LAO PEOPLE'S DEMOCRATIC REPUBLIC

Technology Needs Assessment:

Barrier Analysis and Enabling Framework for Climate Change Adaptation

Supported by

November 2017

Barrier Analysis and Enabling Framework for Climate Change Adaptation

Vientiane, November 2017

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DISCLAIMER

This report is intended to identify barriers and enabling framework for developing and sustaining technologies for climate change adaptation in water resources and agriculture in Lao PDR. The results presented in this publication are entirely those of the author, revivers and coordinator, and should not be attributed in any manner to the Global Environment Facility (GEF), which funded the production of this publication.

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List of Abbreviations

CWSH	Centre for Water Sanitation and Hygiene
COP	Conference of the Parties
DRR	Department of Disaster Recovery, MLSW
DoI	Department of Irrigation, MAF
DoA	Department of Agriculture, MAF
DLF	Department of Livestock and Fishery, MAF
DRW	Department of Water Resources, MoNRE
EIA	Environmental Impact Assessment
EWS	Early Warning System
ESMP	Environmental and Social Management Plan
FAO	Food and Agriculture Organization (of the United Nations)
FoE	Faculty of Environment, NUOL
FoF	Faculty of Forestry, NUOL
FoWRE	Faculty of Water Resources and Engendering, NUOL
GDP	Gross Domestic Product
GIZ	Deutsche Gesellschaftffs Internationale Zusammenarbeit (German Agency for International Cooperation)
GOL	Government of Lao PDR
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
kfW	Kreditanstalt fur Wiederaufbau (German Development Bank)
MAF	Ministry of Agriculture and Forestry
MEM	Ministry of Energy and Mines
MLSW	Ministry of Labour and Social Welfare
MOF	Ministry of Finance
MONRE	Ministry of Natural Resource and Environment
MPI	Ministry of Planning and Investment
MPH	Ministry of Public Health
MWBP	Mekong Wetlands Biodiversity Conservation and Sustainable Use Programme
NAFRI	National Agriculture and Forestry Research Institute
NEC	National Environment Committee
NGOs	Non-Government Organizations
NUOL	National University of Laos
NSAP	National Strategy and Action Plan on Climate Change
NSCCC	National Steering Committee on Climate Change
NUOL	National University of Laos
ODA	Official Development Assistance
SNC	Second National Communication
TWGs	Technical Working Groups
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

Executive Summary

A Barrier Analysis and Enabling Framework (BAEF) is an important element of the Technology Needs Assessments (TNA) and technology transfer, required by the United Nations Framework on Climate Change Convention (UNFCCC), especially under Articles 4.3, 4.5 and 4.7. This report focusses on the BAEF for the following eight adaptation technologies and practices, which were prioritised for the enhancement of climate change and disaster adaptation and resilient capacity in water resources and the agriculture sector (MoNRE, 2013):

1. Early warning system
2. Disaster impact reduction fund
3. River basin management
4. Climate-resilient water supply system
5. Livestock disease prevention and control
6. Agricultural development subsidy mechanism
7. Climate-resilient rural infrastructure
8. Crop diversification

The BAEF was conducted based on barrier analysis processes, which consists of barrier identification, screening, decomposition and analysis of root causes of barriers before prioritisation of the key barriers. The preliminary barrier analysis was carried out by the project implementation team in consultation with the technical working group on climate change. The barriers were identified through review and synthesis of barriers from strategies and technical reports, interviews of key informants including the climate change working group who created a long list of barriers. This was then screened and revised by grouping similar barriers, while unimportant and irrelevant barriers were eliminated through votes. The decomposition was performed by using a decomposition matrix, where the barriers are clustered into eight main categories (financial and economic, market, policy and regulation, organisational capacity and human skills, network, information and awareness, technical and other barriers). Within each category barriers, elements and dimensions were then identified. In addition, a logical problem tree was employed to investigate and gain insight on the root causes of problems related to the development and deployment of technologies. The barriers were then scored and ranked, where score 1 was given to least significant barrier, 2 to moderate and 3 to most significant. The analysed results were finally validated, revised and agreed upon after two stakeholder consultation meetings in May 2016 and March 2017.

Results show that each technology or practice face more than 15 barriers on average, of which five to eight are critical barriers. All eight technologies share eight common barriers namely: 1) insufficient financial resources and support for development and deployment, 2) high investment cost, 4) insufficient effective financing mechanisms, 5) insufficient technical knowledge and skills on the deployment of technologies for climate change adaptation and disaster resilience, 6) inadequate reporting and inaccurate information, 7) insufficient tools, best practices, technologies and reference projects, and 8) geographical difficulties including access by and unsustainable settlement of local people.

Overcoming the key barriers of these eight prioritized technologies in both sectors, requires: 1) improvement in public financing including transparency in budgeting, resource mobilisation and

financial resources management, 2) further research and develop (R&D) on effective models and best practices on sustainable financing of the technologies' development and deployment, 3) a reduction in investment costs and an increased incentives, 4) increased technical knowledge and skills, 5) increased R&D on technical information, plans, policy and framework to govern the technologies, and 6) pilot interventions and technology promotion. Furthermore, the following enabling environments also need to be created and facilitated in order for the technologies to thrive:

1. The overall macro-economic growth through the promotion of investments and business activities through engaging the private sector, and providing easy access to capital market and finance
2. Policies on promotion of investment and development of environmentally friendly, climate adaptation and disaster resilient technologies,
3. Policies on the integrated socioeconomic planning and developments, including integrated land uses and town,
4. Policies on the national scientific and technological research and development,
5. Environment, climate adaptation and disaster expert network,
6. Regular environment, climate adaptation and disaster campaign programme on media and education systems and promoting public participation in the development and deployment of climate change adaptation and hazard resilient technologies.
7. Enhancement of international cooperation on financial and technical support including transfer of technologies.

Chapter 1: Introduction

Technology transfer is an important element of the United Nations Framework on Climate Change Convention (UNFCCC), defined under Articles 4.3, 4.5 and 4.7 Barrier Analysis and Enabling Framework (BAEF) is a part of the Technology Needs Assessments (TNA), which is prerequisite for technology transfer under the convention.

The Ministry of Natural Resources and the Environment (MoNRE), in collaboration with the relevant ministries and organisations in Lao PDR, carried out the TNA project phase I from 2011 to 2013. The project phase I focused on prioritisation of sectors and technologies for adaptation to climate change, and it resulted in selection of 2 sectors, water resources agriculture and following 8 adaptation technologies or practices for enhancing climate change and disaster adaptive and resilient capacity in the 2-selected sector.

1. Early warning system (for floods) (EWS)
2. Disaster impact reduction fund
3. River basin management
4. Climate resilient water supply systems
5. Livestock disease prevention and control
6. Agricultural development subsidy mechanism
7. Climate resilient rural infrastructure
8. Crop diversification

The TNA project phase II is being implemented between 2015 and 2017. This project phase II aims at 1) Barriers Analysis and Enabling Framework (BAEF), 2) development of Technology Action Plans (TAP) and Project Ideas for the prioritised technologies in water resources and agriculture sector. This report covers only BAEF for the 8 adaption technologies. The TAP and project concepts are reported separately.

The BAEF was conducted following barrier analysis processes and methods suggested in the TNA guidelines. It includes barrier identification, screening, and decomposition and cause-effect analysis by literature review, key informant interview, data analysis, focus group and stakeholder consultation meetings. The details on methods were described in Chapter 2.

This BAEF report consists of five main chapters. Chapter 1: introduction provides an overview of technology transfer and TNA implementation in Laos and outcomes. Chapter 2 methodology, describes the process and techniques for BAEF. Chapter 3 provides details on BAEF for the 4 adaption technologies in water resources sector, namely EWS, river basin management, climate resilient water supply system and fund for water related disaster. Chapter 4 described details BAEF for the 4 adaption technologies in the agriculture sector: livestock diseases prevention and control or surveillance, agriculture development subsidy mechanism, climate resilient infrastructure and crop diversification. Chapter 5, conclusion, provided BAEF process and results in brief as well as how to address barriers, develop, deploy the 8 technologies for enhance adaptive and resilient capacity in water resources and agriculture sector to climate change and disaster.

Chapter 2: Methodology

Barrier analysis is not only identification of barriers, but also defines measures and enabling environment to overcome the identified barrier. The analysis of barrier to develop, streamline and deploy the adaptation technologies in the water resources and agriculture sector was conducted based on the barrier analysis process and techniques in the TNA guideline series (Nygaard and Hansen, 2015). The process consisted of three main steps: data collection and initial analysis, technical working group and stakeholder consultation (Figure 1).

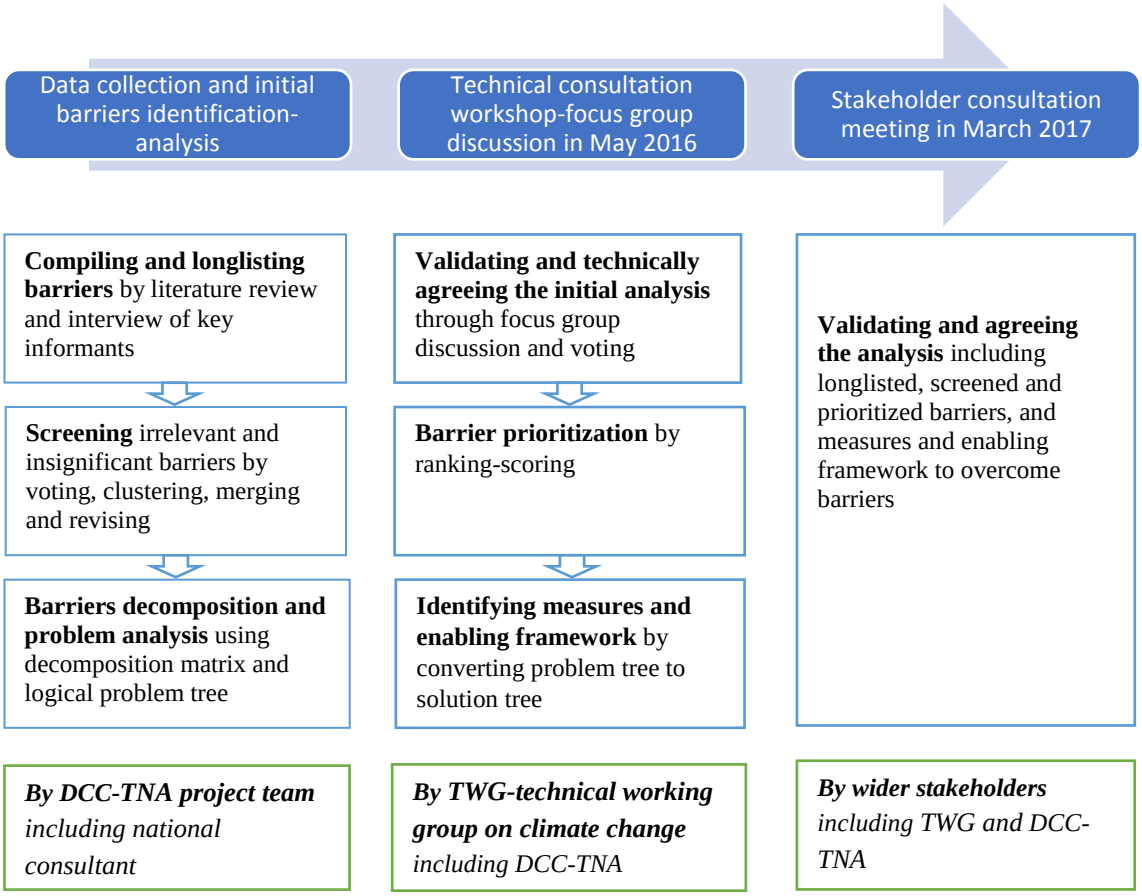

Figure 1 General methodology of barrier analysis

The data collection and initial analysis included barriers compilation, screening, decomposition and problem tree analysis was initially undertaken by the project implementation team including national consultant (Annex 1), by reviewing literature and interviewing key informants using checklist questions (Annex 2). As a result, longlist of barriers was produced and discussed in the project team meetings, which validated and screened out irrelevant, invalid and insignificant barriers by voting. The remaining barriers were then decomposed, starting from clustering the barriers into 8 main categories (financial and economic, market, legal framework, organisational capacity and human skills, network, information and awareness, technical and other barriers), decomposed further into 3 levels and aspects (barriers within each category, its elements and dimensions). In addition, logical problem tree analysis was employed to understand root causes of the problems and barriers.

