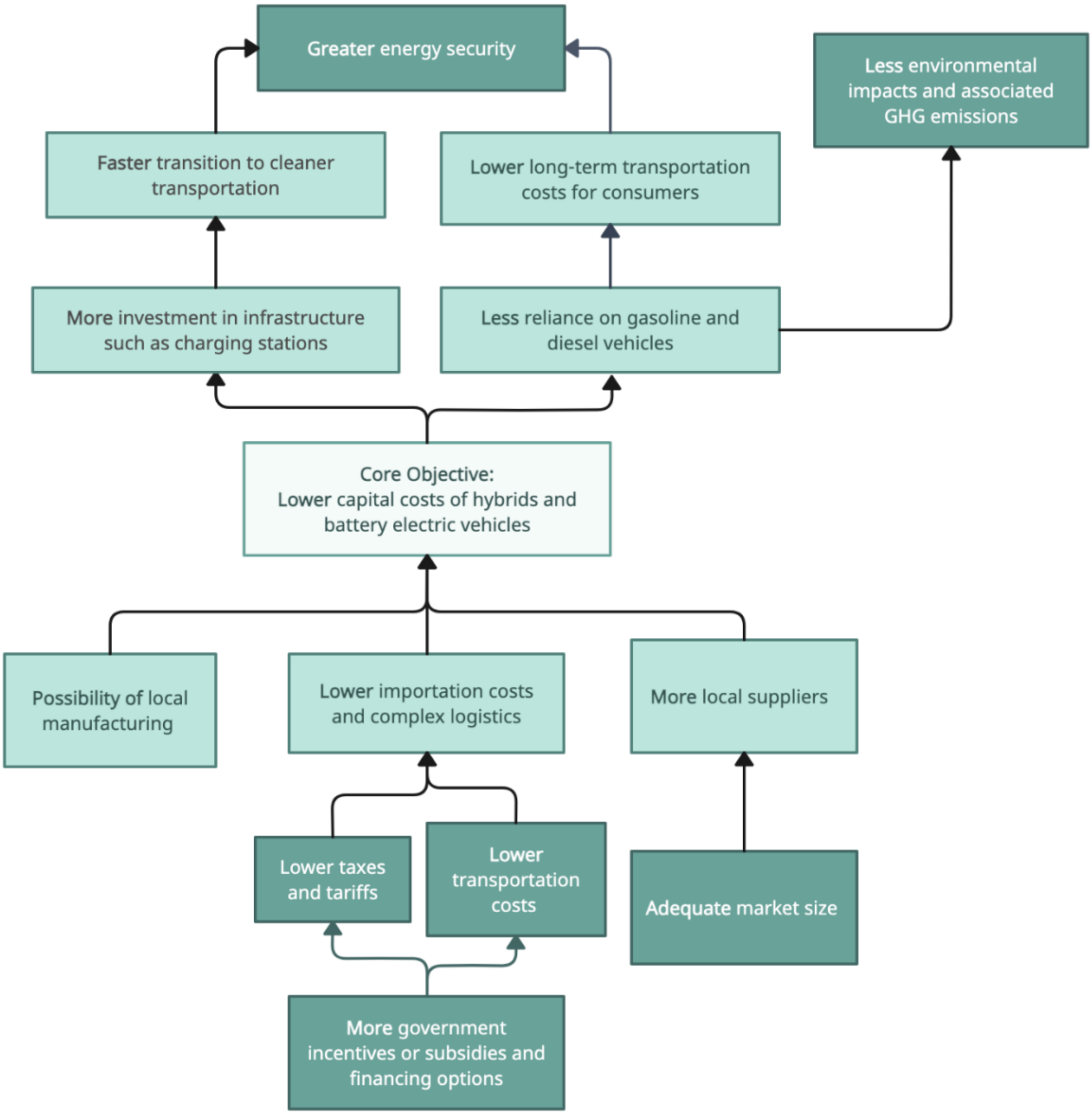

Greater energy security
Less environmental impacts and associated GHG emissions
Lower long-term energy costs for consumers
Less reliance on fossil fuels for electricity
Core Objective:
Adequate policy/legal/regulatory framework especially feed-in tariffs for residential grid-tied solar PV systems
High public and political awareness of the benefits of residential PV systems
Greater government resource allocation for RE incentives such as feed-in tariffs
Sufficient grid infrastructure to support feed-in systems
Good exposure to successful models of feed-in tariff implementation
Balancing of feed-in tariffs with other fiscal responsibilities
Greater government mandates for supporting residential PV systems

