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TECHNOLOGY NEEDS ASSESSMENT

Barrier Analysis & Enabling Framework for the Diffusion of Climate Change Coastal Zone's Adaptation Technologies

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Foreword

In September 2015, Liberia, as a signatory of the UN Climate Change Convention, submitted the Nationally Determined Contribution (INDC) in advance of the new climate change agreement reached at the UN Climate Conference in Paris in December. Liberia's INDC was designed as a platform to integrate its Low Carbon Development Strategy into the country's long-term sustainable development vision by 2030 (Agenda for Transformation). Liberia ratified the Paris Agreement in August 2018 and is working hard to revise its NDC for submission. Regardless of the many contributions to climate change, Liberia, like many other developing countries, is especially vulnerable to its impacts. The country is at this moment susceptible to the adverse effects of climate change such as shifting cultivation in the agriculture sector, unsustainable logging practices, unregulated coastal mining, high level of biomass consumption in the form of charcoal and fire wood for local energy use, and decreasing river flow due to high level of evaporation. The agricultural sector, which ensures the livelihoods of around 70% of the population, remains vulnerable to flooding and erosion with changing rainfall patterns putting lives at risk in a country where nearly 8 out of 10 people do not have secure access to food. Current climate change vulnerability in Liberia include; increase in extreme events (e.g., exacerbated floods, extreme drought), sea level rise, flooding and coastal erosion being experienced on an annual basis that eats up the coast as observed in Monrovia, Buchanan and Greenville.

I would like to add that Liberia has an overall lack of energy. In most rural areas in Liberia, less than 5% of the population has access to electricity while most homes run mini generators. The current energy situation in Liberia is characterized by a dominance of traditional biomass consumption, low access to poor quality and relatively expensive modern energy services. It is estimated that over 95% of the population rely on firewood, charcoal, and palm oil for their energy needs.

The EPA of Liberia is overly happy with the level of the assessment done by the Technology Needs Assessment Team (TNA) through a national stakeholder's participatory process emulating from the identification and prioritization of environmentally sound technologies to the diffusion of these technologies to mitigate and adapt to climate change. We would like to recognize the United Nations Environment Programme (UNEP), DTU Partnership and Global Environment Facility (GEF). Your contributions have resulted in this rich source of information and we hope that this report will spur parties into seeking out partnerships for the purpose of accelerating climate action and increasing ambition in Liberia.

Dr. Nathaniel T. Blama Sr.
EXECUTIVE DIRECTOR/CEO

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List of Acronyms and Abbreviations

BA&EF	Barrier Analysis and Enabling Framework
CAGs	Community Action Groups
CBOs	Community Based Organizations
CSOs	Civil Society Organizations
EPA	Environmental Protection Agency
FWS	Flood early Warning System
GEF	Global Environment Facility
GOL	Government of Liberia
ICZM	Integrated Coastal Zone Management
ICZMU	Integrated Coastal Zone Management Unite
IPCC	Intergovernmental Panel on Climate Chang
LPA	Logical Problem Analysis
MCA	Multi-Criteria Analysis
MGCSP	Ministry of Gender, Children and Social Protection
MME	Ministry of Mines and Energy
NDMA	National Disaster Management Agency
NAP	National Adaptation Programme
NAPA	National Adaptation Programme of Action
NGOs	Non Governmental Organizations
SWGs	Sect oral Working Groups
TNA	Technology Needs Assessment
TWG	Technical Working Group
UDP	United Nations Environment Programme Technical University of Denmark Partnership
UNEP	United Nations Environment Programme
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development

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Report II

BA&EF Report

Executive Summary

In the Technology Needs Assessment (TNA) report 1, two sectors of adaptation were prioritized in Liberia to address the technology gap in those areas. The priority sectors retained in the TNA project for adaptation were Agriculture and Coastal Zone. These two sectors were consistent with national development priorities while taking into account the vulnerabilities of climate change impacts in the country. Therefore, this report exclusively covers the Coastal Zone sector.

In Liberia, more than 70% of the population lives within its coastal areas which cover approximately 580km in length, (DAI 2008). However, the direct impacts of coastal erosion, floods and related sea level rise impacts have become some of the alarming climate change risks currently affecting coastal cities and communities along the majority of Liberia's coastline. The impact of coastal erosion is currently disrupting livelihoods, destroying properties and leaving many residents homeless in coastal communities due to the lack of sustainable approach to mitigate or adapt to the direct threats presented to the communities. As such, the TNA's Coastal Zone first report for climate change adaptation in Liberia has been a set of activities to identify and determine coastal adaptation technologies to reduce the ongoing risks and vulnerabilities. In this light, three technologies have been identified and prioritized for Liberia's coastal zone.

The identification and prioritization of the technologies were based on the technology's potential to reduce vulnerability to climate change, and its social, economic, and environmental benefits. The process was participatory and ensured the involvement of cross-sectorial experts and stakeholders. Below are the three technologies that were identified and prioritized to be used:

1. Integrated Coastal Zone Management (ICZM);
2. Flood early Warning System (FWS), and
3. Armour or Rock Revetments.

In order to successfully adopt these prioritized technologies in the coastal zone of Liberia, there are some critical barriers that are needed to be addressed. Therefore, this TNA's second report, *Barrier Analysis and Enabling Framework (BA&EF)* on Liberia's coastal zone, assesses the

potential barriers that could impede the transfer and diffusion of the technologies. As well, it provides an enabling framework or possible measures to overcome the identified barriers to the transfer and diffusion of the above technologies *(Table: 1).* In order to facilitate the analysis of the potential barriers and provide an enabling framework, the technologies were firstly categorized according to the types of goods and services they belong to or contribute to, in respect to their distinct market characteristics (IPCC, 2000 and Lundvall et al., 2009). As such, the three technologies were categorized as follow:

- Technology 1: *Other non-market goods*
- Technology 2: *Other non-market goods*
- Technology 3: *Publicly provided goods*

The barriers identified and analyzed during the process were categorized into two major categories: *Economic/ Financial Barriers, and Non-financial Barriers.* The non-financial barriers were analyzed from a Socio-environmental cost-benefit context (Perman et al., 2003) because the three technologies are all *non-market goods.* From the Socio-environmental cost-benefit context, the non-financial barriers' category was furthermore classified into seven subcategories: *social and gender, information and awareness, technical, environmental, legal and regulatory, institutional arrangement and other (political).* In this light, the identified enabling framework or measures to overcome the identified barriers were as well classified as *Economic/ Financial Measures, and Non-financial Measures.* The barriers and measures identification process (Nygaard and Hansen, 2015 and Painuly, 2001), was conducted using a logical problem analysis by means of problem and objective trees *(Annex: I).*

In order to have had a participatory process in reference to Chambers (2005) and Rocheleau (1995), the Liberia's TNA workshop for barrier analysis and enabling framework was conducted on January 9, 2020 in Monrovia through a cross-sectorial stakeholder's consultation working group, expert knowledge, available literature and other investigations for the coastal zone. After the general workshop, there were series of technical working sessions carried out for a comprehensive process. The stakeholder's engagement was one of the key aspects of the process; therefore, the names, contacts and institutions of the stakeholders are presented in *Annex II* of this report.

Inserted in the table below, is the enabling framework or possible measures to overcome the identified and analysed barriers to the adoption, transfer and diffusion of the three prioritized adaptation technologies to be used in Liberia's coastal zone.

Table 1: Enabling framework for the major cross-cutting barriers to the technologies

Barrier category	**Broad/ common barrier**	**Enabling framework**	**Technology**
Economic & Financial	-High capital cost	A regular annual national budgetary allotment should be secured to specifically address the setup, operations and long-term sustainability of the prioritized technologies. The available funds can be used to train technicians, conduct research, monitor and support deployment activities of the technologies.	1-ICZM 2-FWS 3-Rock Revetments
	-Limited access to funding	To have access to public, external and other private funding, it was analysed and recommended to develop a comprehensive funding proposal that meets local and international climate change adaptation funding requirements for the technologies. A partnership could also be created with other available international donors that support climate change adaptation projects through funding, capacity building, equipment and etc.	
Social & Gender	-Limited & inadequate involvement and participation of affected local communities and vulnerable groups by decision makers. (Lack of invited involvement)	Involve the participation of local community leaders and concerned stakeholders, vulnerable groups that are directly affected by the impacts of climate change in the transfer and diffusion of the prioritized technologies. For example, a *Community Action Groups (CAG)* could be created in each affected coastal community to enforce the established regulations of the technology at local levels. The design of a revetment could affect the livelihood of some coastal residents (fish mongers); therefore, it is important to invite and solicit the views and recommendations of affected community leaders during the design stage of a revetment to avoid the disruption of livelihoods. The involvement of local groups will promote the technology at the community level and also increase the sensitization of policies and regulations. This will also promote behavioural change against beach sand mining and other destructive activities in the coastal zone.	1-ICZM 2-FWS 3-Rock Revetments

	-Potential loss of cultural and heritage sites	To overcome the potential loss of cultural and heritage sites specifically for the diffusion of rocks' revetments, it is important to avoid damaging said sites by negotiating with local residents and their leaders for possible applicable and acceptable suggestions or solutions.	
Information & Awareness	-Limited & inadequate information sharing and awareness among the population	Improve and increase awareness; provide adequate information dissemination through direct text messages, radio and television announcements, community and high school environmental groups, workshops and etc. Encourage and promote the acceptance of the project by relevant group leaders and end-users. These measures are recommended to be repeated regularly to increase sensitisation.	1-ICZM 2-FWS 3-Rock Revetments
Technical	-Limited data & Research	Provide, improve, encourage and increase funding for research and data collection.	1-ICZM 2-FWS 3-Rock Revetments
	-Lack of technical expertise	Provide regular technical capacity building trainings for personnel involved with the establishment and diffusion of the technology at all levels. It is important to involve both local and international experts and institutions to conduct the recommended trainings.	
Institutional arrangement	-Inadequate coordination between institutions.	Improve, regulate and support coordination through regular cross-sectorial regulatory meetings and working groups to ensure a proper coordination among institutions, personnel, stakeholders and local communities.	1-ICZM 2-FWS
Legal & Regulatory	-Lack or inadequate legal act /framework	Create and adopt a legal act or framework and ensure straight acceptance to local and international standards. Create *Community Action Groups (CAG)* to enforce established regulations of the technologies at local levels.	1-ICZM 2-FWS
	-Non-existence or unclear framework of current ICZM	Revisit the existence of an Integrated Coastal Zone Management Unit (ICZMU) at the ministry of mines and energy; if applicable, create a proper framework and a functional office. Hire initial qualified personnel and experts to initiate the proper establishment and operations in respect to the fundamental principles and objectives of ICZM.	