A 3-days technical workshop was held in May 2016 to validate and seek feedback to improve the initial outcome of the analysis with the working group on climate change, which assigned by relevant ministries and organisations (Annex 1). In the consultation workshop, the working group was introduced to the objective and methods of the BAEF by the project team. They were then engaged in in-depth discussion on the development targets, the identified barriers, the measures for overcoming barriers of each technologies and the enabling framework of each sector. The consultation was with two focus groups whom revisited and prioritised the identified barriers and measures in the two sectors. The prioritisation of the barriers was performed by ranking and scoring, where score 1 was given to an insignificant barrier, 2 to a moderate and 3 to the most significant barrier. In the overall discussion, all participants cross-checked and reached a consensus on the results and provided comments for following up.

As a result of the above method of analysis, a long-list of barriers to develop the climate change adaptation technologies in the water and agriculture sectors were derived and are presented in Annex 3 and 6. The key barriers decomposition matrix (Annex 4 and 7) and problems-solutions trees (Annex 5 and 8) were also formulated. The most important barriers are discussed in detail in Chapters 3 and 4: barrier analysis and enabling framework for water and agriculture sector, respectively.

Measures and enabling environment for an effective and sustainable development and deployment of the technologies in the water and agriculture sectors were identified alongside the barrier analysis. The measures were derived by converting the barriers or problems trees into solutions trees. Importantly, they were validated through stakeholder consultation meetings, which took place in May 2016 and March 2017.

Chapter 3: Barrier Analysis and Enabling Framework for the Water Resources Sector

3.1 Preliminary Targets for Technology Transfer and Diffusion

3.1.1 Overall Development Targets of the Water Resources Sector

The overall development targets for water resources were specified in the National Water Resources Strategy to the year 2025 and in the Action Plan 2016 to 2020-NWRSAP (2014). Specific targets were also set in relevant sectoral strategies, especially in energy, irrigation, water supply, and water and sanitation. Based on the NWRSAP, Laos envisages "coordinated, optimized and sustainable development and use of water resources, protection of the environment and improvement of social well-being." To realise this vision, four following missions and twelve action plans including two action plans on flood and drought, water risk management and climate change adaptation are targeted.

1. Ensure sustainable development and management of water resources, and minimize impact on water, environment and society;
2. Manage and protect water sources and systems, conduct comprehensive planning for water resources development and use, balance socioeconomic outcomes and water ecosystems;

3. Strengthen ownership and participation of stakeholders in the management of water resources development and use through capacity building and harnessing local knowledge;
4. Prioritize water allocation for basic human needs, ensure equitable water uses and share the benefits of water availability and development.

Specific goals and targets of the river basin management, the early warning system, disaster impact reduction fund and resilient water supply systems that were identified as priority for climate change adaptation (MoNRE, 2013) are as follows.

3.1.2 Technology Development Targets

1. Watershed and River Basin Management

The primary goals for a river basin management is to ensure adequate quantity and quality water supply for socioeconomic development, environmental and ecosystems protection, enhance water use efficiency and minimise impact from water related disasters. The specifically, the goals are to ensure water supply for the following development targets, while maintaining water balance and ecosystems.

- Hydro-energy production of 15,000 MW by 2025 and beyond (MEM, 2011; MPI, 2015),
- Industrial processing and manufacturing in industrial zones, transport and tourism industries,
- Ensuring, on an average, 82% and 100% of population gets access to safe drinking water by 2020 and 2030; 77.5% and 100% of population gets access to water hygiene and sanitation by 2020 and by 2030, respectively (WSP & WB, 2014).
- Production of rice and crops in 4 million hectares; production of meat, fish and eggs of 487,500 and 711,000 tons by 2020 and 2025, respectively (MPI, 2015),
- Effective conservation of all national and international important wetland, water resources including fish conservation pools in rivers,
- Minimising water disaster such as flood, drought and water born disease and pollutions,
- Minimising water use conflicts.

2. Early Warning System (EWS)

The overall development goal is to develop end-to-end EWS to provide timely, accurately and effectively warnings and enhance the response capacity of all provinces, districts and villages that are at risk of floods, landslide and storm (DMO, 2012; MoNRE, 2013, 2015; MPI, 2016). Specific targets defined in the eight Five-Year NSEDP (2016) include:

1) Development and modernisation of 18 weather forecasting and eight hydrology stations,
2) Improvement of flood warning systems in six priority river basins in the provinces of Attapeu, Sekong, Saravan, Champasak, Savannakhet and Khammouane,
3) Development of hazard maps and disaster risk reduction plan for at least eight provinces, 45 districts and 160 villages,
4) Establishment of a National Emergency Coordination and Command Centre including ICT system for the EWS.

3. Disaster Risk and Impact Reduction Fund

Laos has experienced storms and floods almost every year. Between 1992 and 2012, Laos encountered 693 storms and 60 high intensity rainfall events which caused total direct economic loss and damage of about US$ 326 million. At the same period, 1,205 riverine and 32 flash floods which resulted in a direct economic loss of about US$ 517 million (MLSW, 2012). Previously, on an average, about US$ 100 million per year has been lost due to storms and floods (GoL, 2011 cited in MLSW, 2012; GFDRR, 2014). However, in the near future, it is estimated that socioeconomic damage resulting from climate-related disaster would be, on average, US$ 278 million per year from 2010 to 2029 (ISDR et al., 2012).

The Government of Laos is committed to spare LAK 100 billion (US$ 12.5 million) per year for emergency response including disaster affairs. This amount of fund is inadequate, and the actual disbursement has not been in full or timely. Therefore, to enhance resilience and reduce disaster risks a specific fund is needed to cover at least 50% of the potential disaster damage and loss or about US$ 139million by 2020, 65% (US$ 181million) by 2025 and 85% (US$ 236million) by 2030.

4. Water Supply System

The Lao PDR aims at developing the quantity and quality of domestic water supply systems to ultimately ensure all people can access and afford clean water. Three main objectives Laos needs to achieve this are:

1) Ensure 90% (100% of urban and 80% of rural) of the population have access to safe water (MPI, 2015);
2) Ensure 77.5% (90% urban and 65% rural) of the population can access basic water hygiene and sanitation systems, and the entire population can access clean water, basic hygiene and sanitation systems by 2030 (MPI, 2015; WSP &WB, 2014);
3) Ten towns along the national road No. 13 deploys climate smart planning (MPI, 2016).

3.2 Barrier Analysis and Possible Enabling Measures for Early Warning System

3.2.1 General Description of the Early Warning System

Early warning system (EWS) is a system of hazard monitoring and forecasting, risk assessment and informing people at risk, relevant organisations and stakeholders to be prepared and enabled to take timely action to reduce disaster risks in advance of hazardous events. Overall, an effective or “end-to-end” and “people-centred” EWS includes an effective organisation system performing 4 interlinked components of works namely risk knowledge, monitoring and forecast, warning dissemination and response, under a standard operational procedure (SOP) (ISDR, 2004). Similarly, In Laos, the national EWS consists of the four elements, which is operated by the ministry of natural resources and environment MoNRE) (Figure 2).

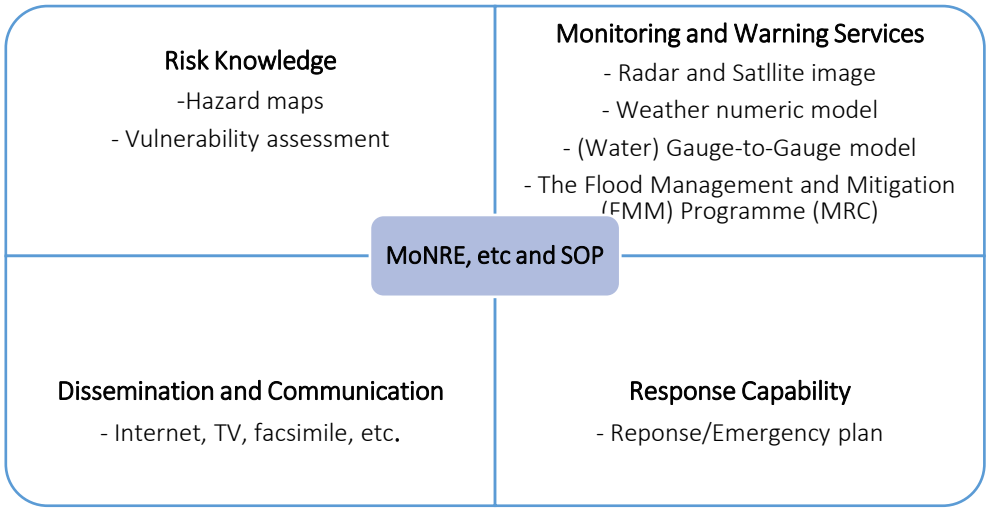

Figure 2 Structure of EWS

An EWS is a non-market and publicly provided technology that requires wider cooperation from and participation with the private sector and local people, especially those whom reside in hazard prone areas. Storms, floods and landslide EWS are currently not fully developed to be able to provide timely and accurate forecast, warning, and response (DMH, 2012; MoNRE, 2013; DDMCC, 2015). This barrier analysis, apart from revisiting the overall problem, investigates the underlying barriers that impede the EWS development and their performances.

3.2.2 Identification of barriers to early warning system

As described in Chapter 2, the identification of the barriers to the EWS development and deployment was carried out in accordance with the barrier analysis process, which barriers were initially compiled, screened, decomposed and then analysed causes and effects, by literature review, key informant interviews, information analysis and stakeholder consultations. Results showed that 23 barriers were initially listed as the obstacle (Annex 3). However, following decomposition of the barriers (Annex 4) and problem analysis using logical problem tree (Annex 5), screening and revising; it was found that there are 12 important barriers that restrict EWS development and operation. Out of the 13 barriers, there are 9 barriers, which were scored 3, are considered as critical barriers (Table 1). Three of them are financial and economic and six are non-financial and economic barriers as discussed in subsection 3.2.2.1 and 3.2.2.2.

Table 1 Barriers to the development, effectiveness and sustainability of EWS

Barriers to the development, effectiveness and sustainability of EWS	Score	Category
1. Public budget deficit	3	Financial and economic
2. High investment cost on EWS	3	
3. Variable external financial and technical support	3	
4. Insufficient knowledge and skills on EWS	3	Human skills
5. Inadequate tools, techniques and facilities for EWS	3	Technical

Barriers to the development, effectiveness and sustainability of EWS	Score	Category
6. Ineffective coordination amongst stakeholders	3	Organisation
7. Uncertainty and inadequate information and awareness about hazards and risks	3	Information and awareness
8. Unsustainable settlement/defective land use planning	3	Others
9. Insufficient legal framework and ineffective law enforcement on EWS and mainstreaming DRR and EWS in developments	3	Legal framework
10. Insufficient disaster risk reduction and EWS financing mechanisms	2	Financial and economic
11. Polarisation of planning and developments	2	Organisation
12. Insufficient expert association to support EWS including knowledge and information exchange	2	Networking/ organisation
Remark: *Score 3 = significant; 2 = moderate; 1 = least significant barrier*		

3.2.2.1 Financial and economic barriers

The main financial and economic barrier to the development and management of an EWS is financial shortfall. In which, the underlying barriers which MoNRE or even Lao PRD alone to address are: 1) high investment cost, 2) the national budget deficit and 3) variable external funding as discussed as follows.