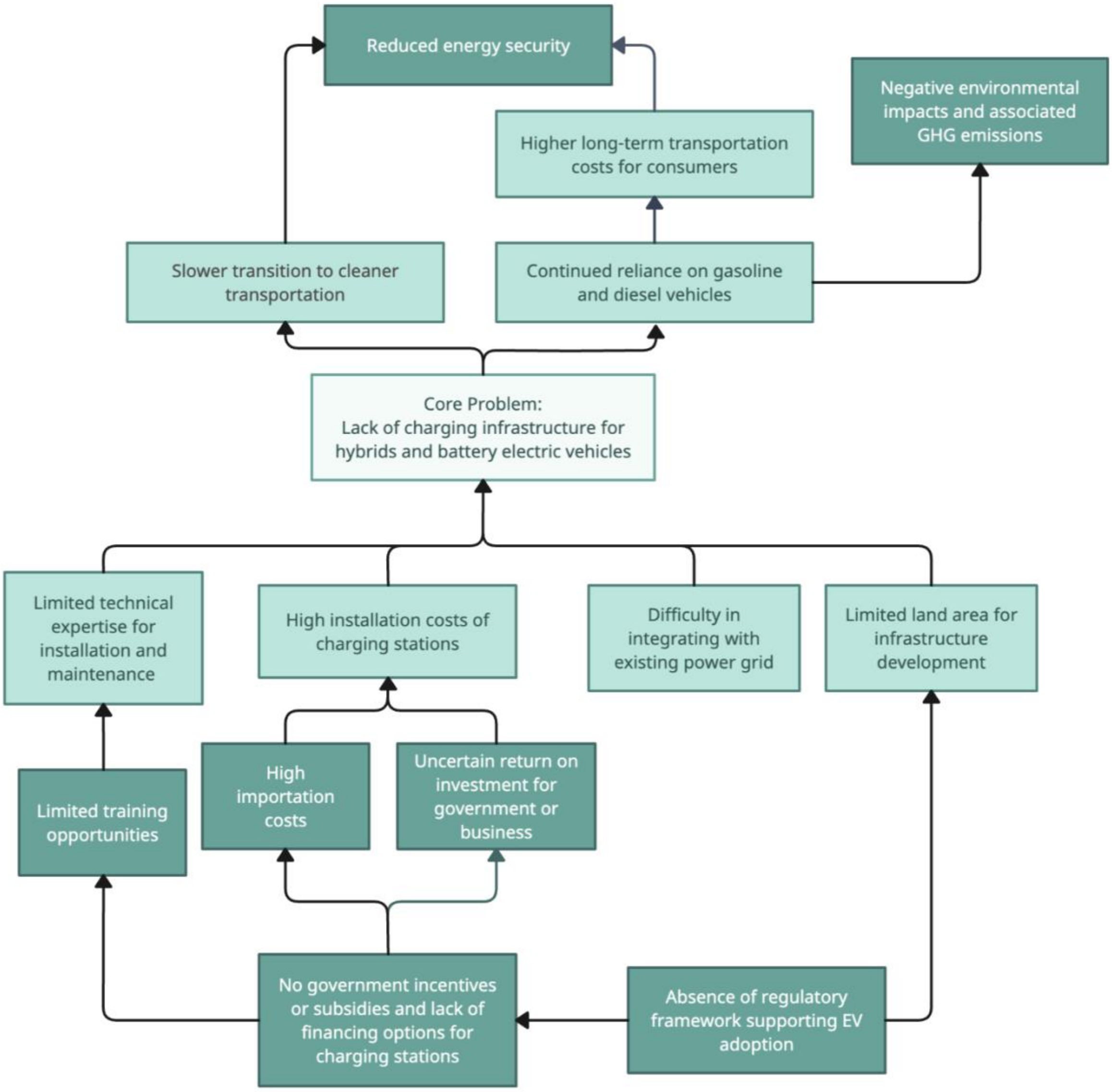

Continued energy import dependency
Negative environmental impacts and associated GHG emissions
Higher long-term energy costs for consumers
Continued reliance on fossil fuels for electricity
Core Problem:
Grid infrastructure inadequacy to handle variable output of residential solar PV systems
Limited local expertise in managing smart grid technologies
Insufficient investment in grid modernization and capacity upgrades
Outdated grid infrastructure not designed for intermittent renewable sources
Lack of training and development for utility staff
Limited resources for energy infrastructure development
Lack of advanced grid management and storage technologies
Dependence of external expertise for grid improvements
Inadequate planning for integration of variable renewable energy sources
Absence of government mandates for supporting grid improvements

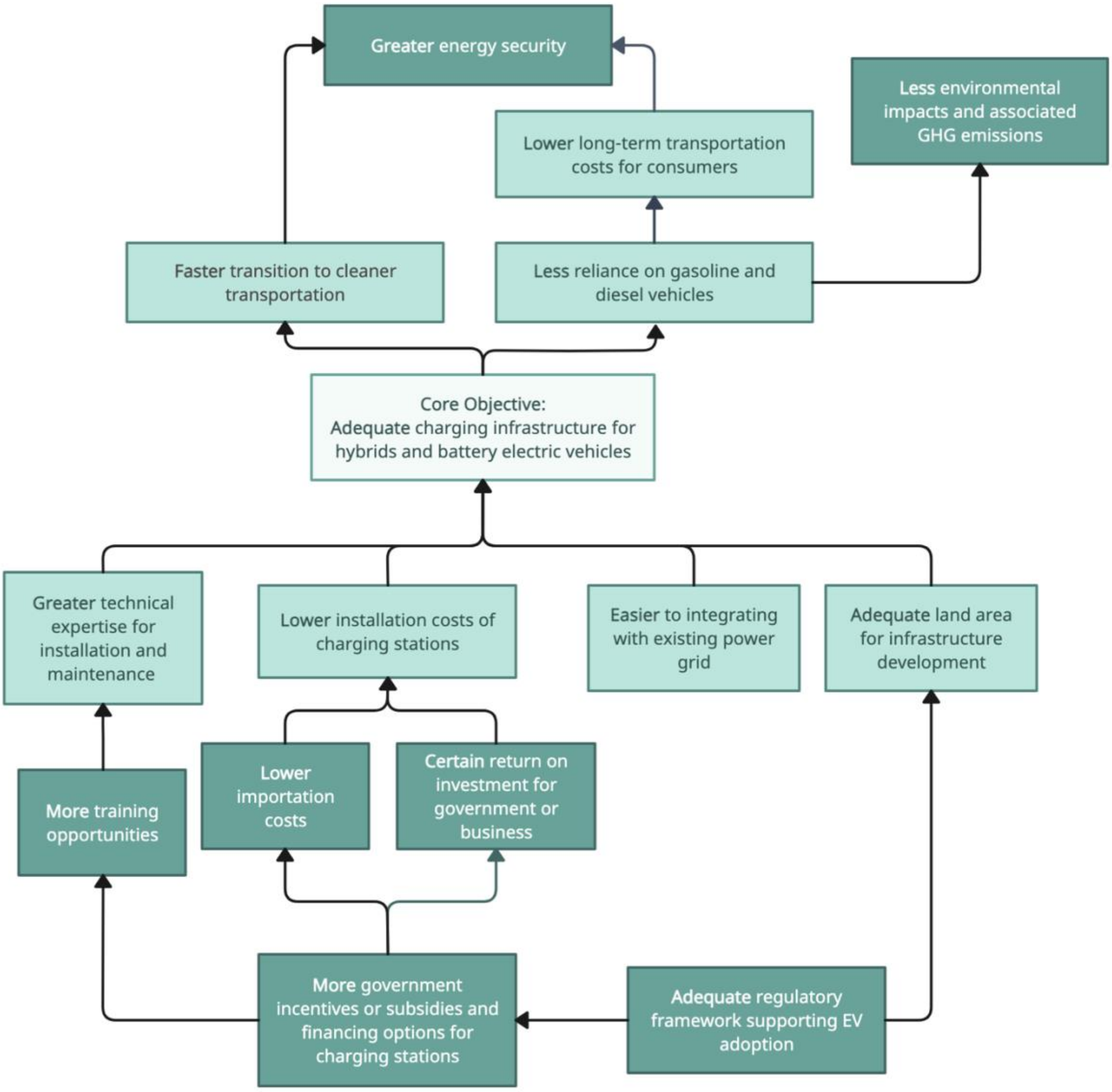

Greater energy security
Less environmental impacts and associated GHG emissions
Lower long-term energy costs for consumers
Less reliance on fossil fuels for electricity
Core Objective:
Adequate infrastructure to handle variable output of residential solar PV systems
Greater local expertise in managing smart grid technologies
Sufficient investment in grid modernization and capacity upgrades
Upgraded grid infrastructure designed for intermittent renewable sources
Available training and development for utility staff
Adequate resources for energy infrastructure development
More advanced grid management and storage technologies
Less dependence of external expertise for grid improvements
Adequate planning for integration of variable renewable energy sources
Strong government mandates for supporting grid improvements