Others	-The lack of political will to support implementation and long-term sustainability	To overcome most of the other barriers that may even be considered as cross-cutting, it was analysed and recommended to solicit political will /support to facilitate a smooth implementation, adoption and diffusion of the prioritized technologies. This can be done by getting those politicians that are responsible for policies understand and convinced on the social economic and environmental importance to support the adoption / implementation and diffusion of the technology. The accomplishment of the above will facilitate and support an adequate budgetary allotment for coastal projects.	1-ICZM 2-FWS 3-Rock Revetments

Acknowledgements

This coastal zone's Technology Needs Assessment (TNA) on Barrier Analysis and Enabling Framework (BA&EF) for the diffusion of climate change adaptation technologies in Liberia has been achieved through a tremendous collaborative effort by many institutions, affected and vulnerable coastal communities through stakeholders' engagements, sites' visits, documents and interviews with residents of coastal communities facilitated by the Environmental Protection Agency of Liberia (EPA) and the TNA. The institutions, communities and individuals mentioned in this report are duly acknowledged for their valuable contributions that successfully resulted to this report.

We would like to express our sincere appreciation to the national TNA team headed by its national coordinator *Mr. Christopher B. Kabah* and also in particular, *Mr. Benjamin S. Karmorh* of the Environmental Protection Agency of Liberia (EPA) climate change department and specifically the Executive Director / CEO of the EPA, *Dr. Nathaniel T. Blama, Sr.* for their support and commitment to this process. Our heartfelt gratitude goes to the coastal zone technical working group *(Annex II)* for their tireless efforts and contributions to this report.

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Figure 1: Group photo for Barrier Analysis and Enabling Framework; January 9, 2020

1. Coastal Zone Sector

Liberia is a developing country with a small population with the vast majority of its population living in poverty. The coastal zone sector is a major economic asset in Liberia. Said sector provides a means of livelihoods / income for the majority of the people, as more than 70% of Liberia's population lives within its coastal areas of about 580km long (DAI 2008).

Sadly, various global climate models project a sea-level rise in Liberia of 0.13 to 0.56 m by the 2090s relative to the sea level from 1980-1999 (McSweeney et al. 2010). Liberia has a low infrastructure capacity for basic social services, making the country highly vulnerable to climate change. DAI (2008) reported current beach erosion rates are as high as 3 m/yr with ongoing structural damage and loss. According to USAID (2013), the underlying rates of erosion are likely primarily related to natural conditions (e.g., geology, longshore currents, wave action). In 2005, it was projected that a rise in sea level by 1 m, would cause a loss of about 95 km^2 of the estimated 580 km long coastline (due to inundation); and 50% of the area inundated (48km^2) will be areas with settlement such as parts of the capital city of Monrovia, River Cess, Buchanan, and Robert Sport, which are less than 1 m above mean sea level (Wiles, 2005). This was projected to result in a loss in infrastructure and land of around $250 million apart from the social and psychological stress to the population, with women and children being particularly vulnerable (Tumbey, 2015).

According to USAID (2013), the underlying rates of erosion are likely primarily related to natural conditions (e.g., geology, longshore currents, wave action), but recent human interventions (e.g., uncontrolled sand mining, vegetation destruction, dams, poorly placed breakwaters and ports, groynes, or gabions,) also likely have accelerated or directly caused coastal erosion in all these areas.

In so doing, the direct impacts of coastal erosion, floods and related sea level rise impacts such as seawater /saline intrusion into fresh drinking water have become some of the alarming climate change impacts currently affecting coastal cities and communities along the majority of Liberia's coastline. Coastal erosion has been severe in Monrovia, Buchanan, and Greenville. During 1981 to 1997, about 100 m of beaches have reportedly been lost (EPA 2007).

The impact of coastal erosion is currently disrupting livelihoods, destroying properties and leaving many residents homeless in coastal communities due to the lack of sustainable approach to mitigate or adapt to the direct threats presented to the communities. According to Liberia's National Adaptation Program of Actions (NAPA, 2008), the coastal zone, agriculture and energy are the major sectors that are highly vulnerable to climate change threats in the country. Therefore, protecting these areas from climate change direct threats is vital to the nation's economic and developmental agenda.

In order to protect Liberia's coastal sector, three (3) technology options for adaptation were identified and prioritized from others, using the TNA's "Multi Criteria Analysis (MCA)" through stakeholders' engagement, experts' knowledge and cross-sectoral technical working group headed by the national coastal zone consultant with the supervision of the national coordinator. The Liberia's TNA project is led by the Environmental Protection Agency (EPA). The prioritized coastal adaptation's technologies for Liberia's TNA process are given below; table 2.

Table 2: Prioritized Technologies and their Categories - Coastal Sector

No.	List of prioritized Technologies	Market Characterization
1	Integrated Coastal Zone Management (ICZM)	Other non-market goods
2	Flood early Warning System (FWS)	Other non-market goods
3	Armour or Rock Revetments.	Publicly provided goods

1.1. Preliminary targets for technology transfer and diffusion

The preliminary target for the transfer and diffusion for each of the identified and prioritized adaptation technologies in the coastal zone of Liberia aims to reduce and adapt to the many risks and vulnerabilities. These targets also aim to create an enabling framework or measures to reduce the ongoing damages to coastal ecosystems, infrastructures, displacement of coastal residents due to climate change related impacts such as sea level rise, coastal erosion, floods and salt water intrusion into fresh drinking water (wells) in the coastal areas of Liberia.

In order to achieve these targets, the stakeholders and players to be involved include key policy makers, related government ministries and other departments in the sector. Other players include technicians and experts in the coastal zone sector. At local and national levels, community

leaders and Community Based Organizations (CBOs) will be key players in achieving the transfer, diffusion and sustainability of some technologies in coastal areas. The implementers should include women and youth groups at local level, CBOs and Non Governmental Organizations (NGOs) dealing with coastal zone protection issues.

1.2. Barriers analysis and possible enabling measures for Technology 1: Integrated Coastal Zone Management (ICZM)

For the barriers analysis and enabling framework process (Nygaard and Hansen, 2015), a cross-sectorial workshop was held on January 9, 2020 in Monrovia Liberia with stakeholders, technicians, and representatives from NGOs, CBOs and other private groups to identify barriers and develop an enabling framework or measures to overcome the potential barriers that could impede the possible transfer and diffusion of the three prioritized adaptation technologies in the coastal zone of Liberia. There were also a series of technical working sessions carried-out after the general workshop in order to have had a comprehensive process. Some key barriers were identified through the stakeholder's consultation process. All barriers and measures identified during the workshop for the prioritized technologies were grouped under two major categories, namely: *Financial and Non-Financial;* they were further analysed and decomposed. The barriers and measures identification process was conducted using a logical problem analysis (Painuly, 2001), by means of problem and objective trees *(Annex: I)* and as well as tables. Since the three coastal adaptation technologies are all in the *non-market goods* category, their non-financial barriers analysis was done from a Socio-environmental cost-benefit context as recommended by the TNA's BA&EF guidebook (Nygaard and Hansen, 2015).

1.2.1. General description of Integrated Coastal Zone Management (ICZM)

Historically in Liberia, most of the natural beaches sand dunes have been exploited for building or construction purposes. At many public beaches, human activities have also damaged the dune area which usually serves as a natural barrier between the shoreline and the land. Unregulated beach sand mining, private and public constructions on the beaches are also considered as a major problem contributing to the high rate of coastal erosion in coastal communities. Consequently, in addition to the above human induced activities, climate change related impacts such as sea level rise and coastal flooding have accelerated the initial rate of coastal erosion in

the country. However, the Integrated Coastal Zone Management (ICZM) is a dynamic, multidisciplinary and iterative process to promote sustainable management of coastal zones. The ICZM seeks over the long-term to balance environment, socio-economic, cultural and recreational objectives all within the limits set by natural dynamics. It covers the full cycle of information collection, planning, decision making, management and monitoring of implementation in the coastal zone (French, 2005).

Therefore, ICZM is a very sustainable potential coastal technology that was identified and prioritized by stakeholders in the TNA's coastal *Report I*. The ICZM could regulate the above mentioned existing problem if successfully instituted, adopted and diffused.

The successful transfer and diffusion of the ICZM in Liberia will establish comprehensive policies and some approach that would regulate the existing problem and as such, will proportionally create and provide an enabling environment to mitigate and adapt to the ongoing climate change impacts. This is moreover in line with good shore and beach management practice.

Some benefits of ICZM are:

- Dynamic, multidisciplinary and iterative process to promote sustainable management of coastal zones;
- ICZM reduces ecosystem degradation; and also conserves and maintains existing ecosystems from potential climate change impacts;
- Manages / protects coastal resources in a sustainable way;
- Involves local communities or stakeholders participation in decision of sustainable environmental management;
- ICZM seeks over the long-term, to balance environment, socioeconomic, cultural and recreational objectives.

1.2.2. Identification of barriers for Integrated Coastal Zone Management (ICZM)

For initializing the barrier analysis process and identifying enabling measures, the national consultant did a desk study of policy papers and other pertinent documents in order to identify

the primary reasons why the technology is not widely adopted, and why neither the private nor public sectors have invested significantly in it.

After the initial process by the consultant, a cross-sectorial workshop was held with stakeholders, technicians, and representatives from NGOs, CBOs and other private groups to conduct a barrier analysis and develop an enabling framework or measures to overcome the potential barriers that could impede the possible transfer and diffusion of each prioritized adaptation technology. The general workshop was followed by a series of technical working sessions for a successful process.

As such, the ICZM was reviewed and classified as *other non-market goods* (IPCC, 2000 and Lundvall et al., 2009). The identified barriers and their measures were screened and the most essential were then grouped under two major categories, namely: *Economic and Financial and Non-Financial.* In so doing, the non-financial barriers were further classified/ broken into seven subcategories: social and gender, information and awareness, technical, environmental, legal and regulatory, institutional arrangement and other barriers considered as political. These analyses were conducted through stakeholder's consultations and expert inputs using logical problem analysis; the tools used were problem and objective trees, and tables.

1.2.2.1. Economic and Financial Barriers for ICZM

The two major barriers identified under the economic and financial category for the adoption and diffusion of Integrated Coastal Zone Management in Liberia are presented in table 3.

Table 3*:* ICZM Economic and Financial barriers

Barrier Category	Barriers	Barrier Description
Economic & Financial	-High capital cost for equipment;	High capital cost is required for equipment to facilitate the proper transfer and diffusion of the ICZM for sustainable management.
	-Limited and inadequate access to public funding / support.	Nationally, there is limited and inadequate access to public funding or external support for the procurement of coastal zone monitoring equipment to sustainably manage the technology and vulnerable areas.

Most of the government institutions such as marine related protection or conservation, wild life, agriculture, environmental authority, universities, research institutions, etc., involved with different aspects of coastal ecosystem management lack adequate funds for coastal ecosystem related management activities. This major barrier could be due to the lack of understanding on the socioeconomic importance of the sector or it could also be due to the lack of political will to support budgetary allocations for the sector.