1. High investment cost

The cost for development and management of an end-to-end EWS between 2010 and 2029, could be 18.32 million for a stand-alone EWS system and US$ 10.93 million for an integrated regional system. In which, the weather observation and forecast system including radar, ground observation station, hardware and software (model) may cost about 60% of the total cost, and operation and management may account for about 20% of the total cost (ISDR, WB, WMO, DMH and GFDRR, 2012). In addition, it may need US$ 2.2 million for a community-based floods EWS for pilot project (MoNRE, 2009). This is considered as a high start-up cost compared to financial capacity of Laos, especially MoNRE who received the annual budget available for disaster risk reduction and EWS affairs, in last 5 years for example, less than US$ 1.2 million and US$ 0.2 million, respectively. This is even not enough for operation and maintenance of the EWS.

2. The national budget deficit and ineffective public budgeting

The national budget deficit and ineffective public budgeting are also the main barriers causing EWS underfinanced and then underdeveloped. The national budget deficit between 2005 and 2014, for example, was about US$ 0.27 to US$ 0.38 billion, accounting for 4-5% of the GDP (MPI, 2011; MPI, 2015). The public budget allocation has been either imbalanced or ineffective. Between 2011 and 2015 for example, was limited. Most of the public investment was allocated to the economic sector (30%), infrastructure (35%), education (17%), health (9%) and the remaining for other sectors (MPI, 2015). Only a small amount of resources was allocated for MoNRE, especially for the EWS activities.

These have a direct impact on EWS investment. Public investment in EWS affairs was about US$ 0.12million per year and has not significantly increased in the last decade. Importantly, it is difficult to address the problem as it is a national problem and largely beyond the capacity of MoNRE.

3. Variable international support

Financial support on EWS is largely from development partners and international organizations, but funding is variable. Although actual amount of EWS financing is not definable or available, it was estimated by MoNRE, including DDMCC and DMH, that the average amount of funds may be less than US$ 1.5million per year for the last 10 years. The support was mainly between 2010 and 2012 and has declined in recent years.

The variability of international support is either attributed to the regional financial uncertainty or the limited capacity of MoNRE and stakeholders to access to financial resources. For instance, the failure to finance the EWS projects proposed under NAPA (2009) and ISDR et al., (2012) may partly result from the regional financial constraints and the inadequate capacities of MoNRE and its stakeholders. MoNRE itself lacks database and information about funding sources, a resource mobilisation plan, financeable proposal, clear responsibility on resources mobilisation among departments, including the department of disaster management and climate change (DDMCC), the department of hydrology and meteorology (DHM), the department of water resources (DWR), the department of Cooperation (DoC), and the Environment Protection Fund (EPF). In addition, coordination among stakeholders including public and international organisations are ineffective, especially in regard to information sharing, joint resources mobilisation, and monitoring and evaluation.

3.2.2.2 Non-financial and economic barriers

Apart from financial and economic barriers, there are six non-financial and economic barriers that have impeded full-scaled development and operation of EWS as follows.

1. Inadequate knowledge and skills

Knowledge and skills gaps or needs (Annex 6), underdeveloped and underperformed EWS suggest that the key responsible organisations, especially DMH, DDMCC of MoNRE have inadequate knowledge and skills to effectively and sustainably operate an EWS.

The knowledge and skills gaps have occurred because of the staff of the mentioned organisations have not had adequate EWS professional training or education. Currently, there is no comprehensive storms, floods and landslide EWS learning and training curriculum provided by any educational institution and organisation in the country. In-house and on-the-job training is seldom or otherwise being on an ad hoc basis, and not systemized or standardised. Self-learning culture and commitment are not well-established, while leadership capacity to direct and create learning environment and culture is also weak. MRC uses gauge-to-gauge and flash flood model for flood forecast, but training for other stakeholders has been limited. Some DMH staff were trained on the use of some flood modelling such as MIKE and NWM, but they are not able to apply it on the ground.

Ineffective human resources development (HRD) system and budget shortfall are another barrier for capacity building. The HRD system including the HRD plan, staff knowledge and performance management, capacity need assessment and evaluation system of DMH and other stakeholders are not in place. Consequently, some recruitment and positioning of staff do not match job specialisation or HRD demand and supply.

Budgets for capacity building are often cut. Between 2011 and 2015, for example, about US$ 0.2 million was required, for training and capacity building for DHM, but only US$ 50,000 was secured.

2. Insufficient legal framework

EWS involves with multi-sectors and requires concrete legal framework for effective coordination for the development and operation of an effective EWS. Inexistence of specific EWS policy that provide guidelines on how EWS should be developed and managed means insufficient legal framework. Overall, natural and water disasters including floods and drought EWS management are stipulated under the law on environmental protection (2013), and water sources (2017). Management of specific technologies and facilities of the EWS such as hydro-met observation stations, weather forecast, and warning are the decree on meteorology. In addition, other EWS facilities such as telecommunication network and media are under the law on telecommunication and media, which implemented by the ministry of telecommunication and post (MTP) and ministry of information, culture and tourism (MICT), respectively. However, the environment and water resources law provide only general provisions about the management of disaster and EWS. The law on telecommunication and media also fail to provide details about responsibilities amongst the ministries on the development and management of the telecommunication and media network in specifically disaster-prone areas and for the EWS. The specific legal framework or decree to provide principles, practical guidelines, organisational arrangement and responsibilities on this affair in detail has not been developed.

The insufficient legal framework is a main barrier hindering an effective EWS. As a result, responsibilities among key organisations to manage and operate EWS (four components), for example, between ministry of labour and social welfare (MLSW) and natural resources and environment (MoNRE) including departments under MoNRE are duplicated. Management of hazard monitoring technologies, in particular, is partly managed by MLSW, while department of hydrology and meteorology (DHM) of MoNRE has overall mandates to do the hazards monitoring, forecasting and issue warning. Department of disaster management and climate change (DDMCC) has a EWS emergency response division, and so does MLSW. Previously, some water gauges in some watershed were managed by department of water resource (DWR) of MoNRE, while in general, it is under DMH's control.

These have undermining effectiveness of the EWS development and performance.

4. Inadequate reference project and best practices on the early warning systems

A reference project and a best practice on how to effectively, efficiently and sustainably develop, operate and manage an EWS of different types of hazards are limited, lack of comprehensive studies and dissemination. Some community-based flood EWSs in Xiengkhuang, Xaysomeboun and

Khammuane province and disaster awareness in schools in Sayabouly provinces were documented as good practices (DDMCC, 2015), but how could these practices apply in other areas and communities are little known. The gauge-to-gauge and Flash Flood Guidance System (FFGS) are used for forecasting riverine and flash flood in Mekong region by Mekong River Commission (MRC), but it lacks evaluation and documentation of best practices following the application. What a best way and method to communicate and response to a warning and disaster are also unclear and lack best practice guidelines. There are several best technologies and practices on hazard forecast elsewhere such as nowcasting, but studies and exchanges on the application of such promising technologies has not been limited. Furthermore, exchange amongst stakeholder on this issue is also seldom, although disaster risk reduction working group exist.

The absence of the reference project and the best practices hinder the EWS development and operation, especially effectiveness. This is caused by limited research and exchanges, which resulted from budget, skills, knowledge constraints as mentioned above, and information mentioned below. In addition, development of model projects and best practices are challenged regarding time, cost and skills, which may possible limited whereas, the best practices may evolve, are required time and skills to update overtime.

3. Ineffective coordination amongst stakeholders

Coordination is crucial for an effective early warning system, while coordination amongst key organisations that develop, manage and operate EWS[1], and between the key organisations and other stakeholder[2] who support EWS including inter-governmental, international development partners and organisations is ineffective. Dissemination and communication on warnings in the event of disaster is not end-to-end and lacks feedback mechanism. These caused by the lack of clear responsibilities and SOP. In addition, it is because of the absence of EWS operation centre.

4. Inadequate data and information

Data and information about hazards, response capacity of local communities, EWS technologies and best practices, financial and economic of an EWS are not enough for effective EWS development and operation. Although Laos faced hundreds of storms and thousands of floods, research and development of information about floods, landslide, drought and storms, especially its patterns, scales and risks are scanty. Hazard profiles and maps were developed in 2010, but it has not been downscaled and updated. Some information is inaccurate. For example, the assessment indicated that Xiengkhouang province which has not been hit by storms and floods in the history would not be at risk of storms and flood. Reversely, the provinces have encountered disastrous floods since 2013.

[1] (**Public:** department of hydrology and meteorology (DMH), water resources (DWR), climate change and disaster (DDMCC), Lao National Mekong River Committee (LNMRC) of MoNRE; disaster relief (DDR) of MoLSW as well as national disaster management committee (NDMC), communities at risk; **Private:** hydropower projects etc.; **Inter-governmental:** Mekong River Commission (MRC);

[2] UNDP, Asian Disaster Preparedness Centre (ADPC), Caritas Luxembourg, CARE International, Oxfam, Word Food Programme (WFP), Save the Children, World Vision Lao (WVL), Concern World Wide (CWW), The United Nations Children's Fund (UNICEF), International Federation of Red Cross and Red Crescent (IFRC).

Socioeconomic, readiness and response capacity of local people are remained shortage. About 1,200 villages in 54 districts and 14 out of 18 provinces are at risk of storms and floods. However, disaster vulnerability assessments were conducted in only some communities and provinces of Khammouan, Saravanh, Attapue, Sekong, Xiengkhouang. Data updating is not always undertaken.

Information about appropriate EWS technologies and best practices for hazards mapping, monitoring and forecast, risk assessment and communication are limited too. As mentioned, an assessment of existing and studies new technologies are little progressed.

Furthermore, financial and economic information including costs and benefits for justification and support decision making on investment in EWS are insufficient. An estimate of financial investment needs and cost and benefit ratio (CBR) were made once in 2012 (ISDR et al., 2012), but it lacked updates. The financial and economic information on investment specific region, province or communities are not comprehensively assessed and made available for EWS development planning.

The shortage of the information poses difficulty and challenge for EWS planning, development, operation effectively and timely. Moreover, without good financial and economic information for project feasibility study which is required for justify investment (LNA, 2009), it is hard for EWS to be funded.

The lack of information is mainly caused by insufficient research and development (R&D), especially human and financial resources. Human resources, especially EWS researchers in both public and private sector are either limited or undefinable. Financially, it may need US$ 100,000 per year (ISDR et al., 2012). Available budget for R&D, on the other hand, is about US$ 20-30,000 per year. Although government intends to assign 1% of GDP of each year for scientific research (e.g., in 2015, Lao GDP was US$ 12.33 billion, the R&D fund should be US$ 123.3 million), but EWS R&D has not been funded. However, financial demand and competition for R&D fund is high, while fund disbursement is often delayed.

5. Inadequate basic infrastructure

Apart from hazard detection and forecast facilities such as radar, hydro-met stations, software; basic infrastructure such as telecommunication, electricity and road network are not enough for effective EWS operation. The proportion of population that are not accessible to telecommunication, electricity and road network, on average, are about 15%, 16% and 15.49 %, respectively (LSB, 2015; MPI, 2015). Population access to internet was just over 14%[3]. Radio penetration rate is 99.4%, while only 50% of household access to television (ABCID, 2014). In addition, the infrastructure including network failure often happens, especially in the event of storm and heavy rain, while power backup system is not available in local and rural areas.

Inadequacy of the infrastructure has undermined dissemination and communication of warning, and facilitate response to the warning and disaster in effective and timely manner. For example, in the event of flood in Oudomxay province in 2017, several villages did not receive any hazard information and

[3] https://freedomhouse.org/report/freedom-world/2015/laos. Access on 5th August 2017

alerts because of disfunction of telecommunication and media network. During flood in Louangprabang province in 2016, many households were also out of contact because power outage and failure of telecommunication network. In addition, it took about a day or two to access to assist the victims because it poor road access.