Annex V: Problem and Objective Trees – Transport Sector

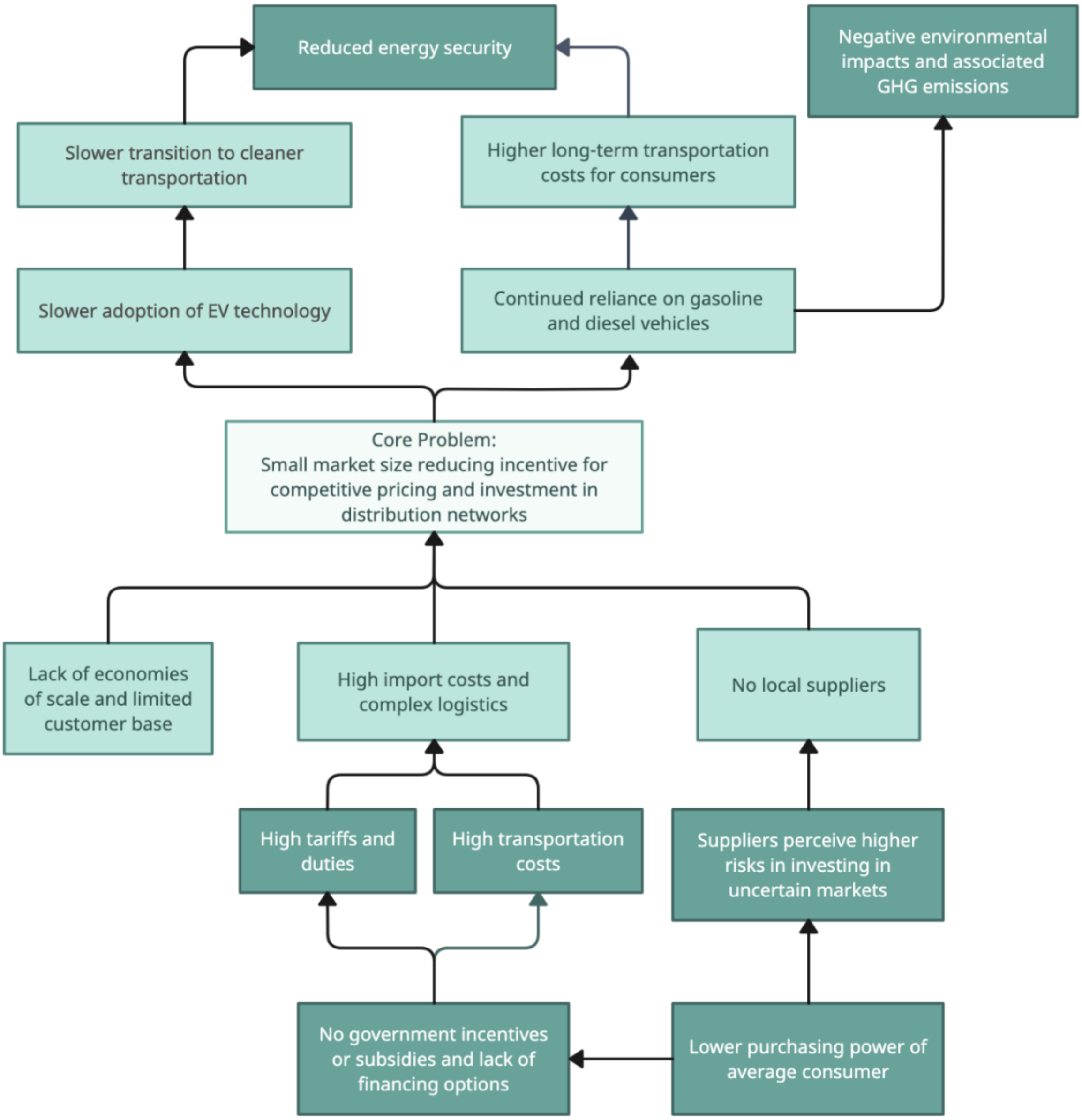



Greater energy security
Less environmental impacts and associated GHG emissions
Faster transition to cleaner transportation
Lower long-term transportation costs for consumers
More investment in infrastructure such as charging stations
Less reliance on gasoline and diesel vehicles
Core Objective:
Lower capital costs of hybrids and battery electric vehicles
Possibility of local manufacturing
Lower importation costs and complex logistics
More local suppliers
Lower taxes and tariffs
Lower transportation costs
Adequate market size
More government incentives or subsidies and financing options