Furthermore, the lack of commitment by central and provincial government agencies to attract project specific funds to ensure social and economic security of the coastal communities through sustainable development and management of locally available natural resources could be considered as another contributing factor for inadequate funding.

1.2.2.2. Non-Financial Barriers for ICZM

Presented in table 4, are the identified non-financial barriers for the transfer and diffusion of Integrated Coastal Zone Management in Liberia that have been classified into the seven mentioned subcategories.

***Table 4**:* Non-financial barriers against ICZM

Barrier Category		**Barriers**	**Barrier Description**
Non-Financial Barriers	Social, Gender & Behavioural	- Limited involvement of local community groups;	Limited involvement of local community groups, CBOs, youth groups; and also the non representation of possible social and vulnerable groups and leaders could impede the proper diffusion, functioning and sustainability of ICZM.
		-Lack of commitment by the local coastal communities and some institutions / industries;	Lack of commitment by the local coastal communities and some institutions / industries to accept the technology and secure or protect existing sand dunes and other coastal ecosystems and environments. Because the human induced destructive coastal activities have been a source of income for them. This problem has being identified as an important barrier arising out of social, cultural, gender and behavioural patterns of the resource users.

	Information & Awareness	-Limited understanding of the functions and fundamental principles of ICZM ;	The limited understanding of the fundamental aim and principles of ICZM by many stakeholders and decision makers/ politicians is a major point to be considered because this has led to an inactive technology; and non-achievement of ICZM's objectives in many places.
		- Limited dissemination of information;	Limited and inadequate dissemination of information on the sustainable management regulations of ICZM, and lack of awareness for the technology's equipment for local coastal residents, concerned stakeholders and the public in general. Inadequate information and awareness has contributed to general lack of awareness and sensitization on the non extractive importance and as well as the role and functions of coastal sand dunes, beach vegetations at all levels of the society.
	Technical	-Lack of technical expertise in the different sectors or disciplines of ICZM;	Limitation of experts and well trained technicians to properly operate the technology. The ICZM is a multidisciplinary coastal technology; it requires knowledgeable people, technicians and experts in each sector or discipline of the technology at the institutional level for its proper transfer and functioning; as well as to achieve the objective of the ICZM. However, a high level of expertise at the local community level is not actually required; although some capacity building will be needed as community-based action groups and local leaders are essential to upholding the policies, regulations and adequate functioning of ICZM at the local level of the society.
	Environmental	-Inapplicability/ unfeasibility of ICZM in some areas;	Inapplicability/ unfeasibility of ICZM monitoring equipment in some natural high risk coastal environments such as highly erosive geological features; or due to Limited scientific understanding and special requirement of a specific coastal environment for the instillation of the technology's equipment.
		-Limited access to some coastal environments;	Limited access to some coastal environment for the transfer and diffusion of the technology due to private land ownership.
	Legal & Regulatory	-Lack of proper legal act or framework;	Lack of proper legal act or framework for the establishment, jurisdiction, transfer and diffusion of ICZM.

		-Non-existence or unclear framework of a current *ICZMU*;	Non-existence or unclear framework of a current Integrated Coastal Zone Management Unite (*ICZMU*) establishment at the Ministry of Mines & Energy of Liberia. The legal / regulatory framework that may serve as rules for required standards regarding the transfer and diffusion of the technology.
	Institutional arrangement & Organization	- Limited and inadequate coordination;	Limited and inadequate coordination among institutions with the same existing between coastal community leaders (stakeholders) and at an individual level. This is a serious challenge to the successful transfer and adoption of a technology; as some institutions and agencies share similar functions in Liberia.
		- Inadequate integration of technologies in policy plans;	Inadequate integration of technologies in policy plans due to the lack of proper policy mechanisms to promote the diffusion and adoption of the technology.
	Others	-Inadequate political will or support;	The lack of political will to support the implementation, transfer and adoption of technologies or some projects due to unknown political reasons.

Beach sand dunes with their associated vegetation act as natural barriers against coastal erosion and inundation caused by wave action, storm surge, and strong winds and also against tsunami waves. These functions of natural coastal resources are considered as non-extractive uses in coastal communities. Due to inadequate awareness within the community on such non-extractive uses, people engage in activities such as, beach sand mining, removal of dune vegetations for small scale or industries activities and construction.

In Liberia, the majority of those involved in the above environmentally destructive activities are most often unaware or not well sensitized about the importance of the sand dunes as soft barriers for protection of their homes, properties and other infrastructure against coastal erosion, inundation and other related climate change impacts. Therefore, an adequate awareness and sensitization is highly needed and recommended at all levels of the society to protect and promote the sustainable management of national coastal areas.

In order to facilitate the recommended adequate awareness and sensitization process, the lack of legal and regulatory framework for the establishment of ICZM in Liberia which is a major barrier to the adoption and diffusion, jurisdiction and adequate functioning of the technology across the country has to be addressed. This barrier is so vital that it could result in a total

breakdown of the ICZM or lead to the lack of political will for budgetary allotment, technical and institutional support if not properly established. It is to be pointed out that the lack of adequate financial support will result in not achieving the objective of the technology. This could be a major reason for the current unclear existence and not functional *Integrated Coastal Zone Management Unite (ICZMU)* at the Ministry of Mines and Energy of Liberia (MME) which is considered, not properly and professionally established in accordance with the ICZM guidelines.

The lack of political will to support the implementation, transfer and adoption of technologies or some projects is very common and widely noticeable in Liberia due to unknown political reasons. Therefore, getting politicians convinced on the social economic and environmental importance to support the implementation of a technology is highly significant. As such, it will provide an adequate budgetary allotment and also facilitate the diffusion of said technology at local level.

1.2.3. Identified Measures

The identified measures to the barriers that could potentially affect the transfer and diffusion of ICZM as a technology were analysed through stakeholder consultations and expert inputs. The measures were thoroughly analysed so as to directly address the identified problem.

1.2.3.1. Economic and financial measures for ICZM

Presented below in table 5 are the identified measures to address the two major economic and financial barriers that were identified for the ICZM establishment, transfer and diffusion in the coastal zone sector of Liberia.

Table 5*:* Measures to overcome the economic and financial barriers against ICZM

Barrier identified	Measures identified to overcome the barriers
Economic & Financial	-It is indeed highly recommended that an annual national budgetary allotment be secured to specifically address the operations and high capital cost for the start-up equipment of ICZM. The available funds can be used to train technicians, conduct research, monitor and support deployment activities of the technology.

	-To address the issue of inadequate access to public, external and other private funding, it was analysed and recommended to create a partnership with other available international donors that support climate change adaptation projects. -It is also important to develop sustainable community based projects and prepare funding proposals that meet climate change funding requirements to implement and diffuse the ICZM projects across all coastal counties of Liberia.

1.2.3.2. Non-financial measures for ICZM

The non-financial measures to address the identified non-financial barriers against the adoption and diffusion of the ICZM were grouped into seven subcategories (Table: 6) based on experts' and stakeholders' knowledge in accordance with the technology's socio-environmental cost-benefit.

Table 6: Identified non-financial measures retained for the ICZM

Identified Barriers' category		**Measures identified to overcome the barriers**
Non-financial Barriers	Social, Gender & Behavioural	- These involve the participation of local community leaders and concerned stakeholders, as well as vulnerable groups that are directly affected by the impacts of coastal erosion and flood in the transfer and diffusion of ICZM. - *Community Action Groups (CAG)* could be created to enforce the established regulations of the technology at local levels. The involvement of local groups will promote the technology at the community level and also increase the sensitization of ICZM policies and regulations. This will also promote behavioural change against beach sand mining and other destructive activities in the coastal zone.
	Information & Awareness	- To overcome the barrier of limited understanding of ICZM functions and fundamental principles, capacity building through training workshops for sensitization should be provided for all relevant stakeholders and also affected local community residents. In so doing, you will increase the public understanding of the technology and the objective for its adoption. - In order to overcome the limited dissemination of information about the ICZM sustainable management regulations, it was recommended to increase awareness and provide adequate information dissemination through the media, radio and television announcements or dramas, community and high school environmental groups, workshops and etc.. These measures are recommended to be repeated regularly to increase sensitisation.

	Technical	To therefore overcome the limited technical expertise in the different sectors or disciplines of ICZM, it was analysed and recommended to provide regular technical training for personnel involved with the establishment and diffusion of the technology at all levels. Because the ICZM is a multidisciplinary coastal technology and it requires knowledgeable people, technicians and experts in each of its sectors or disciplines to properly achieve its objective. It is important to involve both local and international experts / institutions to conduct the recommended trainings.
	Environmental	-In order to overcome the barrier of limited access to some coastal environment for the transfer and diffusion of ICZM, it was recommended to utilize the local residents in such area for the technology transfer, adoption and upholding. - For those areas that are naturally highly risky, and cannot easily allow the technology, it was recommended that the step-back / retreat method of coastal zone management be applied in such areas for the safety of lives.
	Legal & Regulatory	-It was recommended to develop an act and policy to govern the ICZM in order to overcome the lack of legal act for the establishment, jurisdiction, transfer and diffusion of the technology. The development of said act will facilitate budgetary allotment and attract political will to support the proper functioning of the technology. - It is also important to review the existence of an Integrated Coastal Zone Management Unit (ICZMU) at the ministry of mines and energy; if applicable, create a proper legal regulatory framework and a functional office, and to hire initial qualified personnel and experts to initiate the proper establishment in respect to the fundamental principles and objectives of ICZM.
	Institutional arrangement & Organization	It was recommended to create, develop and support cross-sectorial working groups, meetings and to ensure a proper coordination among institutions in order to overcome the barrier of limited and inadequate coordination among institutions, personnel, stakeholders and local communities. This will help to regulate the functional understanding of individual institutions as some institutions share similar functions in Liberia.
	Others	To overcome most of the other barriers that may even be considered as cross-cutting, it was analysed that getting political support for the implementation of the technology is highly significant. This can be done by getting the politicians that are responsible for policies convinced on the social economic and environmental importance to support the adoption and diffusion of a technology. The political will, will facilitate and support an adequate budgetary allotment for the project. It will also support and facilitate the smooth achievement of the technology adoption.

1.3. Barriers analysis and possible enabling measures for Technology 2: Flood early Warning System (FWS)

In order to analyse the possible barriers and to create an enabling measure for the *Flood early Warning System* (FWS) as a technology in the coastal zone of Liberia, a technical workshop was held to brainstorm and analyse the possible barriers that would impede the introduction, usage and diffusion for each of the three prioritized technologies . Said workshop brought together relevant stakeholders, technicians, representatives from other private groups. The analysis of the key barriers identification and the development of enabling measures to overcome the barriers were all done through a stakeholder's consultation process and expert's knowledge using a logical problem analysis (Painuly, 2001). Other technical coastal working sessions were held after the general workshop. The essential barriers and measures identified during the workshop for the prioritized technologies were grouped under two major categories, namely: *Economic and Financial, and Non-Financial.*

1.3.1. General description of the Flood early Warning System (FWS):

A Flood early Warning System is a means of detecting threatening events in advance to help protect lives and properties. In general, it aims to reduce the degree of casualty that could be caused by flooding in coastal areas through alerting the public in advance to take appropriate actions (precaution). Such service is highly important and needed in developing countries such as Liberia where coastal flooding is increasingly becoming a national concern.