The inadequacy of the infrastructure is mainly because of financial constraints as discussed earlier. Moreover, it is because of the lack of disaster action and integrated rural town development plan. Mainstreaming disaster risk reduction and technologies in socioeconomic planning and development has been limited.

6. Defective land use planning

There are several villages that settle at the flood prone areas for long time, with and without knowing of hazard risk. Some villages just encountered floods and landslide due to, apart from changing climate, improper land uses and planning. About 31% of agriculture land are in flood prone area and 70% are in dry prone area (ASO-ASSSC, 2012).

3.2.3 Identified measures

3.2.3.1 Financial and economic measures

Securing adequate financial resources and investment is the main measure for EWS development and sustainability. At least, the government needs to secure US$ 8.34 million for setup and US$ 2.59 million for operation and management (O&M) of a regional integrated system or US$ 13.98 million for establishment and US$ 4.34 million for the O&M of a stand-alone EWS system. Investment in an EWS is worthwhile. Financially and economically, for each US dollar invested in EWS will be saved US$ 5.51 (stand-alone EWS) or US$ 8.7 (integrated EWS) as a result of loss and damage reduction. These demonstrate positive cost-benefit ratio (CBR) and the integrated EWS has an even higher CBR compared to the CBR rate 1:7 defined by WMO (ISDR et al., 2012).

To secure financial resources and investment in EWS, there are five important measures to pursue as follows.

1) Enhancing macroeconomic and national revenue as it would have an overall positive impact on EWS financing. This can be fulfilled by effectively implementing the 8th five-year national socioeconomic development plan (NSEDP) 2016-2020 and recommendations in the 'Development Finance for the 8th five-year NSEDP and the Sustainable Development Goals in Lao PDR'.

2) Improving the effectiveness and efficiency of public budgeting: particularly increasing the capacity building of MPI to re-define the optimal public investment and budget allocation model which optimises economic growth and reduces financial deficit while balancing investment in the social and environmental sectors. This means, there is a need to evaluate the effect of the existing public investment model, following this with studies and adopt best practices on the public investment and budgeting model. In addition, during financial constraint, the government may focus on financial economically viable and critical projects. In this regard, it could be anticipated that EWS which is

economically viable and crucial for loss and damage reduction would be one of the public investment targets.

3) Strengthening the capacity of MoNRE and stakeholders to mobilise, access and manage financial resources from all sources in effective, efficient and accountable manner**.** Realising this, MoNRE needs to increase awareness and justification for convincing the government including MPI on investment in EWS. In any case, MoNRE needs to increase efforts to cooperate with relevant organisations and partners to improve capacity and carry out the following activities.
   - Re-assessment of financial needs for DRR and EWS;
   - Development of financial database including identification and assessment of EWS financial sources of funds;
   - Development of resource mobilisation strategy and plans;
   - increase capacity to develop financeable project proposal including adequate financial and economic analysis;
   - Enhancement of the financial aid management system, especially financial support and investment record, tracking and reporting system, and feedback mechanism in order to ensure effectiveness, efficiency and transparency of the financial aids.

4) Strengthening law enforcement especially by mainstreaming disaster risk and EWS in and enhance enforcement of the Environmental and Social Impact Assessment (ESIA) of development projects such as hydropower projects.

5) Promote investment and contribution of private sector, especially investment and development of the telecommunication and media development and management in disaster-prone areas, cooperation with hydropower developers to develop EWS including hydro-met observation stations and floods detection system in where hydropower situated. In addition, the government may incentives including tax reduction and exemption to import and deploy EWS equipment for the hydropower projects.

3.2.3.2 Non-financial and economic measures

1. Development of legislative framework

Development of law, regulation and policy on disaster management and EWS is a must for effective EWS development, operation and sustainability. At least, following law, regulation and policies shall be developed and enforced by 2020 and beyond.

1) Law or decree on National Prevention and Control of Disasters and Climate Change,
2) Decree or regulation on early warning system, including polices to mainstream disaster risk reduction and management and EWS in a development, financing and funding disaster risk reduction and management including EWS;
3) Regulation or agreement on SOP for EWS operation;
4) Policy for promotion and incentives on operation of business and activity on disaster prevention including import of equipment for disaster prevention and control, and EWS.

These polices are expected to have direct and indirect impact on EWS development and management. In addition, it was perceived to be efficient as it may not need much budget for the development, but needs strong leadership and commitment. However, development and enforcement of such policies requires international support since budget and capacity are limited. In addition, research policy M&E system for shall be established to ensure effectiveness, relevance, efficiency and impact of the policies and provides feedback in the policy development cycle.

2. Develop and implement integrated urban and rural infrastructure planning and development

MoNRE, Ministry of Public Work and Transport (MPWT), Post and Telecommunication (MPT), Agriculture and Forestry (MAF) need to work together to map out the hazard areas and develop integrated infrastructure plans in the areas. This action is not only increase efficiency and synergy of investment, but it reduces duplication as well.

To be more effective, disaster steering committee is needed to be activated and policies on DRR-oriented planning and development, integrated planning and development and land use planning for flooded land shall be developed to guide and be reference for the development of the EWS.

3. Develop strategy and action plan on disaster risk reduction and management including EWS

Strategy and action plan on disaster risk reduction and management, and EWS including emergency response plan shall be developed to clearly define risk reduction and EWS targets, methods and resources needs for an effective and sustainable EWS development national and local levels. However, to be more effective and practical inclusive stakeholder participation and comprehensive studies shall be pursued to support the development.

With the strategy and action plan in place and effective implementation, more resources, effective and advance EWS development could be expected. Investing in the development the strategies deems efficient, especially in long-term. There are only some costs involved such as research and consultations, but may be worthwhile compared to positive impacts that may be generated following implementation of the strategies.

4. Improve information for EWS

Information on hazards, technologies, financial and economic feasibility of EWS shall be developed and made available for decision on the investment and development of the EWS. Research shall be carried out to improve: 1) hazards and risks, 2) best suitable EWS technologies and best practices, 3) adaptive and resilient capacity of disaster prone communities, 4) EWS technical, financial and economic feasibility including financial needs, financial and economic returns on investment or cost and benefits, 5) financing models and mechanism, and 6) funding sources for EWS development.

To achieve this, it requires more promotion and investment in R&D as well as research and educational institutes, think-tank and private sector, for example, consultancy service and hydropower projects to

participate in and contribute to hazards and EWS study. Importantly, it needs R&D capacity building including mobilisation and access to technical and financial support for information development and management.

5. Enhance capacity on the development and management of early warning systems

Capacity, especially knowledge and skills gaps outlined in Annex 6 shall be addressed along with human resources development (HRD) system, incorporation of EWS in higher education and enhance professional training, particularly:

- Incorporate storms and flood forecast in the high educational institutions, such as Faculty of Water Resources Engineering, Environment, Forest and Agriculture of NUoL,
- Develop HR and capacity development plan, and putting in place staff knowledge management, capacity needs assessment,
- Develop short term EWS training modules including specific course on storms, floods, and landslide shall be developed and standardised,
- Develop financial mechanism for capacity building,
- Improve leadership and self-learning mechanism and environment such as on the job-training, organisation of learning and exchange day and policy for promotion of good performers,
- Set up M&E of capacity shall be developed and applied as a measure for assurance of the capacity building.

6. Develop reference projects and best practices on early warning systems

Reference projects and best practices to be a showcase and best guiding EWS development and operation shall be developed. The development may focus on creating and sharing effective and successful emergency response including response planning, organisational arrangement, communication and awareness raising and application of tools to effectively and timely response to alerts and disasters. Secondly, it is important to focus on effective methods and best technologies for hazards detection and forecast, especially real-time and accurate forecast. Furthermore, reference projects and best practices may focus on sustainable and integrated land uses and urban-rural planning, financial mechanism and best coordination that help avoiding and reducing disaster risks.

With the reference projects and best practices, far better EWS would be developed and operated. However, budget shall be secured, and skills and R&D shall be performed to support the development and extension. Importantly, international support is still needed, and more effective international cooperation shall be enhanced.

3.3 Barrier analysis and possible enabling measures for development and sustainability of disaster impact reduction fund

3.3.1 General description of the disaster impact reduction fund

The disaster impact reduction fund is the financial mechanism to finance climate change adaptation, disaster risks and impacts management. This financial mechanism may include subsidy, fund, loan and insurance for reducing risks, losses, damage and sustain people's livelihood, production and businesses.

Disaster risk and impact reduction fund is non-market goods, either publicly provided and other non-market goods. Currently, the government allocates 100 billion LAK (US$ 12 million) per year from the state reserve fund for emergency response, including disaster recovery. At local levels, at the movement, some flood prone communities in some districts in Xayabouly province, in Thathom district of Xiengkhouang and in Mok district of Xaysomboun province, for example, established the community funds to cope with disaster impacts, with support and contribution of households, originations and private sector in the districts. In 2016, these communities could raise fund of about US$ 50,000 per year and end year balance was of about US$ 5,000. However, compare to the financial needs, there is large financial gap. Sometimes, the fund is not available in time of need, especially in the event of disasters. Despite the government promotes, there are barriers impeding expansion and sustainable management of the fund as discussed in the following.

3.3.2 Identification of barriers to the development of the disaster impact reduction fund

Barriers to development of the fund were identified following the process and methods described in Chapter 2. Barriers were initially compiled, and long-list barriers was created. At this stage, it was found there are eight barriers that possibly prevent the development of the fund. However, after decomposition of the barriers (Annex 4) and analysis of a problem using logical problem tree (Annex 5); it found that there are only six important barriers that impede the fund development, and were scored 3. These barriers comprise two financial and economic and four are non-financial and economic barriers (Table 2). More information about the 7 essential barriers are discussed in subsection 3.3.2.1 and 3.3.2.2.

Table 2 Barriers to the Development of the Disaster Impact Reduction Fund

Barriers to the development of the disaster impact reduction fund	Score	Category
1. Public budget shortfall for expansion of the disaster financing and establishment of the disaster impact reduction fund	3	Financial and economic
2. Ineffective resources mobilisation	3	Financial and economic
3. Insufficient legal framework	3	Legal framework
4. Limited knowledge and skills on disaster financing including development and management of the disaster reduction fund	3	Capacity/ Skills
5. Inadequate effective and successful mechanisms and models	3	Capacity/ Skills
6. Insufficient information for development and sustaining the disaster impact reduction fund including financing mechanisms	3	Information
7. Ineffective internal and external coordination and networking	2	Organisation
Remark: *Score 3 = significant; 2 = moderate; 1 = least significant barrier*		

3.3.2.1 Financial and economic barriers

1. The national budget shortfall

The national budget shortfall is barrier to expand the emergency funds or establish the specific fund for disaster risk and impact reduction. Total government's annual budget which is allocable for addressing emergency events including disaster is only about US$ 12.5 million. In comparison to the average annual economic loss and damage due to disasters of about US$ 278 million, that is only 5%. Furthermore, budget was not always available and immediately releasable in the event of disaster. In some worst cases, the financial support arrived 3 months or a year after disaster took place.

The budget shortfall is rooted from limited national revenue, budget deficit and ineffective public budget allocation as explained in previous Section. In addition, it is also because of inadequate knowledge and skills, legal framework, financing models and information to enable access to financial resources. Details of these issues are discussed in the section 3.3.2.2, non-financial and economic barrier.

2. Weak financial access and resources mobilisation systems

Although accessing and mobilising resources for disaster prevention and control is recognised as a critical action, but the implementation remains ineffective. Technical know-how to access to fund, for example, the climate change adaptation and least developed countries (LDC) fund have been limited. Resources mobilisation is operated on an ad hoc basic and not been systematically organised, resulting in a fluctuation of financial resource received. For example, between 2013 and 2014, about US$ 439,000 and 446,750 were mobilised from society, especially hydropower, mining, construction and industrial companies (MLSW, 2015). Currently, the resource mobilisation are limited, and the financial contributions have been reduced by far. Critically, information and analysis of funding sources, development of financing M&E system and resources mobilisation plan have not been developed.