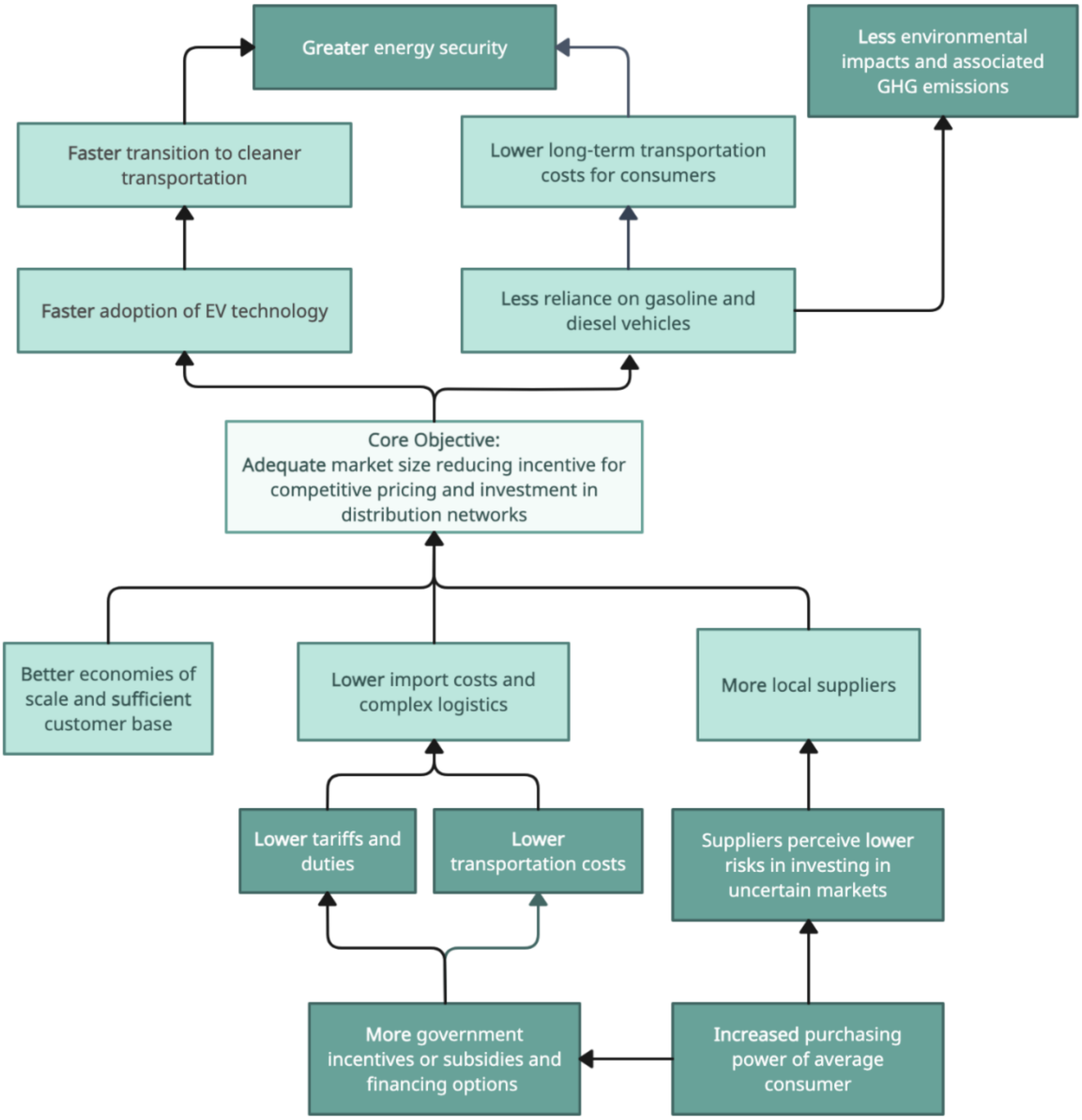

Reduced energy security
Negative environmental impacts and associated GHG emissions
Higher long-term transportation costs for consumers
Slower transition to cleaner transportation
Continued reliance on gasoline and diesel vehicles
Core Problem:
Lack of charging infrastructure for hybrids and battery electric vehicles
Limited technical expertise for installation and maintenance
High installation costs of charging stations
Difficulty in integrating with existing power grid
Limited land area for infrastructure development
Limited training opportunities
High importation costs
Uncertain return on investment for government or business
No government incentives or subsidies and lack of financing options for charging stations
Absence of regulatory framework supporting EV adoption