This technology functions in a way that; once an event exceeds a given threshold, a warning will be issued. Said message is likely to be disseminated to the 'at risk' population. To achieve a successful FWS, a constant monitoring of meteorological and tidal conditions is required in conjunction with river and coastal flood forecasting models. As such, the data collected (tidal, meteorological, wave, river, wind and etc.) for this service could also be used for mitigation and sustainable environmental planning.

<u>Some benefits of FWS are:</u>

- The technology promotes human capacity building as it requires technical training, monitoring and forecasting.

- The technology provides job opportunities.
- A frequent high risk flood occurrence environment could be used or reserved for different purpose rather than residential.

1.3.2. Identification of barriers for Flood early Warning System (FWS):

In order to commence the identification and analysis of barriers for the FWS during the workshop, the technology was firstly analysed and categorized as *other non-market goods (*Lundvall et al., 2009). After which, the identified barriers for the technology were analysed through stakeholder consultations and expert inputs using a logic problem analysis from a socio-environmental cost-benefit context (Perman et al., 2003), with problem and objective trees, and tables as tools (*Annex: I*). The important barriers identified during the working session for the technologies were grouped under two major categories, namely: *Economic and Financial and Non-Financial.* The non-financial barrier's category was further analysed and decomposed into subcategories considering their socio-environmental cost-benefit.

1.3.2.1. Economic and Financial Barriers to the technology; FWS:

After the barriers analysis, two essential barriers were retained for the FWS under the category of *Economic & Financial*. The approach of FWS requires a significant volume of detailed information to be collected and analyzed in order to detect accurate flood threats. As such, the FWS requires significant investment in equipment and training of personnel. The barriers retained under this category are presented in table 7 below.

Table 7: FWS economic and financial barriers and their description

Barrier Category	Barriers	Barrier Description
Economic & Financial	-High capital cost for FWS installation	FWS requires significant investment in equipment, monitoring, training of personnel to operate the system and assure timely information dissemination.
	-Inadequate / limited access to funding	Nationally, there is no dependable or reliable budgetary allotment for the long term sustainability of the technology.

One of the most important objectives for the diffusion of this technology is a timely dissemination of information or alert to the "at-risk" population in order to take necessary

precautions for the safety of lives and properties. When the situation is threatening, a well trained and equipped emergency response team and timely action is vital. Hence, the technology requires adequate and reliable funding to successfully achieve this objective.

1.3.2.2. Non-Financial barriers against the FWS:

After the analysis of all possible barriers that could impede the FWS transfer and diffusion across the coastal areas of Liberia, the technical team with the guidance of the national consultant categorized the essential non-financial barriers into seven sub-categories with regards to their socio-environmental cost-benefit; table 8.

Table 8: FWS Non-economic barriers and their description

Barrier Category		**Barriers**	**Barrier Description**
Non-Financial Barriers	Social & Gender	-Not gender sensitive to vulnerable group	-Lack of short-term mitigation and adaptation measures to reduce the vulnerability of women and children groups and other vulnerable groups to flooding.
	Information & Awareness	-Limited data to predict coastal flooding.	-Unavailability and limited essential scientific data needed to substantially operate the technology.
		-Inadequate and limited information sharing.	-Inadequate and non-timely information sharing/ dissemination between institutions and people at risk.
	Technical	-Limited technicians & expertise	Limitation of experts and well trained technicians to properly operate the technology. Some operational examples are monitoring of substations, data collection, timely information sharing and etc.
	Environmental	-Environmental uncertainty	Limited scientific understanding and special requirement of a specific coastal environment for the instillation of the technology's equipment.
	Legal & Regulatory	-Lack of legal framework	No existing legal / regulatory framework that may serve as rules for required standards regarding the transfer and diffusion of the technology.
	Institutional arrangement	-Inadequate coordination between institutions.	The lack of proper understanding between institutions in sharing specific responsibility.
	Others	-Inadequate and limited political support	Limited political will to support the technology adoption and budgetary allotment for sustainable management.

1.3.3. Identified Measures for FWS:

The identified measures to the barriers that could potentially affect the transfer and diffusion of the FWS technology were analysed through stakeholder's consultations and expert inputs. The measures were thoroughly analysed so as to directly address the problem and they were also grouped under two major categories, *Economic and financial measures; and Non-financial measures* (Tables: 9 & 10).

1.3.3.1. Economic & financial measures for FWS:

During the workshop, the measures identified by the coastal zone technical working group to overcome the economic and financial barriers to the adoption and diffusion of the FWS are stipulated in table 9.

Table 9: Measures to overcome economic barriers to FWS

Barrier identified	Measures identified to overcome the barriers
Economic & Financial	To overcome the high capital cost for FWS installation and operations, a regular annual national budgetary support/ allotment should be secured or established for the proper functioning of the technology.
	To overcome the Inadequate / limited access to funding, it is recommended to develop a comprehensive funding proposal that meets international climate change adaptation funding requirements in order to have access to such funding. A partnership could also be created with external organizations that support climate change adaptation projects through funding, technical training and etc.

1.3.3.2. Non- financial measures for the FWS:

The non-financial measures for the FWS were group into seven subcategories based on experts' and stakeholders' knowledge with regards to the technology's socio-environmental cost-benefit. Indicated below in table 10 are the identified non-financial measures to adopt the FWS.

Table 10: Identified non-financial measures retained for the FWS

Identified category	Barriers'	Measures identified to overcome the barriers
Non-financial Barriers	Social & gender	To overcome the barrier of non gender inclusion for the FWS, create and provide mitigation and adaptation measures that will have direct positive impact or result on vulnerable women, children, youth and disable groups. As such, a timely emergency response team should be instituted to evacuate / prioritize people within such category in times of potential risk of flooding.

	Information & Awareness	Provide and improve quick information sharing between institution, stakeholders and the population at risk through direct text messages to individual phones or by radio awareness programmes.
	Technical	- To overcome the barrier of limited available data, provide and increase funding for research and data collection. -To also overcome the barrier of limited technicians and experts to fully and properly operate the technology, it was agreed that providing adequate capacity building trainings for personnel should address the problem. The trainings should be done by institutions and experts that have successfully operated the FWS in other areas.
	Environmental	To overcome the barrier of limited scientific understanding of a specific coastal environment for the instillation of the technology, conduct proper environmental impact assessments to understand the environmental feasibility of the technology.
	Legal & Regulatory	In order to overcome the legal and regulatory barrier to the transfer and diffusion of the FWS, create and adopt a legal framework and ensure straight acceptance to local and international standards.
	Institutional arrangement	To overcome the problem of inadequate coordination between institutions, it is highly important and recommended to develop, regulate and improve coordination through regular cross-sectorial regulatory meetings and working groups to ensure a proper coordination among institutions and also at individual level.
	Others	To overcome some of the others barriers that may exist, it is therefore highly important and recommended to solicit political support and the involvement of politicians to understand the significance for the implementation and diffusion of the FWS which is to protect lives and properties from the risk of coastal flooding.

1.4. Barriers Analysis and Possible Enabling Measures for Technology 3: Rock Revetments

Like the initial two technologies' barriers analysis procedure, the analysis of the *rocks' revetment* barriers was conducted through a cross-sectorial, technical and stakeholder consultation workshop. To facilitate the process, the technology was firstly analysed and categorized as a *publicly provided goods (*Lundvall et al., 2009). The stakeholders' engagement was one of the key aspects of the process; the names, contacts and other details of the stakeholders are presented in *Annex II*. The problem and objective trees for the rock revetments are inserted in *Annex I.*

The essential barriers and their possible measures identified during the workshop were carried out using the logical problem analysis (Painuly, 2001). The barriers identified and their enabling frameworks were grouped under two major categories: *Economic and financial*, *and Non-Financial* in regards to their socio-environmental cost-benefit.

1.4.1. General description of the Rock Revetments:

A revetment is a sloped seaward structure of hard engineering option which protects against erosion caused by wave action, storm surge and tidal effects. It is often built with armour boulders (rocks), concrete or other durable materials to protect a scarp, shoreline, embankment or sand dune against erosion (UNFCCC, 1999). Revetments provide protection against shoreline change and related coastal flooding, and fix the boundary between the sea and land; these actions protect and assist in maintaining the landward environment. Revetments are frequently used in locations where further shore erosion will result in excessive damage; e.g. when roads and buildings are about to fall into the sea. Said technology provides a high level of security which can favour the development of coastal communities.

As coastal erosion vulnerabilities and risks have become a national concern in Liberia, the application and diffusion of rock revetments as adaptation option was accepted through a stakeholder's consultation process to be widely adopted nationally due to the availability of ideal rocks quarries in country.

Some benefits of the technology:

- Rock revetments minimize the destructive and hazardous risks to coastal ecosystem, vegetation, sand dunes and important infrastructures. They also prevent coastlines that are subjected to erosion, high wave impact and coastal flooding from related degradations.
- Revetments that are in continuous contact with the water promote the formation of coral reefs and attract many coastal species. This option of coastal defence helps to stabilize the beach environment and in general, reduces coastal vulnerability to climate change impacts.

1.4.2. Identification of barriers for the adoption of rock revetments

In order to better analyse the possible barriers to the introduction and diffusion of rock revetments in the coastal zone of Liberia, the technology was firstly reviewed and classified as a *publicly provided good.* The barriers were then identified and analysed, and those considered as essential were grouped under two major categories: *Economic and Financial, and Non-Financial.* This was done through stakeholder consultations and expert inputs during a technical cross-sectorial workshop using a logical problem analysis, after which other technical working sessions were held.

1.4.2.1. Economic and financial barriers against the rock revetments

The essential economic and financial barriers retained against the diffusion of rock revetments in the coastal zone of Liberia are presented in the table below.

Table 11: Economic and financial barriers retained against the diffusion of rock revetments

Barrier Category	Barriers	Barrier Description
Economic & Financial	-High cost of construction & periodic maintenance	-The construction of rock revetments requires the buying of several thousand tons of massive ideal rocks that meet geotechnical standards. The price of said rocks may vary depending on different factors and conditions such as the proximity of quarry from construction site, availability of required rocks, demand, and site accessibility. - Complexity of design and length of the revetment to be constructed. The duration of the project is to be

		considered. -Procurement / renting of construction materials and equipment such as large excavators, front-end loaders, cranes, geotextiles, fuel and etc. -Salaries for engineers and other labourers. The maintenance of the revetment is to be considered, but it is often forgotten in the construction budget (Swan River Trust, 2009).
	- Limited access to funding and lack of national budgetary support.	Nationally, there is no reliable available budgetary allotment to support the construction and maintenance of revetments.