3.3.2.2 Non-financial and economic barriers

1. Limited knowledge and skills

Knowledge and skills gaps summarised in Annex 6 and the remaining barriers regarding disaster fund development indicate that key responsible organisations, especially DMH, DDMCC, DWR and DDR have limited skills for developing and managing the disaster impact fund in effective and sustainable manner.

The knowledge and skills gaps of the organisations have resulted from insufficient professional training. The training on disaster financing organising for DMH, DDMCC, DWR, DDR and other stakeholders in Laos has been seldom. Participating the training overseas of the organisations' staff have been limited due to limited financial support and opportunities. Furthermore, disaster financing is not mainstreamed in higher education system and several education institutes including the faculty of economics and environment of NUoL lack knowledge and skills in this area. Another factor that undermines capacity

building is the lack of HR and capacity development plan, capacity needs assessment and M&E, good governance, organisational and staff learning culture and commitment.

2. Insufficient legal framework on the management of disaster risk and impact reduction fund

Establishment of a fund, in principle, requires legal references. The environmental protection, forestry and poverty reduction fund, for example, were established following the specific decree. This means the absence of the decree or regulation on the disaster impact reduction fund is an obstacle for setting up the fund.

MoNRE, in fact, has made efforts on the development of disaster legislation since last 5 years, but it has been not complete. The Decree on National Prevention and Control of Disasters was drafted in 2012 and updated in 2015. In 2016, the Decree was upgraded to become the law on disaster prevention and control. However, there are numbers of unclear and unagreeable issues, including who (amongst the government emergency fund under the Ministry of Finance (MoF); environmental protection fund, DDMCC and water resources development fund under MoNRE; disaster recovery fund under the Ministry of Labour Social welfare (MLSW) should manage the fund since these organisations 'mandates and responsibilities on the funds are either unclear or duplicated.

Limited knowledge and skills on disaster and climate change legislation and financing is the main factor that prevent the MoNRE and the relevant organisations to develop the legal framework. Specifically, skills and expertise to define and justify best organisational arrangement, effectiveness and impacts of the fund on the disaster risk reduction.

3. Insufficient information

Data and information for good designing and decision about disaster financing and development of the fund are insufficient. Disaster economic impact, especially indirect economic loss is rarely estimated. Information on financial needs, apart from EWS, for disaster risk reduction, resilience and climate change adaptation have not been thoroughly studied and well-known. Information about financing mechanism best practices are, too, limited. In addition, surveyed and reported information and data by different stakeholders are often inconsistent.

Overall, disaster and climate change impact data or statistics, although the record of a disaster impact has been recorded since 1966, has not been systemized, standardized, inclusive and regularly updated. The absence of the data and information poses difficulty to design an appropriate and reliable financing mechanism and amount of fund for disaster risk and impact management.

The absence of these information is because of inadequate research including understaffed and underfinanced. MoNRE and other government organisations' staff who have disaster financing background are very few. There are some financial and economic experts in the private sector and international organisations, but expert network and information exchange are inactive.

Financial shortfall for R&D is well-recognised, but solving this problem remains challenge because of several reasons mentioned early. The government, especially DDMCC and WRD of MoNRE, on average, have their annual budget less than US$ 0.2 million, and only very little budget spent for R&D.

3.3.3 Identified measures

3.3.3.1 Financial and economic measures

1. Increased the national revenue and improved the public budgeting

Increasing the national income and effectiveness of the public budget allocation would enable and create chance for the development of the disaster financing and the disaster impact reduction fund. This means there is an immediate need to increase access to financial support and mobilisation of resources, while increase effectiveness of the public budget management and reduce leakage in revenue collection.

Furthermore, relevant organisations, particularly MoNRE and MLSW needs to make available data and information on financial needs, cost and benefit on investment in disaster risk management and effective financing mechanism for justifying and supporting decisions on the disaster financing and the development of the disaster impact reduction fund.

2. Increase effectiveness of resources mobilisation

To increase resources mobilisation, following activities should be implemented.

- Assessment of financial needs for DRR;
- Research and identification financial sources and funds;
- Formulation of a resource mobilisation strategy and plan;
- Increase capacity and develop financeable project proposals;
- Increase cooperation and partnership with stakeholders, especially development partners, NGO and non-profit organisations (NPO) to increase access to financial support and funds;
- Improve the financial aid management system, especially effectiveness, efficiency and transparency.

Mobilising resources would have direct impact on the growth of the existing emergency and the community fund. In addition, this would also pave foundation for sustainable resource mobilisation and fund raising in future.

3.3.3.2 Non-financial and economic measures

1. Enhance capacity for developing and sustaining disaster risk and impact reduction fund

The knowledge and skills to be enhanced are outlined in Annex 6. It includes, apart from disaster financing, overall knowledge and skills such as financial and economic, legal, organisational and management skills on disaster financing, subsidy and insurance etc. Such skills can be strengthened by provision of a short- and long-term trainings. In long-term, capacity building shall be achieved through higher education system including long-term study. Importantly, local capacity builders, network and

platform for capacity building and exchange shall be strengthened to advocate the capacity building. However, realising capacity and human resource goal requires technical and financial support from regional and international communities.

2. Develop legal framework on disaster risk and impact reduction and management

Law on National Prevention and Control of Disasters and Climate Change is being drafted by the Ministry of Natural Resources and Environment, with financial support from UNDP. This law improvement shall be pursued. Furthermore, the decree or the policy on the establishment of the disaster impacts reduction fund shall also need to develop to provide principles, procedures and guidelines on the development and management of the fund.

The developed law would have substantial impact and simulate the development of the fund for disaster impact reduction as it is mandatory. In addition, it should provide enabling framework and reference for expansion and sustainability of the fund management.

3. Improve data and information including information management system

The data and information to be improved are 1) hazards including its risks and impacts, 2) Information on financial needs, cost and benefit of the development of the disaster impact reduction fund on disaster resilience and climate change adaptation, and 3) best practices on disaster financing including mechanisms to sustain the fund management. In addition, disaster impact statistics, methods for data collection and assessments, and information management system shall be upgraded and in line with international practice such as the DesInventar[4].

Having adequate and accurate data and information shall lead to, apart from overall disaster risk management, better planning to develop the disaster impact reduction fund and how to sustain it. Importantly, it should lead to convince better overall disaster and climate change risk and impact reduction, including national report and information sharing about disaster management. Realising these, however, need more investment on R&D, capacity building of, and coordination and information exchange amongst stakeholders.

4. Develop and pilot an effective disaster financing model

Following data and information improvement, an effective or best disaster and climate change adaptation financing mechanism (or a product of the disaster impact reduction) shall be created, diversified and piloted to expand financial resources and sustainability of the existing emergency and the community fund. In addition, this should be a model for deployment in the development and management of the disaster impact reduction.

With the effective and best financial models in place, it could be expected that existing emergency and the community fund would increase or more effectively and sustainably performed. Or at least, it should provide useful lessons and experiences of key stakeholders to pursue a sustainable disaster risk reduction in future.

[4] http://www.desinventar.net/index_www.html

3.4 Barrier analysis and possible enabling measures on river basin management for climate change adaptation

3.4.1 General description of the watershed and river basin management

River basin management, especially integrated water resources management (IWRM) is essential for enhancing adaptive and resilient capacity to cope with disaster risks, loss and damage in a river basin. Like many countries and organisations, IWRM in Laos means "a process that promotes the coordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems". Its management cycle includes 5 steps or components (Figure 3).

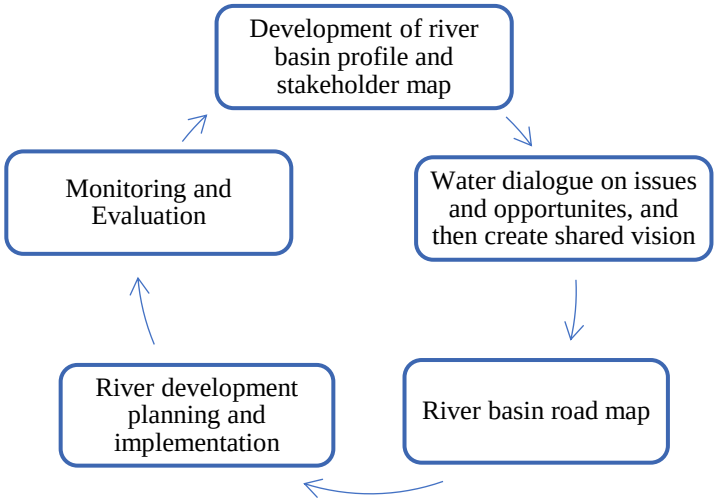

Figure 3 IWRM Cycle

IWRM for adaptation is a non-market and public technology. As of now, only few river basins initiated application of IWRM for river basin planning and development, particularly for Nam Ngum and Nam Theun-Kading River basins, but mainstreaming climate change adaptation and disaster resilience in the planning were weak. In overall, deployment of IWRM is ineffective, and there are number of barriers to address as discussed in the following sections.

3.4.2 Identification of barriers to the river basin management for adaptation

The identification of barriers to river basin management (RBM), as discussed in Chapter 2, follows barrier analysis process which barriers were firstly compiled, screened, decomposed and then analysed of root causes of key barriers and problems, by literature review, key information interviews, information analysis and stakeholder consultations. As a result, a list comprising 32 barriers was derived (Annex 3), and after screening and revising of the long-listed barriers, decomposition (Annex 4) and analysis of the key problem using logical problem tree (Annex 5); it found that there are some similar and related barriers which can be grouped and revised, while some were not underlying barriers. So, only 13 barriers were finally identified as important obstacles to RBM. Of which, there are 7 critical

barriers, which were scored 3. Three of them are financial and economic and four are non-financial and economic barriers (Table 3). Details of 7 essential barriers were discussed in subsection 3.2.2.1 and 3.2.2.2.

Table 3 Barriers to River Basin and Watershed Management for Climate Change Adaptation

Barriers	Score	Category
1. Inadequate budget and investment on river basin management including IWRM	3	Financial and economic
2. Insufficient financial models on sustainable financing river basin development and management	3	Financial and economic
3. Insufficient legal framework on water allocation, right, tax	3	Legal framework
4. Limited knowledge and skills on effective and sustainable sustain on river basin management including adaptation	3	Capacity/Skills
5. Inadequate successful, effective models and best practices on RBM/IWRM	3	Technical/ Information and awareness
6. Inadequate information on water resources, hazards and best technologies and practices for RBM/IWRM	3	Information and awareness
7. Polarisation and conflicts of interest on river basin water and other resources allocation and uses	3	Other
8. Limited civil organisations on water resources advocacy	2	Organisation
9. Ineffective coordination and communication among the key organisations	2	Organisation/ networking
10. Low awareness and commitment on water resources, IWRM and climate change adaptation implementation	2	Awareness/Other
11. Insufficient comprehensive and inclusive river basin development strategies and plans	2	Organisation
Remark: *Score 3 = significant; 2 = moderate; 1 = least significant barrier*		

1.4.2.1 Financial and economic barriers

1. Inadequate budget and investment on the river basin management for adaptation

Budget for river basin including integrated water resources management (IWRM) is inadequate. This resulted in performance gaps, constraining effective management, sustainability of river basin development and management. Based on the national indicative plan 2011 to 2015 for IWRM, about US$ 369 million was needed for river basin management, while only about US$ 144 million (about 39%) was secured (Lao PDR, 2012). In addition, it may need was about US$ 1.50 million[5] per year for climate change adaptation, while budget deficit could be about 80%.

The shortage of funds is due to public budget deficit. The national budget deficit was, on average, about US$ 0.27 billion (4.98% of GDP) between 2005 and 2010 (MPI, 2011) and US$ 0.38 billion (4.07% of

[5] Expert judgement and estimate based on Nam Ngum watershed management project which used IWRM and cost about US$ 0.45 million for planning and US$ 0.15 million for basic IWRM, although intensive watershed management at Nam Thuen II costed about US$ 1 million per year

GDP) between 2010 and 2014 (MPI, 2015). Larger proportion of public investment was usually allocated for other sectors rather than environment including water sector. Between 2011 and 2015, more than 91% of public investment went to economic, infrastructure, education and health, and less than 1% of the public investment or less than 0.01% of the GDP spent for environment including water sector.