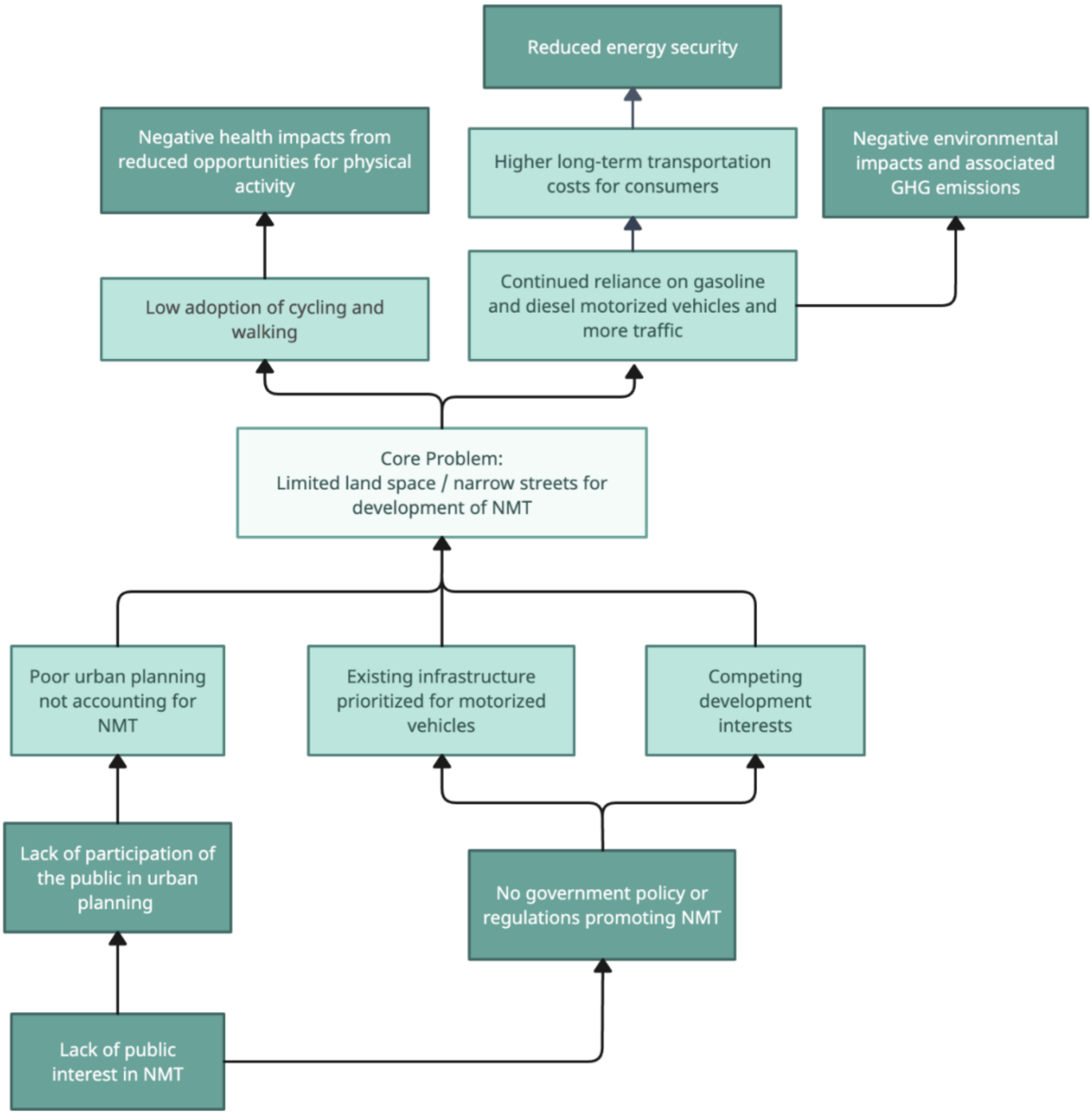


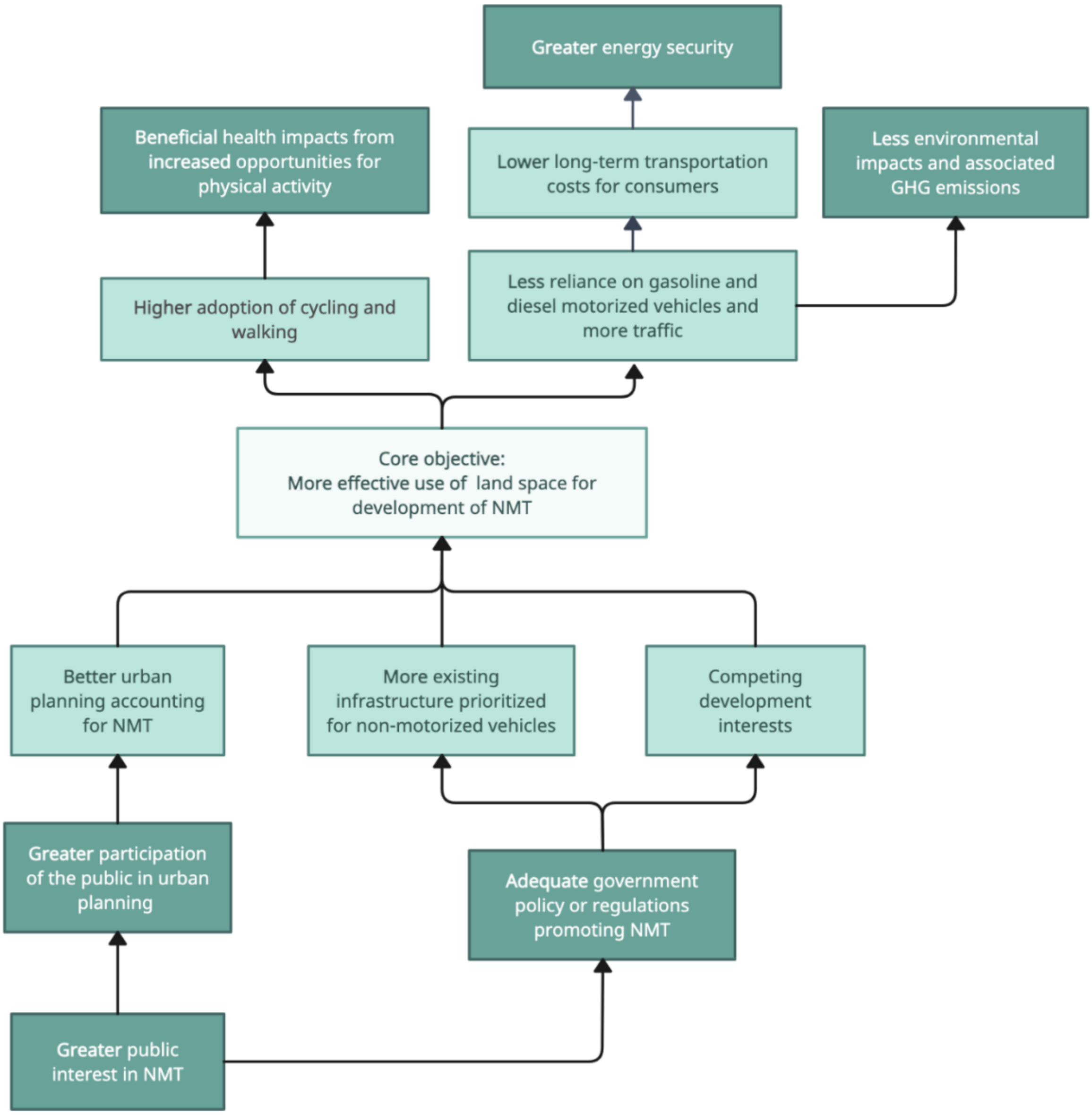
Greater energy security
Less environmental impacts and associated GHG emissions
Lower long-term transportation costs for consumers
Faster transition to cleaner transportation
Less reliance on gasoline and diesel vehicles
Core Objective:
Adequate charging infrastructure for hybrids and battery electric vehicles
Greater technical expertise for installation and maintenance
Lower installation costs of charging stations
Easier to integrating with existing power grid
Adequate land area for infrastructure development
More training opportunities
Lower importation costs
Certain return on investment for government or business
More government incentives or subsidies and financing options for charging stations
Adequate regulatory framework supporting EV adoption