1.4.2.2. Non-Financial barriers to rock revetments

The identification and analysis of the non-financial barriers to the adoption and diffusion of rocks' revetments in the coastal areas of Liberia were conducted through a cross-sectorial stakeholder consultations and expert's knowledge process. With the guidance of the national consultant, the essential non-financial barriers were grouped into seven sub-categories presented in table 12 while considering their socio-environmental cost-benefit.

Table 12: Essential non-financial barriers retained against the diffusion of rock revetments

Barrier Category		Barriers	Barrier Description
Non-Financial Barriers	Social & Gender	-Potential loss of cultural & heritage sites	A cultural or heritage site in a vulnerable or high risk coastal community affected by the impacts of coastal erosion or flood could be destroyed due to the site being in the construction pathway of the revetment that is intended to prevent the erosion.
		-Loss of landing sites for canoes and fishing boats	The placement of the rocks along the beach can prevent / block direct access of the canoes / boats to the beach or the sea. Under some conditions, the revetment may consume or occupy the landing space of the fishermen's boats.
		-Disruption or change of livelihood for vulnerable groups	The structure of the revetment along the beach can disrupt and change the regular livelihood of vulnerable coastal groups that depend on fish mongering.
	Information & Awareness	-Limited & inadequate information and awareness of the technology to coastal communities	The technology may not be accepted by vulnerable coastal residents due to the lack or inadequate information and awareness in coastal communities about the technology to be adopted. This usually results to a negative perception for the

			implementation of the technology.
	Technical	-Limited scientific data	Unavailability and limited essential scientific data needed for the construction of the technology. The design of an effective rocks' revetment requires good quality, long-term understanding of the environmental and data such as wave heights, sediment transport, extreme sea level rise and etc.
		-Lack of human skills & institutional ability	Limitation of experts, engineers and well trained technicians to design and construct an effective and standard rock's revetment.
	Environmental	-Loss of beach front	The construction of rock's revetments usually covers the beach front and prevents / limits direct access to the water.
		-Physical environmental damage of landscape used for quarry	The massive blasting and excavation of the earth surface in search of ideal rocks result into the creation of large pits in the environment. This process affects the natural ecosystems in the environment.
	Legal & Regulatory	-limited or inadequate enforcement of zoning laws / building code	The limited enforcement of the zoning laws and building codes in coastal communities has facilitated private constructions on public beaches which result in land disputes and request for relocation / resettlement benefits in Liberia. The construction of private homes very close to the beach or at the beach front impedes the construction, adoption and diffusion of revetment in said areas.
	Market condition	-Inadequate and limited specialized equipment	Lack of proper specialized equipment in country for an effective and standard rock revetments construction. Example, lack of proper geotextile, large excavators, proper crane and etc.
	Others	Inadequate and limited political support	Limited political will to financially support the construction of revetments.

1.4.3. Identified Measures for rock revetments:

The measures to the identified barriers against the transfer and diffusion of the rock revetments were thoroughly analysed so as to directly overcome the barriers. The analysis and development of an enabling framework were effectuated through stakeholder consultations and expert's

knowledge with the guidance of the national consultant during the general workshop and other technical working sessions.

1.4.3.1. Economic and financial measures for rock revetments:

The economic and financial measures to overcome the identified barriers to the diffusion of rock revetments under this category are hereby indicated below in table 13.

Table 13: Economic and financial measures for the identified barriers against rock's revetments

Barrier identified	**Measures identified to overcome the barriers**
Economic & Financial	To overcome the high cost of revetment construction and that of the periodic maintenance, a regular annual national budgetary support/ allotment should be secured for the implementation and maintenance of rock revetments in vulnerable coastal communities.
	To overcome the inadequate / limited access to funding resources, develop a comprehensive funding proposal that meets international climate change adaptation funding requirements in order to have access to such funding. A partnership could also be created with external organizations the support climate change projects through funding, technical training and etc.

1.4.3.2. Non-financial measures for rock revetments:

Below in table 14 are the non-financial measures to overcome the essential identified non-financial barriers that could possibly impede the adoption and diffusion of rock revetments as a technology to protect lives properties and coastal ecosystems against the impacts of coastal erosion.

Table 14: Non-financial measures to overcome the identified barriers to rock revetments

Identified barriers' category		**Measures identified to overcome the barriers**
Non-financial barriers	Social & gender	To overcome the potential loss of cultural and heritage sites, avoid possible damage of them and most importantly, negotiate with local residents for possible applicable and acceptable suggestions or solutions.
		-In order to overcome the loss of landing sites for fishermen's canoes and boats, create access / pathway to the beach through the revetment during the design stage to avoid disruption of regular livelihood activities.
		To overcome the barrier of disruption or change of livelihood for vulnerable groups such as the fish mongers, create and provide alternative livelihood such as eco-friendly drying facilities and storages for vulnerable fish mongers (women & disables).

	Information & Awareness	To overcome the limited and inadequate information and awareness of the technology to vulnerable coastal communities, provide and improve awareness of the technology through a detailed community involvement. Create community-based action groups and promote the acceptance of the project by relevant group leaders and end-users.
	Technical	In order to overcome the barrier of limited available data, provide and increase funding for research and data collection.
		To overcome the lack and inadequate human skills and institutional ability, provide adequate capacity building trainings at institutional and individual level. This will allow the personnel to improve their skills to fully implement and operate the technology. It is highly recommended that the trainings should be conducted by institutions and experts that have acceptable relevant expertise in implementing the technology.
	Environmental	To overcome the loss of a beach front to the technology's implementation, create or provide recreational activities or infrastructures such as a volleyball court on the sand at the back of the revetment, landward.
		In order to overcome the physical environmental damage of the landscape used for a quarry, convert the abandoned quarry sites / pits into touristic sites or recreational parks. For examples, the abandoned pit could be converted into a fishpond.
	Legal & Regulatory	To overcome the limited enforcement of zoning laws and building codes in vulnerable coastal areas, fully enforce the existing zoning laws and building codes in coastal areas to avoid the constructions of private properties on public beaches and owning of those public beaches, and converting them for private use. This will facilitate the smooth implementation and diffusion of revetment.
	Market conditions	To overcome the inadequate and limited specialized equipment and materials being available in country, promote and increase funding for the procurement of appropriate specialized equipment for the implementation and construction of rocks' revetments. Also, encourage and facilitate the creation of such business/ market in country to reduce the cost of implementation.
	Others	To overcome some of the others barriers, it is important and recommended to solicit political will /support to facilitate a smooth implementation, adoption and diffusion of the technology.

1.5. Linkages of the Barriers Identified

This section focuses on the linkages of the barriers identified against the three prioritized coastal zone's technologies. The three prioritized coastal zone technologies for Liberia are all *non-market goods* technologies in general (IPCC, 2000 and Lundvall et al., 2009). As such, the analysis and linkages of their barriers showed some specific and common barriers among them from a socio-environmental cost-benefit perspective. Those common barriers faced with more than one of the three prioritized technologies are presented below; table 15.

Table 15: Linkages of common barriers identified among prioritized technologies

Barrier category	Broad/ common barrier	Technology
Economic & Financial	▪ High capital cost; ▪ Limited access to funding	1-ICZM 2-FWS 3-Rock Revetments
Social & Gender	▪ Limited & inadequate involvement and participation of affected local communities and vulnerable groups; ▪ Potential loss of cultural & heritage sites	1-ICZM 2-FWS 3-Rock Revetments
Information & Awareness	▪ Limited & inadequate information sharing and awareness among the population	1-ICZM 2-FWS 3-Rock Revetments
Technical	▪ Limited data & the lack of Research ▪ Lack of technical expertise	1-ICZM 2-FWS 3-Rock Revetments
Institutional arrangement	▪ Inadequate and limited coordination between institutions.	1-ICZM 2-FWS
Legal & Regulatory	▪ Inadequate / lack of legal framework	1-ICZM 2-FWS
Others	▪ The lack of political will to support implementation and long-term sustainability	1-ICZM 2-FWS 3-Rock Revetments

The analysis of the commonly identified barriers has shown a link between the financial and non-financial barriers. Under the barriers category of *others,* the lack of political will to support implementation or budgetary allotment will significantly impede long-term sustainability and operations of the technology. The lack of said political support is often linked, or it is the result for the inadequate/ lack of *legal and regulatory* framework which could have legally demanded

financial and political support from national government. By consequence, the lack of financial support due to inadequate *legal and regulatory framework* will then facilitate a limited availability of required data and non support for research; *technical* category. In so doing, there would also be an inadequate *institutional arrangement* and a limited coordination due to the same lack of *legal and regulatory framework.*

As such, an inadequate *institutional arrangement* and limited coordination will result to inadequate *information sharing and awareness* among the population or end-users of the technology. In said regard, limited information sharing and awareness as a category is linked to the *social and gender* category of having a limited and inadequate involvement and participation of affected local communities and vulnerable groups.

1.6. Enabling Framework for Overcoming the Barriers

In Liberia, a key component of the enabling framework for overcoming the barriers to the diffusion of all three prioritized coastal technologies is the development and enforcement of a functionally coherent government policy framework on climate change to explicitly recognize the identified and prioritized coastal zone's technologies as essential mechanisms to increase the resilience of vulnerable coastal communities to the impacts of erosion, flood, sea level rise and other related climate change impacts. Such a functional and coherent policy framework will then facilitate and encourage political support to allocate and create access to sustainable funding which is a major barrier to uphold the operations of the technologies. Table 16 consist of the enabling framework for overcoming the barriers.