Majority of financial support for river basin including IWRM was from development partners or international organisations. However, on average, the funding could be around US$ 0.5 million per year in last 10 years, and it is variable and not able to finance all the river basins.

Financial support from the private sector is limited, and lack of regulation and standard practices to guide and regulate the financing including water tax and fees. Private sector that finances IWRM is mainly hydropower projects, while their financing confined to watershed that the projects depend on. Nam Thuen 2 hydropower project, for example, allocates about US$ 1 million per year for Nam Thuen watershed management. Other projects do too, but vary depending on scales of impacts and negotiation, which is not standardised or systemised. Based on decree on protected area management (PAM), a hydropower is required to contribute US$ 800 per ha of any ha of forest converted or inundated, and US$ 2/ha for the PAM in watershed (GoL, 2015), the effectiveness of such law enforcement, however, has not been evaluated. In addition, water tax and fee has not been applied.

Resource mobilisation by the government and social organisations access is limited, fragmented and not systematic. In general, it is ineffective and lacks resource mobilisation plan, study of funding sources, feasibility of access and M&E.

The inadequate budget has limited RBM, especially 1) development and management of information including assessment of water resources, water demand and supply, climate change and disaster risk and adaptive capacity, 2) regulations and agreements on water allocation, uses and tax etc, 3) development and implementation of inclusive river basin development plan, 53) capacity building, and 4) conflict solution. Consequently, it undermines climate change adaptive and hazard risk resilient capacity.

3.4.2.2 Non-financial and economic barriers

1. Limited knowledge and skills on IWRM for adaptation

Knowledge and skills on IWRM for adaptation is insufficient. It includes insufficient knowledge and skill on technical, financial and economic, policy and other management aspects of IWRM as outlined in Annex 6.

The limitation of knowledge and skills stems from weak human resources development system, including professional trainings. At higher education, IWRM and climate change adaptation has just introduced in the curriculum of the Faculty of Water Resources Engineering (FoWRE) and Environment (FoE) of the National University of Laos (NUOL) since 2012, and Forestry (FoF) in 2013. There are number of constraints faced by the faculties such as limitation of human resources, especially

practical experiences, curriculum and materials for IWRM and climate change adaptation. Meanwhile, mechanisms to mobilise local experts and resource person to lecture and share experiences are neither clear or limited budget to do so.

Professional IRWM trainings has been insufficient. For example, IRWM training for Water Resources Department (WRD), FoWRE, FoE and FoF was less than once a year in last 5 years. Training oversea is also limited and not continuous, while some trainees have either limited water resources, IRWM background and English competency or mismatch of responsibilities. Previous trainings were mostly funded by development partners, international organisations. However, it was inadequate. In addition, HRD systems of WRD and relevant organisations such as Department of Disaster and Climate Change (DDMCC), Irrigation (DoI) and FoWRE, FoE, FoF of NUOL are ineffective. They lack comprehensive human resource and capacity development plan including targets, staff knowledge, capacity management and Sometimes recruitments were mismatched and lacked coordination between educational institutes and public, private and other employment organisations as well as demand and supply side.

Inadequate financial investment for capacity building is another factor that impede HRD. Annual budget demand for HRM or capacity building on IRWM may be around US$ 100,000, while actual budge available is about US$ 30,000 per year, on average, for last 5 years. This financial problem, as discussed in the early chapter, rooted in national budget shortage and ineffective allocation. In addition, staff movements, recruiting unqualified and irrelevant specialisation require additional training and investment for capacity building, leading to exacerbation of budget situation.

Another important factor that undermined knowledge and skills are insufficient leadership and personal efforts on learnings. While leadership and personal endeavours are crucial for staff capacity building it is a cost-efficient and more critical in the course of financial shortage. However, initiatives to create and promote self-learning e.g., on the job training, learning culture, seeking and sharing information about learning opportunities are not well-established.

2. Incomplete legal framework and ineffective enforcement of water policy

Several necessary subordinate law and policy to provide detail and clear guidelines and directions on river basin development and management including IWRM for adaptation are not in place. Enforcement of the law on water resources was either ineffective. The main policy gaps regarding enforcement and implementation can be outlined in Annex 3.

The absence of these subordinate laws and ineffectiveness of law enforcement were associated with inadequate skills, financial resources, policy M&E and coordination amongst stakeholders as discussed earlier.

3. Polarisation and ineffective coordination on river basin management

River basin development and management is somewhat polarised. Decision on local socioeconomic planning and development is largely dependent on provincial and sectoral interest and administrative perspectives and approaches rather basin-based approach. Although law on water resources (2003)

requires all developments in the river basin must be in line with river basin development plan; hydropower, irrigation, urban and rural water supply are developed and managed based on strategies and regulations of those sectors. In addition, each province manages water and other resources based on its socioeconomic development priority and plan. On the other hand, department of water resources (DWR), MoNRE has limited capacity and influence on the development and management hydropower, irrigation, water supply in urban and rural area. So, conflict of interests and priority of water resource uses occurred and remained unsolved.

This issue took place because of unclear responsibility and priority of water uses in overall and particular river basin. In addition, it is because of the absence of basin development strategy and successful IWRM model, and technical difficulty of IWRM for adaptation as discussed below.

4. Technical challenges for IWRM

IWRM is complex and requires multi-disciplinary approaches, agreement and effective coordination. It is time and budget consuming to realise successful or effective RBM including IWRM, climate change adaptation. Effective coordination and cooperation is the core of IWRM, but realising effectiveness is difficult due to polarisation and lack of effective steering committee. Furthermore, it lacks successful models and best practices coordination and cooperation amongst stakeholders in river basin management. On the other hand, values are placed on hydropower, irrigation and water supply projects which have tangible and immediate impacts and benefits on socioeconomic developments.

5. Inadequate reference projects and best practices on effective or sustainable river basin management

5 river basins: Nam Ngum, Nam Kading, Nam Thuen, Xebangfai, Xebanghieng and 2 sub-tributary basins: Nam Tone and Nam Song initiated river basin management piloted IWRM. As of now, none of the river basin management including IWRM has been either evaluated and documented its best practices. So, it is unclear whether good model and practice exist and be a showcase guiding for future extension of IWRM or not. Reference and best practices exist in the regions, but research and adoption of those best practices in Laos are also limited. The absence of the reference project and best practices constrained or misappropriate development of river basins including deployment of IWRM for adaptation.

The lack of reference project and best practices is due to inadequate research skills and budget for research, demonstration and technical difficulty of the IWRM as explained above.

6. Insufficient comprehensive river basin development strategy and plan

As mentioned, only some river basins have the strategy and development plan in place. For those that exist, do not provide clear development targets, strategies and measure for sustaining water uses and conservation, and climate change adaptation. In addition, they are not evaluated its effectiveness and regularly updated.

The absence of the development plans related with incomplete integrated land use plans, inadequate water resources and hazards information, capacity and budget. The integrated land use planning initiated by Ministry of Natural Resources and Environment (MoNRE) and agriculture and forestry (MAF) several years ago, but it is incomplete and not downscaled to local levels and considered climate disaster vulnerability and resilience. The integrated planning was piloted in few provinces such as Oudomxay and Champasack about 10 years ago under SIDA's funds for strengthening environment management (SEM) and Finnish government's funds for the environment management support programme (EMSP). However, it was in an initial stage or at provincial level; the plans have not been updated and downscaled to district and village level and not mainstreamed climate change and disaster risk reduction policies and actions. Incomplete integrated spatial and land use planning was mainly and outcome of budget shortage, ineffective coordination and poor information sharing. Incompleteness of the integrated land use planning resulted information gaps for river basin planning.

Shortage of budget obviously has affected the development of river basin development planning. Last five years, US$ 0.35 million was required for fulfilling river basin resources assessment and planning, but such required budget was not attainable. The limited knowledge and skills on IWRM was as discussed above.

3.4.3 Identification measures

3.4.3.1 Financial and economic measures

1. Improve financial resources and investment on the river basin IWRM

Improvement of the financing and investing is an immediate need and critical measure for ensuring effective river basin development and management for climate and disaster resilience. The improvement includes increasing (1) access to financial supports from public investment, development partners and resource mobilisation from other financial sources (2) revenue from the exploitation of resources and reinvest in a river basin management, and (3) effectiveness and efficiency of financial resources management.

The first and second measures are achievable by strengthening capacity and implementation of following activities.

1) River basin water resources assessment and valuation;
2) Financial and investment need assessment;
3) River basin development plan;
4) Resources mobilisation plan;
5) Assessment of financial or funding sources and access feasibility;
6) Financeable project proposal including financial and economic analysis;
7) Water resources tax schemes;
8) IWRM cooperation policy and the development plans.

In addition, effectiveness, efficiency, relevance and sustainability of the financing will be enhanced by improvement of financial and investment management system including budgeting, tracking and

reporting, and M&E. This means Ministry of finance (MoF) and MPI, which have a financial record system of both public investments and development partner's funding will be enhanced. In addition, in order to ensure effectiveness and accountability, financial management sub-systems will be established at sectoral and local levels to link with MoF and MPI system as a one-door service or end-to-end.

3.4.3.2 Non-financial and economic measures

1. Enhance knowledge and skills on integrated and sustainable river basin management for adaptation

Knowledge and skills is a determinant for sustainable river basin management in both short and long term. Overall, the knowledge and skills gaps outlined in Annex 6, especially to overcome the barriers shall be addressed. Apart from on-the-job train, short-term and long-term IWRM professional training, study and research in high education shall be improved.

In addition, human resource development and management system including capacity development plan, staff knowledge and capacity management, effective staff recruitment and positioning, and M&E shall be upgraded. Coordination of HR demand and supply sides will be enhanced to provide feedback and support the HRD and capacity development planning. In addition, leadership, internal learning culture and staff commitment shall be strengthened shall be promoted.

With adequate knowledge and skills, leadership, learning culture and commitment; it could be expected that the relevant organisations, to great extent, would be able to overcome the barriers and pursue more effective and sustainable river basin management.

2. Improve policy on the integrated river basin management for adaptation

Policy is enabling environment and measure for effective integrated river basin for adaptation. First, the policy and policy gaps outlined in Annex 4, especially policies on integrated or inclusive development shall be addressed. Formulation of the policy shall be carried out through in depth analysis of gaps, consistency and potential impact of the policies. The best practices and the law enforcement M&E system will be developed to provide lessons for upgrading effectiveness of the legislation system.

3. Develop reference projects and best practices on effective or sustainable river basin management for adaptation

Reference projects on effective or sustainable river basin management including IWRM for adaption will be developed and promoted at river basin and sub-tributary basins, following best practice studies. The best practices as well as reference projects shall focus on one or more elements or aspects of adaption as follows.

1) Early warning systems (multi or single hazards e.g., floods, landslide, storms and drought) particularly, methods for hazard mapping, monitoring and forecast, communication and response, financing and insurance of climate and disaster risk
2) River bank, erosion and landslide structural protection

3) Mainstreaming and application of climate change and disaster resilient technologies/ equipment for hydropower, irrigation and town planning and construction
4) Water storage and reservoir for adaptation to flood and drought
5) Water conflict solutions and mechanism
6) Organisation arrangement for sustainable river basin management and climate change adaptation
7) Law enforcement
8) Financing river basin, access to finance and resources mobilisation
9) Water resources tax
10) Water resource valuation

4. Develop more inclusive river basin development strategy and plan

River basin development plan that defines water resources development targets, water resources state and pressures including its vulnerability to changing climate and disaster, water demand and supply, and measures to secure water resources for ecosystems, consumption, industries and climate change adaptation shall be developed for each river basin. Fulfilling these call for agreements amongst stakeholders especially local authorities in the river basins on the development targets and plans, and implement following activities.