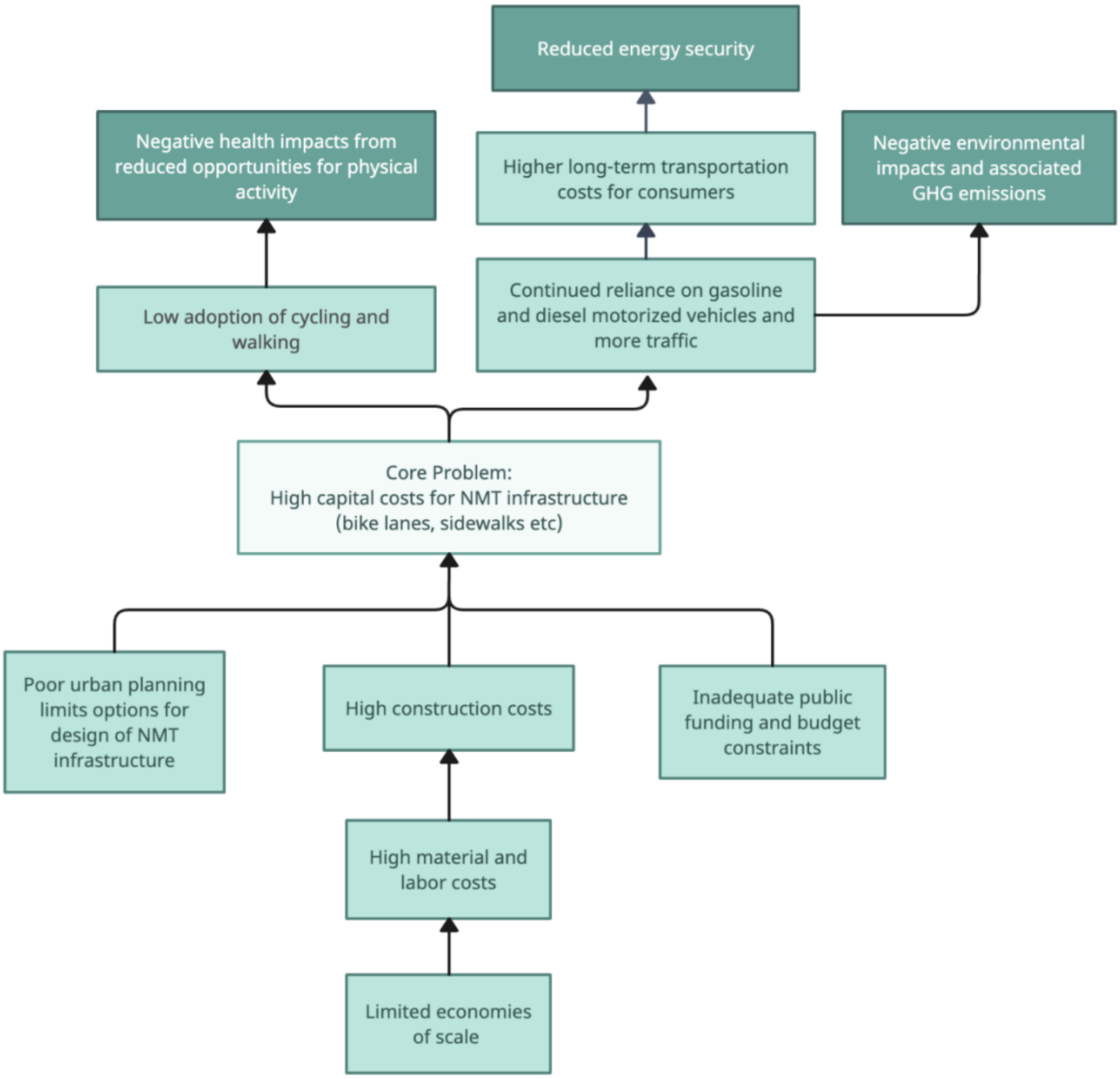


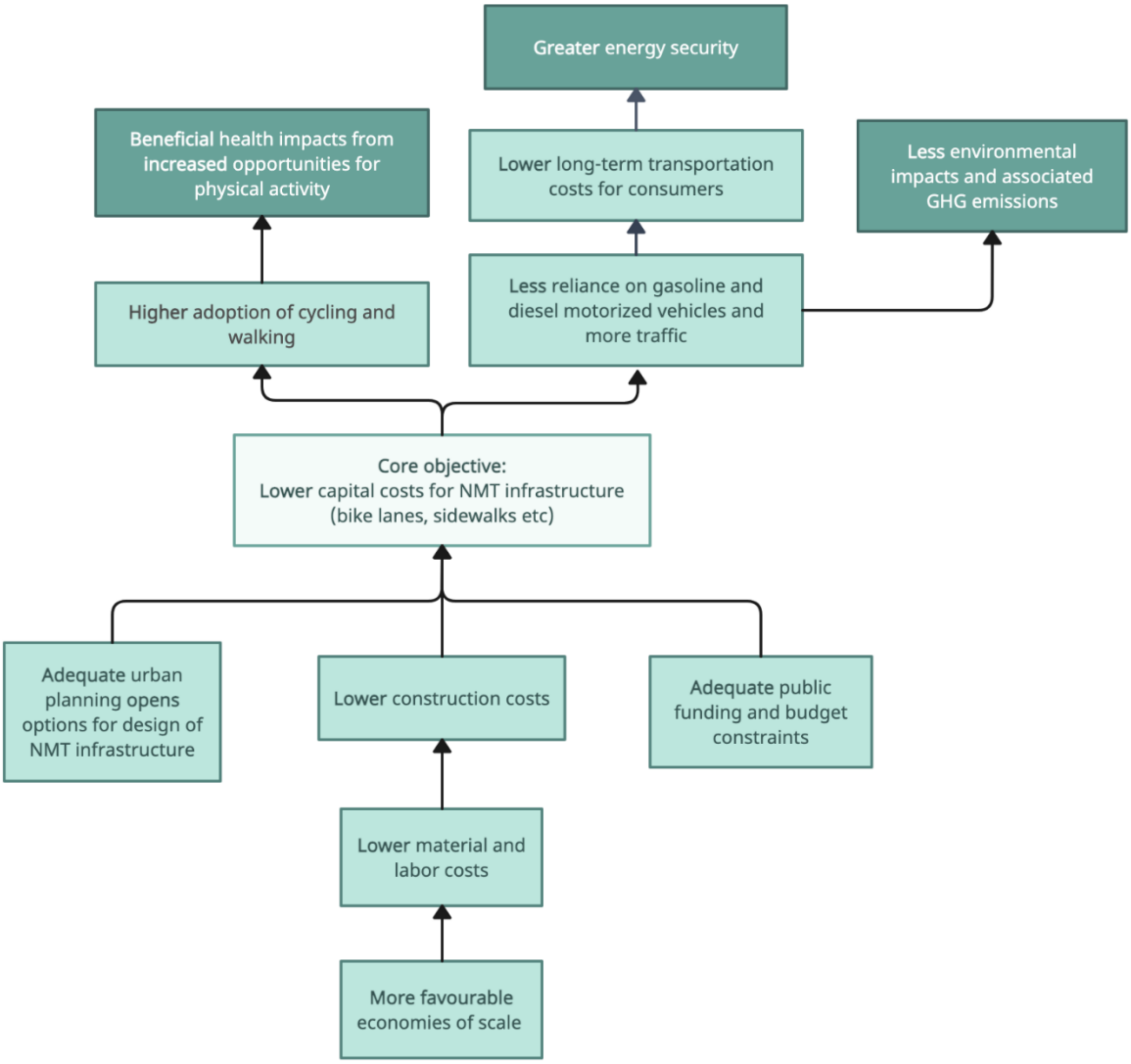
Reduced energy security
Negative environmental impacts and associated GHG emissions
Slower transition to cleaner transportation
Higher long-term transportation costs for consumers
Slower adoption of EV technology
Continued reliance on gasoline and diesel vehicles
Core Problem:
Small market size reducing incentive for competitive pricing and investment in distribution networks
Lack of economies of scale and limited customer base
High import costs and complex logistics
No local suppliers
High tariffs and duties
High transportation costs
Suppliers perceive higher risks in investing in uncertain markets
No government incentives or subsidies and lack of financing options
Lower purchasing power of average consumer