Table 16: Enabling framework for the major cross-cutting barriers to the technologies

Barrier category	**Broad/ common barrier**	**Enabling framework**	**Technology**
Economic & Financial	-High capital cost	A regular annual national budgetary allotment should be secured to specifically address the setup, operations and long-term sustainability of the prioritized technologies. The available funds can be used to train technicians, conduct research, monitor and support deployment activities of the technologies.	1-ICZM 2-FWS 3-Rock Revetment
	-Limited access to funding	To have access to public, external and other private funding, it was analysed and recommended to develop a comprehensive funding proposal that meets local and international climate change adaptation funding requirements for the technologies. A partnership could also be created with other available international donors that support climate change adaptation projects through funding, capacity building, equipment and etc.	
Social & Gender	-Limited & inadequate involvement and participation of affected local communities and vulnerable groups by decision makers. (Lack of invited involvement)	Involve the participation of local community leaders and concerned stakeholders, vulnerable groups that are directly affected by the impacts of climate change in the transfer and diffusion of the prioritized technologies. For example, a *Community Action Groups (CAG)* could be created in each affected coastal community to enforce the established regulations of the technology at local levels. The design of a revetment could affect the livelihood of some coastal residents (fish mongers);	1-ICZM 2-FWS 3-Rock Revetment

		therefore, it is important to invite and solicit the views and recommendations of affected community leaders during the design stage of a revetment to avoid the disruption of livelihoods. The involvement of local groups will promote the technology at the community level and also increase the sensitization of policies and regulations. This will also promote behavioural change against beach sand mining and other destructive activities in the coastal zone.	
	-Potential loss of cultural and heritage sites	To overcome the potential loss of cultural and heritage sites specifically for the diffusion of rocks' revetments, it is important to avoid damaging said sites by negotiating with local residents and their leaders for possible applicable and acceptable suggestions or solutions.	
Information & Awareness	-Limited & inadequate information sharing and awareness among the population	Improve and increase awareness; provide adequate information dissemination through direct text messages, radio and television announcements, community and high school environmental groups, workshops and etc. Encourage and promote the acceptance of the project by relevant group leaders and end-users. These measures are recommended to be repeated regularly to increase sensitisation.	1-ICZM 2-FWS 3-Rock Revetment
Technical	-Limited data & Research	Provide, improve, encourage and increase funding for research and data collection.	1-ICZM 2-FWS 3-Rock Revetment
	-Lack of technical expertise	Provide regular technical capacity building trainings for personnel involved with the establishment and diffusion of the technology at all levels. It is important to involve both local and international experts and institutions to conduct the recommended trainings.	
Institutional arrangement	-Inadequate coordination between institutions.	Improve, regulate and support coordination through regular cross-sectorial regulatory meetings and working groups to ensure a proper coordination among institutions, personnel, stakeholders and local communities.	1-ICZM 2-FWS
Legal & Regulatory	-Lack or inadequate legal act /framework	Create and adopt a legal act or framework and ensure straight acceptance to local and international standards. Create *Community Action Groups (CAG)* to enforce established regulations of the technologies at local levels.	1-ICZM 2-FWS

	-Non-existence or unclear framework of current ICZM	Revisit the existence of an Integrated Coastal Zone Management Unit (ICZMU) at the ministry of mines and energy; if applicable, create a proper framework and a functional office. Hire initial qualified personnel and experts to initiate the proper establishment and operations in respect to the fundamental principles and objectives of ICZM.	
Others	-The lack of political will to support implementation and long-term sustainability	To overcome most of the other barriers that may even be considered as cross-cutting, it was analysed and recommended to solicit political will /support to facilitate a smooth implementation, adoption and diffusion of the prioritized technologies. This can be done by getting those politicians that are responsible for policies understand and convinced on the social economic and environmental importance to support the adoption / implementation and diffusion of the technology. The accomplishment of the above will facilitate and support an adequate budgetary allotment for coastal projects.	1-ICZM 2-FWS 3-Rock Revetment

List of References

Chambers, R. (2005). 'Notes for Participants in PRAPLA Familiarisation Workshops in 2005, Sussex', Participation Resource Centre IDS.

DAI (2008), Liberia Environmental Threats and Opportunities Assessment (ETOA) Final Report to USAID/Liberia, Office of Economic Growth, Development Alternatives International, Bethesda, MD.

EPA (2007). National Report on the Marine and Coastal Environment in Liberia, Report to the Abidjan Convention.

EPAa (2013). Identification of Capacity Barriers Gaps and Needs for Enabling Climate Change Mitigation Measures under the Project Management of Environmental Services and Financing for Sustainable Development, Liberia, Monrovia.

French, P.W. (2005) Coastal Zone Management in Schwartz, M.L. (ed.). Encyclopedia of Coastal Science. The Netherlands: Springer, 313-319.

Government of Liberia EPA (2003). National Environmental Policy of Liberia (NEP) 2003, Environmental Protection Agency of Liberia, viewed 15 December 2019, <https://postconflict.unep.ch/liberia/index_4b.php?m=4&sm=4b>.

Government of Liberia 2012, National Disaster Management Policy **(NDMP, 2012).** Prevention Web, viewed 4 January 2020, <http://preventionweb.net/go/59847>.

Haselip, J., Narkeviciute, R., Rogat, J., Traerup, S. (2019). TNA Step by Step – A guidebook for countries conducting a Technology Needs Assessment and Action Plan.

IPCC (2000). 'Methodological and technological issues in technology transfer'. Bert Metz et al., editors. Special report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Linham, Mathews M. and Robert J. Nicholls (2010). Technologies for Climate Change Adaptation – Coastal Erosion & Flooding- (Xaanil Zhu Ed.). UNEP Riso Centre, University of Southhampton. ISBN978-87550-3855-4

Lundvall, B., Joseph, K., Chaminade, C. and Vang, J. (2009). 'Handbook of Innovation Systems and Developing Countries: Building Domestic Capabilities in a Global Setting', Edward Elgar, London.

McSweeney, C., New, M., Lizcano, G., Lu, X. (2010). The UNDP Climate Change Country Profiles. Bulletin of the American Meteorological Society 91, 157-166.

NAPA. (2008). National Adaptation Program of Action, Republic of Liberia

NEP (2003). National Environmental Policy, EPA Republic of Liberia

NPRSCC (2018), National Policy and Response strategy on Climate change Liberia, NUDRR Prevention Web, viewed 6 January 2020.

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

Painuly, J.P. (2001). 'Barriers to renewable energy penetration: a framework for analysis'. Renewable Energy, vol. 24, p. 73-89.

Rocheleau, D. and Slocum, R. (1995). 'Participation in Context: Key Questions'. In Slocum, R., Wichhart, L., Rocheleau, D., Thomas, B. (1995). Power, Process and Participation: Tools for Change. London: Intermediary Technology Publications.

Rogat (Ed.) (2017). Identification and Engagement of Stakeholders in the TNA Process: A Guide for National TNA Teams. UNEP DTU Partnership, Copenhagen.

Tumbey, A. (2015). Analytical research on climate change impacts on key sectors in Liberia. Environmental Protection Agency of Liberia (Unpublished Report).

UNEP DTU Partnership. Retrieved from http://www.tech-action.org/Publications/TNA Guidebooks

UNFCCC (United Nations Framework Convention on Climate Change) (1999). Coastal Adaptation Technologies. Bonn: UNFCCC. Available at: http://unfccc.int/resource/docs/tp/tp0199.pdf

USAID (2009) Adapting to Coastal Climate Change: A Guidebook for Development Planners. Rhode Island: USAID. Available from: www.crc.uri.edu/download/CoastalAdaptationGuide.pdf

USAID (2013). Liberia Climate change assessment. Prepared by USDA Forest Service Office of International Programs, Liberia.

Wiles, D. L. (2005). Coastal zone vulnerability and adaptation to climate change in Liberia. In Training Workshop on Adaptation and Vulnerability to Climate Change, Maputo. Mozambique.

Annex I: Logical Problem Analysis (problem & Objective trees)

Annex I-a: Problem Trees for Technologies 1, 2 and 3

Figure 2: Problem tree for Technology 1; Integrated Coastal Zone Management (ICZM)

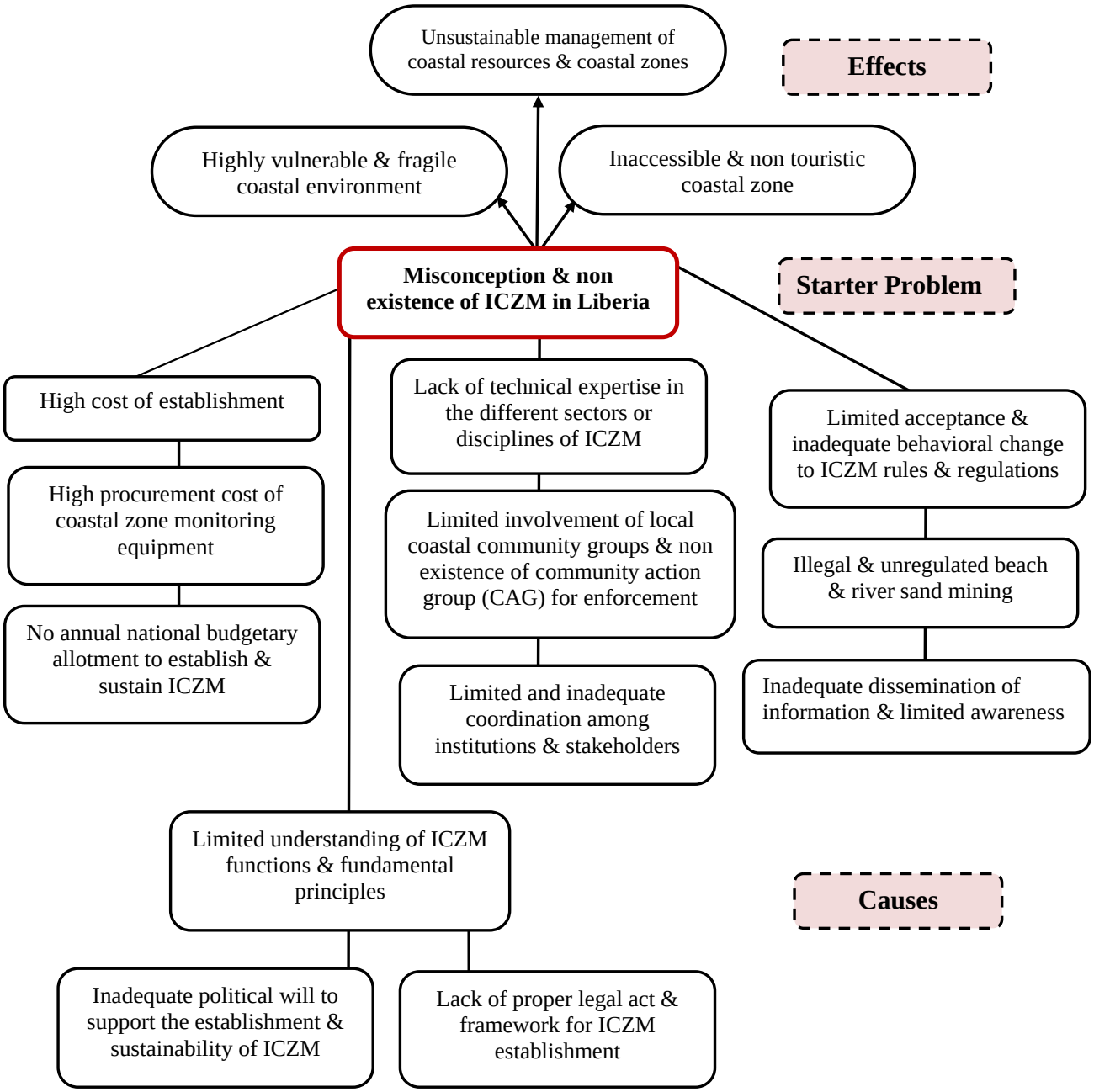


Figure 3: Problem tree for Technology 2; Flood early Warning System (FWS)