1) Review and update the existing water resource strategy and plans;
2) Conduct resources assessment, Preliminary assessments for climate and disaster vulnerability and adaptive capacity;
3) Redesign the IWRM plan for climate change adaptation and disaster resilience in each river basin.

5. Improve research and development

Research is a fundamental measure to ensure effective river basin and climate resilient planning for sustaining water resources conservation and uses. Action shall be conducted in accordance with capacity performance gaps identified in Annex 6. In addition, for effectiveness and sustainability, research plans will be developed as standalone plan or as component of the river basin development and management and climate change adaptation plan. Data and information management system and dissemination of researches outcomes shall be enhanced as well.

3.5 Barrier analysis and possible enabling measures for a climate resilient water supply system

3.5.1 General description of a climate resilient water supply system

Water supply systems include stationary system (e.g., gravity flow system, deep borehole wells and water storage) and mobile system (e.g., portable water purification and supply devices to deliver water to water shortage communities, especially in the event of floods and drought). In term of management, it is also divided 2 main categories. The urban water supply systems or Nam Papa are mostly electric pump and gravity-fed systems. The rural water supply system, apart from the electric pump and gravity-fed systems, include deep boreholes, dug wells with concrete ring, rain water harvest systems, jars and elevated tanks.

The climate resilient water supply system is the water supply system that incorporate and deployment of climate and disaster resilient and adaptation technologies and develop specifically for adaptation. It is a publicly provided technology. However, private sector also has critical a role to invest and supply technologies for the development the water supply system. Communities and individual household too are encouraged to develop and manage rural water supply in their communities or household. Currently, however, the urban and rural water supply systems are not adequate, resulting in low access to water. As of 2015, only about 84% of the urban population[6] access to clean water and 67% accessible to sanitation (MPI, 2015). In rural area, only 65% of the population are accessible to water supply, 55% are accessible to sanitation (WSP &WB, 2014). Moreover, they are not resilient to disaster or enhance-able to adapt to climate variability. In 2011, for example, Haima Typhoon caused a flood, loss and damage to the urban water supply systems in a value of about USD 146,639 or at least US$ 1.8 million is needed for reconstruction. Th rural water supply systems including 2,684 gravity fed water supply systems were damaged in the value of US$ 732,796, and requires US$ 762,796 for recovery (Lao PDR, 2011). Despite the government intends to develop more and resilient water supply system to ensure all people are accessible and affordable to water, but there are number of barriers constraining the developments as described in the followings sections.

3.5.2 Identification of barriers for water supply system

The barriers to the development and deployment of climate resilient water supply systems, as discussed in Chapter 2, were identified by compilation, synthesis and produced longlist of barriers (Annex 3) by literature review, key information interviews and focus group meeting. The barriers were then decomposed by decomposition matrix (Annex 4) and cause-effect by problem tree analysis (Annex 5). Finally, the longlisted barriers were screened and revised by voting and expert judgement and prioritised by scoring, which score 1 is insignificant, 2 is moderate and 3 is very significant barrier, during technical stakeholder consultation meeting. Additional stakeholder consultation was also held for validation and agreement on the analysis process and outcomes. As a result, 32 barriers in the longlist were reduced to 14 (Table 4) as some barriers are not significant, similar and can be grouped and revised. Out of the 14 barriers, however, there are 9 barriers, which were scored 3 are critical ones; three of them are financial

[6] Total population of Laos was about 6.5 million; urban population was 2.14 million (app. 32.9% of the total population) and rural population was about 4.36 million (67.1% of the total population) (Lao PDR, 2015).

and economic and six are non-financial and economic barriers. Subsection 3.5.2.1 and 3.5.2.2 elaborated about the critical financial and non-financial and economic barriers are in, respectively.

Table 4 Barriers on the development and sustainability of climate resilient water supply system

Barriers on the development and sustainability of climate resilient water supply system	Score	Category
1. Inadequate public budget and investment on climate resilient and quality water supply system	3	Financial and economic
2. High investment cost for climate resilient technologies	3	Financial and economic
3. Limited access to finance	3	Financial and economic
4. Incomplete policy and regulation on climate resilient technologies /infrastructure	3	Legal framework
5. Limited knowledge and skills on climate resilient water supply system and infrastructure	3	Capacity/Skills
6. Inadequate information about water resources, hazards and risks, disaster resilient technologies and best practices	3	Information and awareness
7. Ineffective quality assurance and control of water supply system planning and development	3	Technical
8. Insufficient legal framework and ineffective law enforcement	3	Legal framework
9. Insufficient strategy on climate resilient water supply systems	3	Organisation
10. Low or economic unviable water supply systems	3	Financial and economic
11. Insufficient financing mechanisms on water supply systems	2	Financial and economic
12. Disperse population, settlement and difficult access	2	Others
13. Insufficient civil organisations and think-tank to advocate and support climate change adaptation and disaster risk reduction	2	Organisation
14. Variability of climate and hazards including its risks and impacts	2	Others
Remark: *Score 3 = significant; 2 = moderate; 1 = least significant barrier*		

3.5.2.1 Financial and economic barriers

1. Insufficient public budget and investment in the development and deployment of the climate resilient water supply systems

Insufficient budget has been barrier for the investment in and the development of a water supply systems. At least US$ 36.7 million per year was required for urban water supply development, while only US$ 19.9 million (54.22%) was financed. An annual financial need for rural water supply was 30.4 million, whereas actual funding was only 6.1 million (20.01%), between 2012 and 2015 (WSP and World Bank Group, 2014). on average, about 4.75 million per year are needed to achieve the water and sanitation target for until 2015, but available budget was only about US$ 1.5 million per year (Robinson, 2009).

National public budget deficit is a root cause of the budget inadequacy as mentioned in early Chapter. Majority or about 90% of the investment in water supply, for example, between 2012 and 2015 was

from development partners and INGO (WSP and World Bank Group, 2014). However, this funding sources are subject to be variable, depending regional financial trends. In addition, it is because of limited capacity of relevant organisations to mobilise and access to financial support.

2. Limited capital and access to finance

Public investment mainly focuses on rural water supply; while state enterprise and private sector are promoted to develop and operate urban water supply service. Nam Papa State enterprise and private sector that engage in the water supply industries, however, have limited capital and financial difficulties for investing, upgrading and up-scaling the water supply systems and production capacity. Access to capital and finance, in the meantime, is challenge, due to underdeveloped capital market, especially high interest rate, limited long-term loans, while some water supply projects however are not financial and economic viable or low rate of return on investment. On one hand, the government has not had financial and economic mechanism and incentives and polices to promote private investment and facilitate to access to finance. These resulted in underdevelopment of the water supply systems including restricting investment from private sector.

3. Higher investment cost for environmental including climate resilient technologies

Investment cost on some water supply systems is high. It is not only high cost to develop high quality water systems, it is also costly to incorporate climate resilient technologies and practices. For instance, the relocation of infrastructure to avoid floods, landslide, adjust to and maintenance of the water supply systems as shown in the Table 5. The higher cost, lower return on investment. In addition, many Nam Papa operators are facing the cost for incorporating climate resilient technologies.

Table 5 Existing climate resilient technologies and additional cost

No	Types of water supply systems	Climate resilient technology deployment and additional cost
1	Electric pump water supply	Development of adjustable head pump to adapt with lower or higher water level in a river may Increase additional cost of about 20-30% of total initial investment compared to normal head pump or US$ 2,000-4,000/head pump.
2	Urban water supply/ Nam Papa (Gravity fed and Electric pump water supply system)	Cost on water filtering and purification equipment and operation increased 10-15% compare to normal cost as a result of high turbidity resulted from floods and erosions.
3	Water proof deep borehole	Lifting up the head water pump from flood level and use water proof system including concrete for building base of the pump. This could increase 40-50% of total initial investment cost compare to normal deep borehole (US$ 1,200/deep boreholes).
4	All gravity fed or weir- based water supply system	Erosion protection of weir and head of water supply. 20-30% increased compare to normal weir.

5	All, but usually medium to larger scale that required IEE or EIA	Cost associated with site selection, risk assessment and design. 0.01-1% increase of total investment cost compares to usual practices or US$ 12-13,000/scheme.

3.5.2.2 Non-financial and economic barriers

1. Inadequate information

Information for effective and climate resilient water supply systems is insufficient, especially the information about availability of underground water, water demand, changes of water resources in each river basin or water sources due to climate and land use changes, disaster risks of the existing water supply systems, disaster resilient technologies and feasibilities.

Although groundwater has been extracted in many places in suburb and rural areas through the country, but its availability is little known. Drilling and digging for groundwater were randomly conducted, but it is harder now as it increases cost and loss of time. At the same time, it is perceived that numbers of ground water sources and dug wells reduced, but studies have not been conducted to assess the changes. These are challenges to explore and manage groundwater in effective and sustainable manner.

These issues caused by inadequate budget, tools especially for groundwater study. Budget required for a comprehensive research including acquiring adequate tools in last 5 years was at least US$ 0.3 million per year or US$ 1.5 million for complete and make available necessary water resources information for planning and adaptation. The actual budget and investment was only 20% and 08% shortage.

The major causes of the budget shortage were disused in the previous section, capacity issues were discussed in a section below.

The disasters risks and resilience of existing water supply systems is not well-known. Previous construction and existing water supply system were not effectively and sufficiently incorporated climate and water related disaster, and as of now, an in-depth study and assessment of risk and resilience of them have not been conducted. Despite it is believed that most of the water supply systems including water production are at risk of climate and water disaster such as drought, floods and storms; to what extent the risk is and what kind of engineering design and climate resilient technologies are needed for each scheme, and how much financial investment is required have not been identified or studied in detail. Consequently, it inhibits planning and decisions on investment of climate resilient technologies in the sector.

The absence of the information and development plan are related with limited skills on research and budget of the key stakeholders[7], impeding the effective planning:

1) Climate change and disasters risk on water resources and water supply systems,

[7] Nam Papa State Enterprise (NPSE), Department of Urban Planning and Housing (DUPH) of Ministry of Public Work and Transport (MPWT), Centre for Water Sanitation and Hygiene (CWSH) of Ministry of Public Health (MPH), Disaster and Climate Change (DDMCC) of MoNRE

2) Water demand and management,
3) Criteria for site selection to avoid disasters,
4) Disaster and climate resilient or proof equipment,
5) Structure design and technologies to prevent erosion, landslide, water filtering and purification, and other risks of hazards, and
6) Financial assessments on the climate and disaster resilient technologies.

2. Limited knowledge and skills

Knowledge and skills that are insufficient for deployment and diffusion of climate resilient water supply system are particularly in the areas listed in Annex 6. The limitation of capacity is, as mentioned, because of ineffective human resources development system. In addition, it is due to inadequate financing. Financial needs in last 5 years (2010-2015) were about US$ 1 million or US$ 0.25 million per year, while about 80% of the budget was not attained. The causes of financial issues were as explained in financial and economic section.

3. Imperfect rural water supply policy

Decentralised rural water supply policy, for example, has mixed impacts, and impede development and access to clean water in rural area. The policy encourages household and community's contribution or responsible for part or total investment of the rural water supply systems. Despite the policy has a good will in term of promoting self-reliance, strengthening ownership and reduce public budget burden, but it has trade-off and caused a stagnancy and delay in the rural water supply development in many areas since many households in rural areas are poor, not ready and or unwilling to cover the cost.

4. Inadequate reference projects and best practices on climate resilient water supply system and technologies

Reference climate and disaster resilient water supply systems are not available or definable to guide and drive its expansion. As mentioned, the majority of the water supply schemes have not even been evaluated its risks and resilience to disasters. Successful, effective model including best practices in the country and regions have not been explored and disseminated. There is no pilot project to be a representative model for diffusion of disaster and climate resilient technologies and practices. These to great extend undermine adaptation capacity of the water supply system and extension of the disaster and climate resilient technologies and practices.