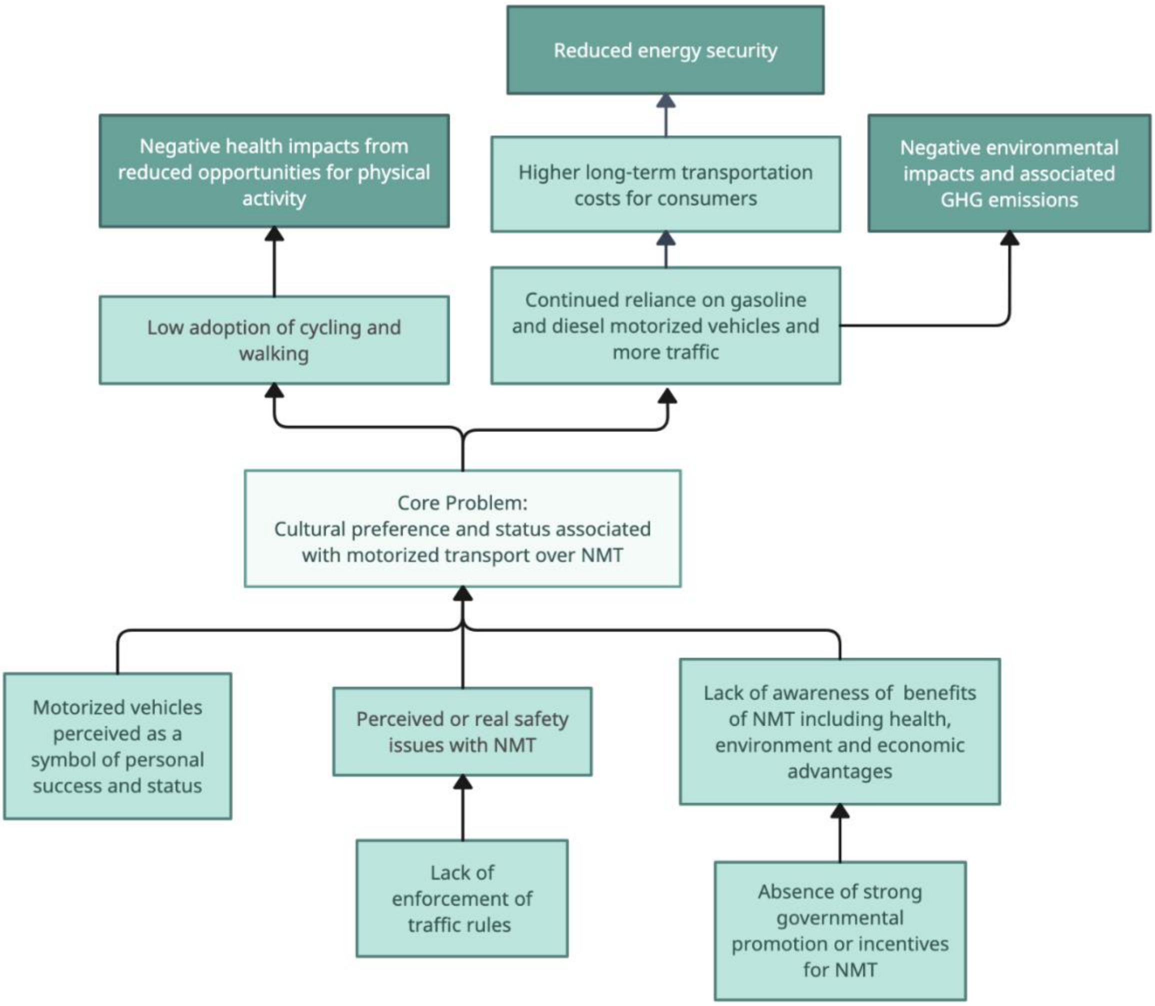

Greater energy security
Less environmental impacts and associated GHG emissions
Faster transition to cleaner transportation
Lower long-term transportation costs for consumers
Faster adoption of EV technology
Less reliance on gasoline and diesel vehicles
Core Objective:
Adequate market size reducing incentive for competitive pricing and investment in distribution networks
Better economies of scale and sufficient customer base
Lower import costs and complex logistics
More local suppliers
Lower tariffs and duties
Lower transportation costs
Suppliers perceive lower risks in investing in uncertain markets
More government incentives or subsidies and financing options
Increased purchasing power of average consumer