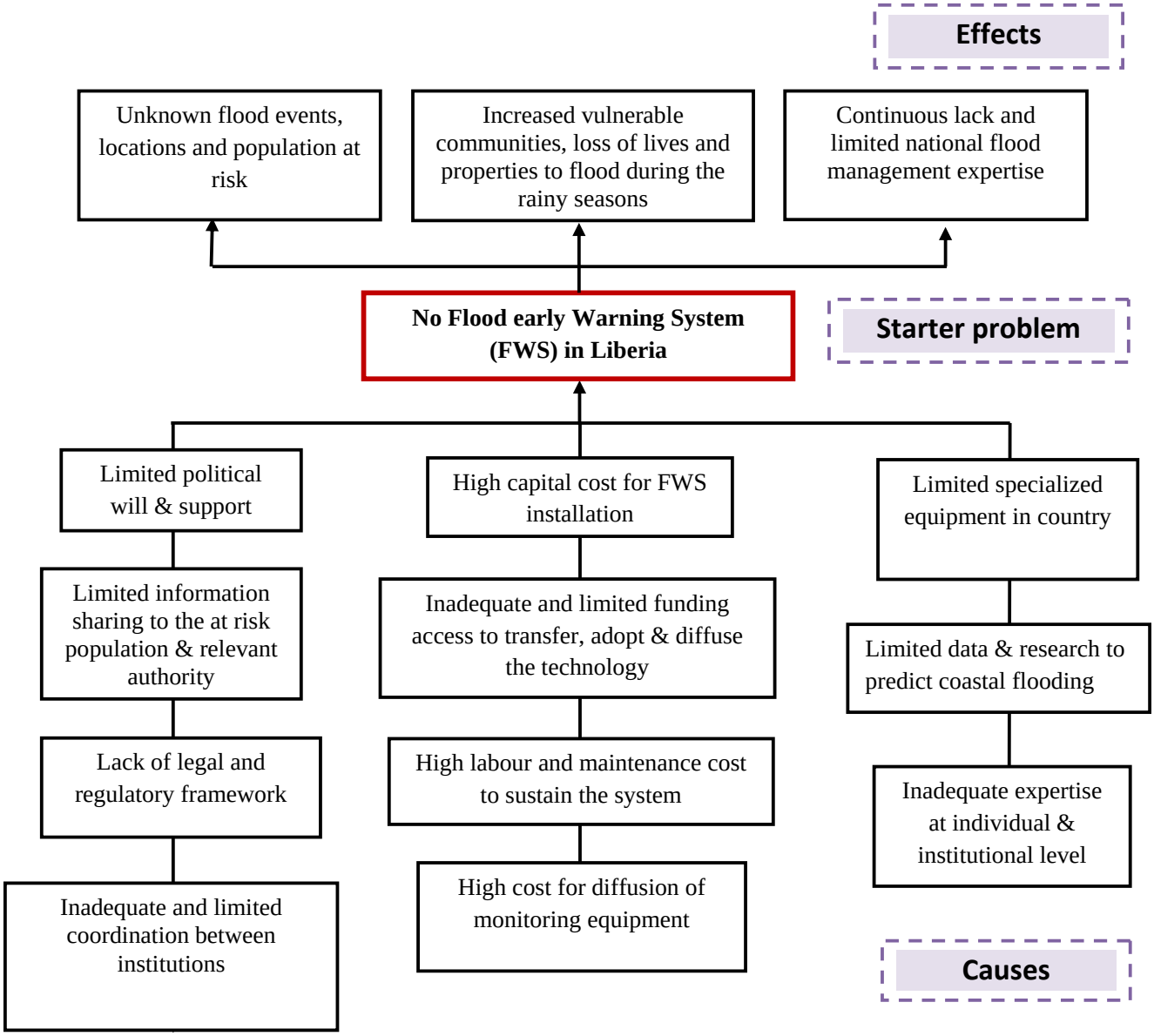
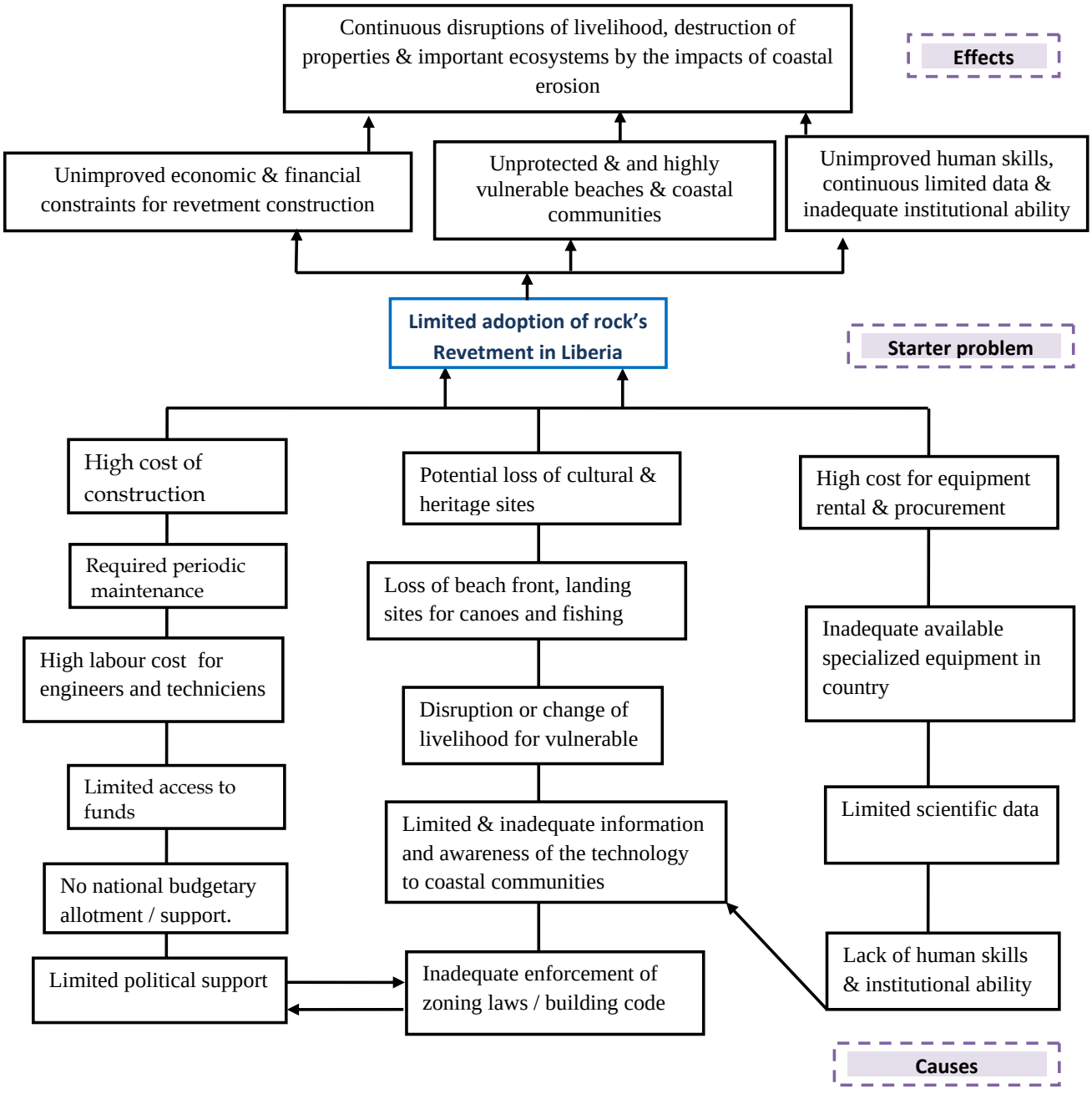


Figure 4: Problem tree for Technology 3; Rock Revetments



Annex I-b. Objective trees for Technologies 1, 2 and 3

Figure 5: Objective tree for technology 1; Integrated Coastal Zone Management (ICZM)

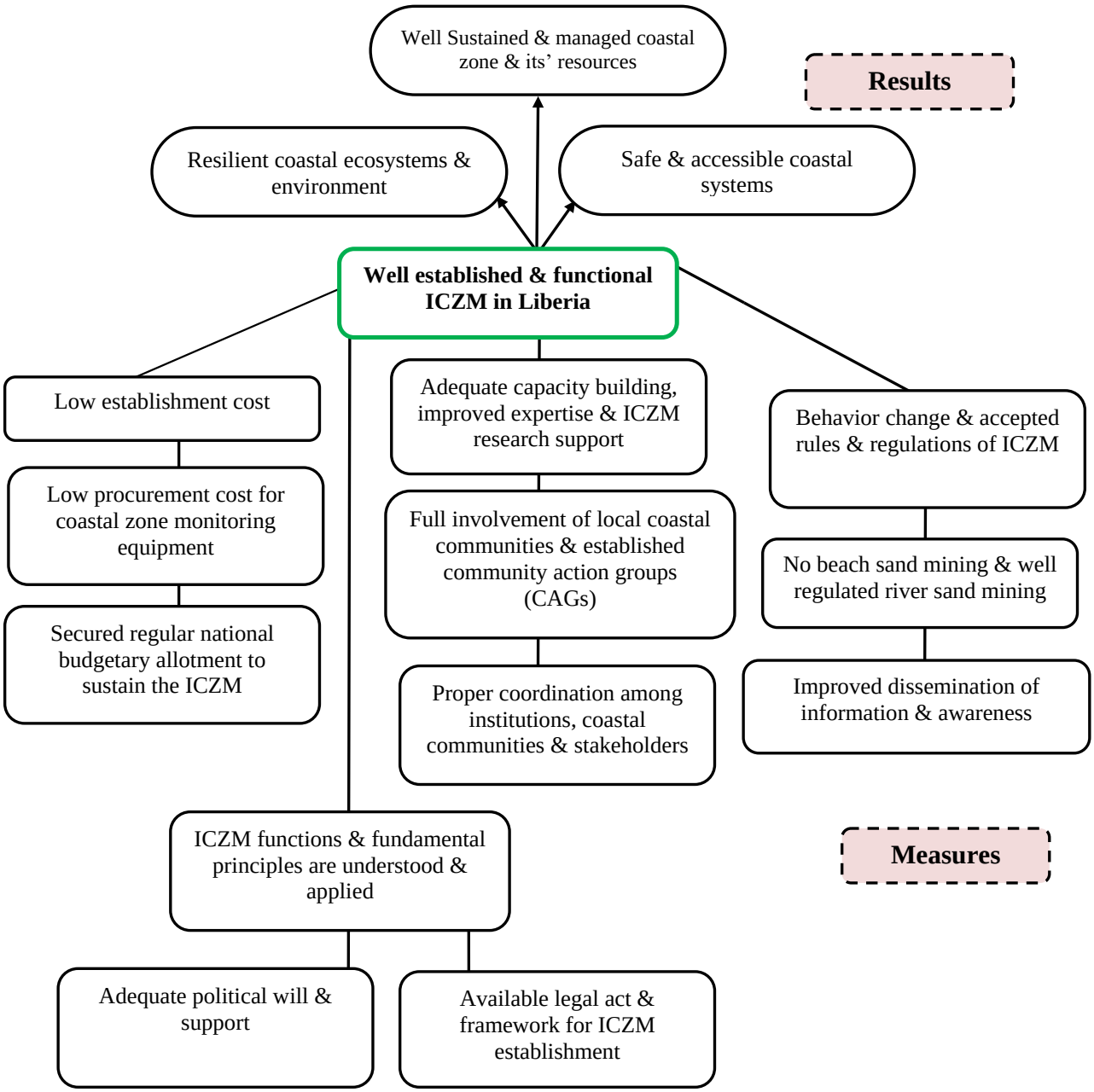


Figure 6: Objective tree for technology 2; Flood early Warning System (FWS)