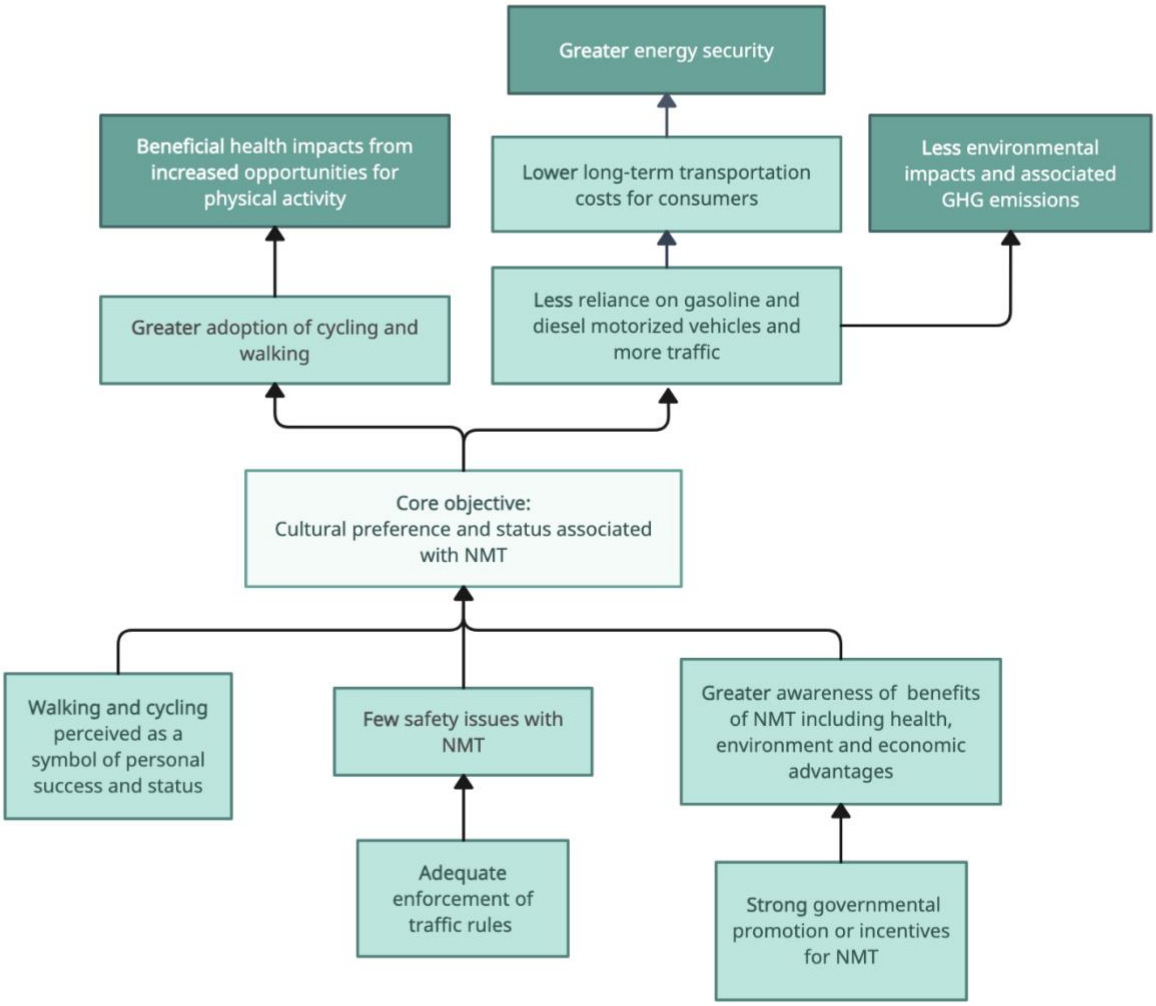

Reduced energy security
Negative health impacts from reduced opportunities for physical activity
Higher long-term transportation costs for consumers
Negative environmental impacts and associated GHG emissions
Low adoption of cycling and walking
Continued reliance on gasoline and diesel motorized vehicles and more traffic
Core Problem:
Limited land space / narrow streets for development of NMT
Poor urban planning not accounting for NMT
Existing infrastructure prioritized for motorized vehicles
Competing development interests
Lack of participation of the public in urban planning
No government policy or regulations promoting NMT
Lack of public interest in NMT


Greater energy security
Beneficial health impacts from increased opportunities for physical activity
Lower long-term transportation costs for consumers
Less environmental impacts and associated GHG emissions
Higher adoption of cycling and walking
Less reliance on gasoline and diesel motorized vehicles and more traffic
Core objective:
More effective use of land space for development of NMT
Better urban planning accounting for NMT
More existing infrastructure prioritized for non-motorized vehicles
Competing development interests
Greater participation of the public in urban planning
Adequate government policy or regulations promoting NMT
Greater public interest in NMT


Reduced energy security
Negative health impacts from reduced opportunities for physical activity
Higher long-term transportation costs for consumers
Negative environmental impacts and associated GHG emissions
Low adoption of cycling and walking
Continued reliance on gasoline and diesel motorized vehicles and more traffic
Core Problem:
High capital costs for NMT infrastructure (bike lanes, sidewalks etc)
Poor urban planning limits options for design of NMT infrastructure
High construction costs
Inadequate public funding and budget constraints
High material and labor costs
Limited economies of scale


Greater energy security
Beneficial health impacts from increased opportunities for physical activity
Lower long-term transportation costs for consumers
Less environmental impacts and associated GHG emissions
Higher adoption of cycling and walking
Less reliance on gasoline and diesel motorized vehicles and more traffic
Core objective:
Lower capital costs for NMT infrastructure (bike lanes, sidewalks etc)
Adequate urban planning opens options for design of NMT infrastructure
Lower construction costs
Adequate public funding and budget constraints
Lower material and labor costs
More favourable economies of scale


Reduced energy security
Negative health impacts from reduced opportunities for physical activity
Higher long-term transportation costs for consumers
Negative environmental impacts and associated GHG emissions
Low adoption of cycling and walking
Continued reliance on gasoline and diesel motorized vehicles and more traffic
Core Problem:
Cultural preference and status associated with motorized transport over NMT
Motorized vehicles perceived as a symbol of personal success and status
Perceived or real safety issues with NMT
Lack of awareness of benefits of NMT including health, environment and economic advantages
Lack of enforcement of traffic rules
Absence of strong governmental promotion or incentives for NMT


Greater energy security
Beneficial health impacts from increased opportunities for physical activity
Lower long-term transportation costs for consumers
Less environmental impacts and associated GHG emissions
Greater adoption of cycling and walking
Less reliance on gasoline and diesel motorized vehicles and more traffic
Core objective:
Cultural preference and status associated with NMT
Walking and cycling perceived as a symbol of personal success and status
Few safety issues with NMT
Greater awareness of benefits of NMT including health, environment and economic advantages
Adequate enforcement of traffic rules
Strong governmental promotion or incentives for NMT