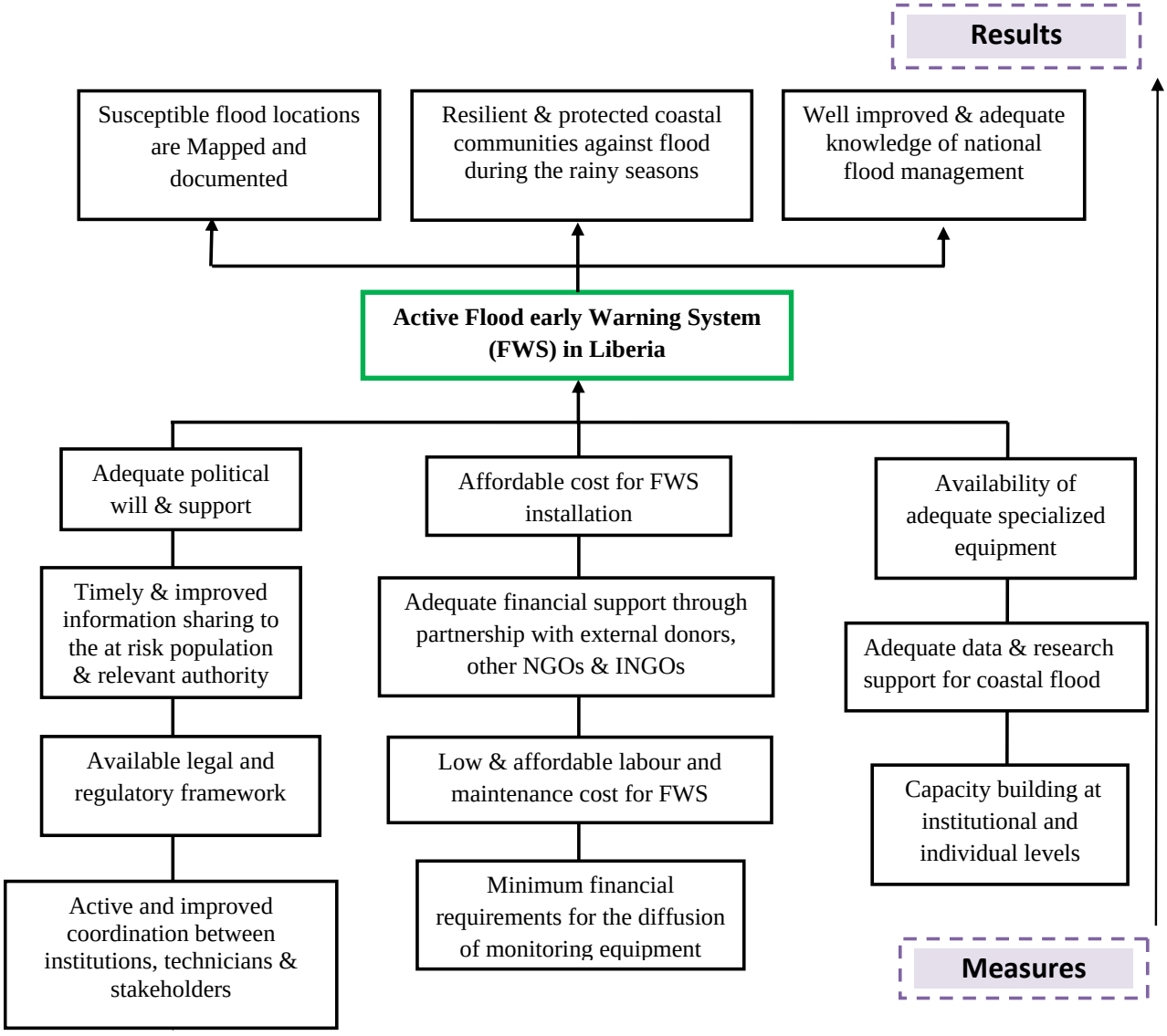
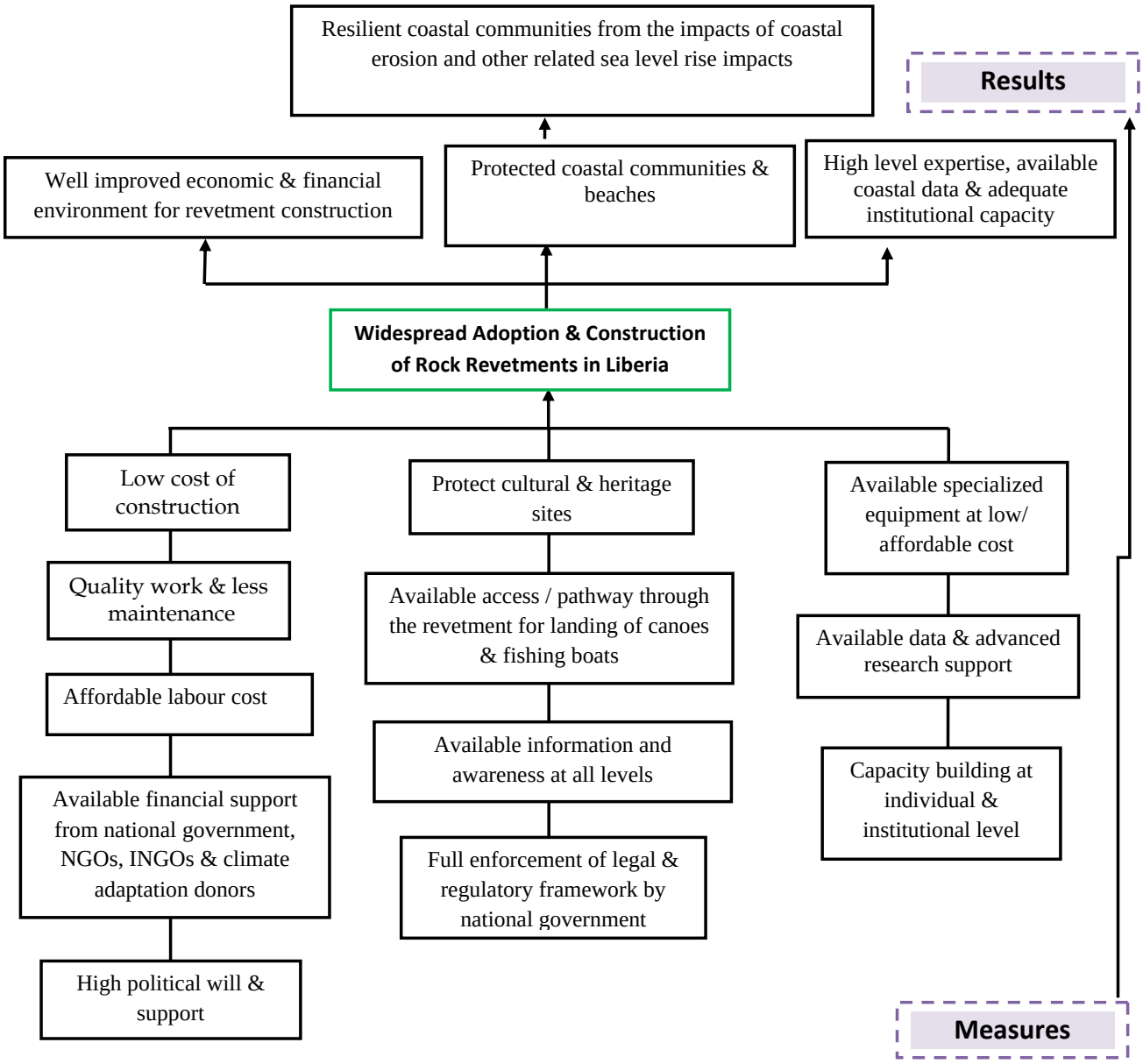


Figure 7: Objective tree for technology 3; Rock Revetments



Annex II: List of Stakeholders involved and their contacts

Table 17: Names and Contacts of Coastal zone stakeholders' working group

No.	Name	Gender	Institution	Contact	Consultation mode	Date	Topic
1	Victor B. Smith	M	Alliance Consulting Engineers (ACE)	vicbo.jarezan@aol.com	Workshop discussion	9 Jan. 2020	BA & EF
					Technical working sessions	After Jan. 9	
2	Ansumana A.M. Turay	M	Environmental Protection Agency (EPA)	turayansu23@gmail.com	Workshop discussion	9 Jan. 2020	BA & EF
					Technical working sessions	After Jan. 9	
3	John C.L. Mayson II	M	NAP- UNDP, Coastal Engineer	Johnclmaysonii@gmail.com	Meeting discussions	Dec. 2019 & March 2020	Coastal erosion & ICZM
					Workshop discussion	9 Jan. 2020	BA & EF
4	Alice B. Weah	F	Governor, New Kru Town, Bushrod Island – Monrovia	00231770197231	Workshop discussion	9 Jan. 2020	BA & EF
					Technical working sessions	After Jan. 9	
5	Dennis K. Yeberth	M	Community youth Empowerment Representative	koffa1908@gmail.com	Workshop discussion	9 Jan. 2020	BA & EF
					Technical working sessions	After Jan. 9	
6	Patricia Togba	F	Ministry of Gender- Children & Social Protection (MGCSP)	mgcspdmrppta@gmail.com	Workshop discussion	9 Jan. 2020	BA & EF
					Technical working sessions	After Jan. 9	
7	Louise K Morris	F	National Disaster Management Agency (NDMA)	louisekdavies4@gmail.com	Workshop discussion	9 Jan. 2020	BA & EF
					Technical working sessions	After Jan. 9	

8	Johnson S. Willabo Jr.	M	Asst. Minister: Ministry of mines & Energy (MME)	Johnson.willabo@yahoo.com	Meeting discussions	Jan. 2020 &	Coastal erosion & BA & EF
						March 2020	ICZM
9	Michael S.A. Zean	M	Disable Youth Representative	Michaelzean37@gmail.com	Workshop discussion	9 Jan. 2020	BA & EF
					Technical working sessions	After Jan. 9	
10	Lorine A. Saizonou	F	Youth Climate Change Initiative-Liberia (YCCI)	alexialorine@gmail.com	Workshop discussion	9 Jan. 2020	BA & EF
					Technical working sessions	After Jan. 9	