The absence of the reference project and best practices are due to inadequate of research including disaster and climate resilient technologies and research skills, and budget for demonstration.

3.5.3 Identified measures for water supply

3.5.3.1 Financial and economic measures

1. Secure adequate financial investment in climate resilient water supply systems

Securing adequate financial investment in water supply is critical measure. About US$ 67 and US$ 34 million is needed to be secured each year for achieving water supply and sanitation development targets for 2020, respectively (WSP and World Bank Group, 2015). US$ 205 million is also needed for the urban water supply system (MPI, 2015). Investing in water and sanitation is, however, worthwhile. Every dollar invested the water and sanitation programme could possibly save US$ 2 (the urban water supply) and US$4 (rural water supply)(Hutton, Larsen, Leebouapao and Voladet., 2009;WSP, 2013).

Achieving these, the government needs more efforts to mobilise additional resources, and financial support from the development partners and international organisations. Moreover, effective public and financial aid management including budget allocation shall be put in place. Following measures or activities including capacity building are prerequisite.

1. Identification and assessment of financing or sources of funds, develop strategy and plan for access to finance and resource mobilisation;
2. Improvement of the financial aid management system to ensure effectiveness and transparency of financial management. This includes: (1) improvement of public investment budget allocation model, procedures and criteria, (2) financial support and investment record, tracking and reporting system, and (3) dialogue or platform for reflecting and planning to improve financial management effectiveness;
3. Implement non-financial measures described section 3.5.3.2 and 3.6 such as policy, cooperation and capacity building.

2. Alleviate investment cost on environmentally friendly including climate resilient technologies

Reduction of the investment cost is crucial for promoting deployment diffusion of climate resilient technologies. Directly, the cost can possibly be reduced by reduction of cost on capital and tax. Indirectly, identification and conservation water sources suitable for water supply, for example, would also save costs.

Reduction of capital cost, especially interest rate of loans is desirable as it would have financial and economic impact largely on water supply industries. The cost is possibly reduced by firstly implementation of the Prime Minister's decree on commercial interest rate (not higher than 7% per year). Secondly, there is a need to study, develop and apply policy to promote and improve access to finance. To fulfil these, there shall be an assessment of the capital market performance in Laos, potential capital market the in regions including access feasibility, and then capacity building to develop financeable project proposal including financial readiness.

Tax reduction for importing of climate resilient technologies/equipment is necessary and important measure. However, since tax is one of the most important sources income of the country; studies on cost-benefit, impacts and the trade-off between tax reduction and avoided loss and damage, and benefits

from adaptation shall be performed to for justification and decision on the tax measure. In addition, it needs practical guidelines on tax exemptions if tax reduction schemes are to be applied.

3.5.3.2 Non-financial and economic measures

1. Improve information and information access

Improvement information and information access on water resources for water supply is an important measure for effective planning and development of effective and climate resilient water supply development. The information to be improved are 1) surface and ground water availability for water supply, 2) its vulnerability to changing climate, 3) adaptation or resilient capacity of the existing water supply systems and 4) best technologies for adaptation.

2. Develop master plan for development and extension of resilient water supply systems

Formulation of climate resilient water supply development plan is necessary for sustainable water supply development in both short and long term. The relevant governmental organisations, especially the department of urban planning, Nam Papa state enterprise and centre for environmental sanitation and hygiene have quite sufficient skills in the planning. The key activity to be done is mainstreaming climate change and disaster risk reduction measure and budgeting and translating into action plan for each water supply system. So, once information is available, the planning should be developable.

3. Enhance knowledge and skills on climate change, disaster and resilient technologies

Key knowledge and skills to be enhanced are as outlined in Annex 6. It includes knowledge and skills on climate change and disaster risks on water supply system, technical knowledge and skills on climate resilient technologies including financial and economic analysis, resource mobilisation, policy and human resources system development.

Securing budget for capacity building, about US$ 0.25 million per year from now to 2020 is rather challenging and seeking for external support is likely unavoidable. Hence, capacity building, in the meantime, shall be implemented in coincidence with resources mobilisation and access to finance.

4. Improve policy on climate resilient technology

Decentralising rural water supply management may work well in several communities. However, the government needs to revise and intervene the infrastructure management at the flood prone areas where infrastructures are often damaged by floods and high cost involved since communities may not be able to cover such high cost. So, policies on land uses and developments in flooded areas will be developed to provide guidance for hazard resilient planning.

5. Enhance research and development of reference projects and best practices on the climate resilient water supply systems

Reference projects and best practices on climate and disaster resilient water supply systems shall be developed and promoted as a showcase for replications and learning process. The development of the reference projects shall be built upon best practices, which studies of requires a comprehensive research.

3.6 Enabling framework for overcoming the barriers in the water resources sector

Following enabling framework for overcoming the barriers in the water resources sector were identified based on the identified barriers and measures, which summarised in the Table 7. The environmental framework consists of overall enabling environment for adaptation in the water sector, specific technologies and measures. Some policies for enabling development and deployment of the technologies already exist, such as the law on environmental protection (2013), water resources (2017), the decree on water supply development and management, water hygiene and sanitation. In addition, five following enabling framework including policies shall be developed and enforced.

1. Policies on promotion of investment and development of environmentally friendly, climate adaptation and disaster resilient technologies,
2. Policies on the integrated socioeconomic planning and developments,
3. Policies on the national scientific and technological research and development,
4. Environment, climate adaptation and disaster expert network,
5. Regular Environment, climate adaptation and disaster campaign programme on media and education systems

Table 6 Barriers and measures on the adaption technologies in the water resources sector

Technologies	Barriers	Measures
Early warning system (EWS)	1. Public budget shortfall and ineffective budgeting	Increase public revenue and effectiveness of public budgeting
	2. High investment cost on EWS	Reduce and alleviate investment cost on EWS
	3. Variable external financial support	Reduce variability and optimise external financial support
	4. Insufficient human resources (HR)	Increase human resources (HR)
	5. Inadequate tools and facilities	Increase tools and facilities
	6. Ineffective coordination amongst stakeholders	Improve coordination amongst stakeholders
	7. Inadequate information and awareness	Increase information and awareness
	8. Unsustainable settlement and defective land use planning	Enhance sustainable settlement and integrated planning including land use
	9. Insufficient legal framework and ineffective law enforcement	Develop legal framework and enhance law enforcement effectiveness
Disaster impact	1. Inadequate budget for the establishment of the disaster fund	Secure financial resources for establishment and operation of the fund
	2. Insufficient legal framework	Develop legal framework

Technologies	Barriers	Measures
reduction fund	3. Unclear roles and responsibilities of stakeholders	Improve roles and responsibilities of stakeholders
	4. Limited knowledge and skills	Increase knowledge and skills
	5. Insufficient information about feasibility, best practices and successful models	Increase information about feasibility, best practices and successful models
Watershed and river basin management (W-RBM)	1. Inadequate budget and investment in W-RBM	Increase budget and investment in W-RBM
	2. Unclear financial models on W-RBM	Develop financial models on W-RBM
	3. Unclear legal framework on water allocation, right, ownership, tax	Develop legal framework on water allocation, right, ownership, tax
	5. Limited knowledge and skills on IWRM	Increase knowledge and skills on IWRM
	6. Inadequate successful models and best practice on IWRM	Develop successful models and best practice on IWRM
	7. Inadequate information on water resources, hazards, technologies and best practices	Increase R&D of information on water resources, hazards, technologies and best practices
	8. Polarisation and conflicts of interests on the uses of river basin resources	Enhance cooperation and harmonise the uses of river basin resources
Climate resilient water supply systems (CRWS)	1. Inadequate public budget and investment in CRWS	Increase public budget and investment in CRWS
	2. High investment cost of climate resilient technologies	Reduce investment cost on climate resilient technologies
	3. Limited access to finance	Expand access to finance
	4. Insufficient policy and regulation on climate resilient technologies	Develop policy and regulation on climate resilient technologies
	5. Limited knowledge and skills on CRWS	Limited knowledge and skills on CRWS
	6. Inadequate information about hazards, risks, climate resilient technologies	Increase information about hazards, risks, climate resilient technologies
	7. Ineffective quality assurance and control of water supply systems	Improve quality assurance and control of water supply systems
	8. Insufficient legal framework and ineffective law enforcement	Develop legal framework and enhance law enforcement effectiveness
	9. Insufficient strategy to develop climate resilient water supply systems	Develop the strategy on climate resilient water supply systems
	10. Low or economic unviable water supply systems	Improve economic viability and subsidise climate resilient water supply systems

Chapter 4 Barrier Analysis and Enabling Framework for the Agriculture Sector

4.1 Preliminary Targets for Technology Transfer and Diffusion

The agriculture development strategy to the year 2025 defined a vision to ensure productive and resilient agricultural production, competitive and commercially viable, clean and safe commodities, leading to food security, poverty elimination and sustainable national economic growth. By 2020, the agriculture sector aims at a continued growth of 3.4% and share 19% of the total GDP per year on average (MAF, 2015; MPI, 2015). Realising these requires a total investment of US$ 9,900 million by 2020 and US$ 23,375 million by 2025. Of which, 1.5% of the total investment is expected from the public sector, 16.4% from official development assistance (ODA) and 82.1% from the private sector including domestic and foreign investments by 2020. By 2025, total investment by the public sector and ODA would be around 1.07% and 13.37% respectively, and private sector investment would increase to 85.56% (MAF, 2015).

Agriculture sector is recognised as one of the most vulnerable sectors due to the changing climate and extreme events (MAF, 2015; MoNRE, 2009 and 2012; MPI, 2015). To enhance climate change adaptation and resilience to these changing climate and disasters, and to respond to the development goals, livestock disease prevention and control, climate resilient infrastructure, crop diversification and agriculture subsidy mechanism are prioritised, among others. its specific development targets are as followings.

Livestock disease prevention and control surveillance system

Livestock disease surveillance system is expected to fully develop to achieve the following livestock development targets.

1) Be free from Foot-and-Mouth Disease by 2020 and other animal diseases are under control, at least from now until 2025 and beyond;
2) Be healthy, sanitary, nutritious and productive and resilient;
3) Minimise mortality due to disease, extreme weather and disaster to the extent it deserves;
4) Livestock sector growth of at least increased by 6% per year. The production of meat including fish and eggs reach 487,500 and 711,000 tonnes. At least 10,000 to 15,000 tonnes of meat, especially beef, is exportable by 2020 and 2025, respectively (MAF, 2016).

Agricultural development subsidy mechanism

Laos' total agricultural export value was about US$ 713 million in 2016, and was expected to increase to US$ 1 billion and US$1.5 billion by 2020 and 2025, respectively (MAF, 2016). The average total economic loss due to storms and floods was about 100 million per year (MLSW, 2012) and could possibly be US$ 278 million per year on average between 2010 and 2029 (ISDR et al., 2012). The financial need for subsidising adaptation technologies, price loss coverage and damage due to natural disasters is necessary. Agricultural subsidies are expected to be around US$ 30 million[8] per year, which is approximately 0.30% of the total investment in agriculture sector (US$ 9,900 million) by 2020. By

[8] The target was generated during BAEF

2025, it is expected that the annual subsidy would be US$ 50 million[9] or 0.21% of the total investment in the agriculture sector (US$23,375 million) (MAP, 2015).

Climate resilient rural infrastructure

Climate resilient rural infrastructure, in this context, includes any infrastructures and facilities that are important for enhancing climate change adaptation and disaster resilient capacity in the agricultural sector such as multipurpose community centers, early warning systems, irrigations and reservoirs, erosion protection, greenhouses, logistics system including warehouses, roads and bridges etc.

The multipurpose community centers that serve as 1) community meeting and training center, 2) be incorporate as part of a warming system regarding natural disasters such as pests, insects and disease outbreak; 3) evacuation area and facilities, 4) warehouses for seeds and crops, storage of equipment for disaster emergency response and recovery. These centers shall be adequately developed in nine provinces and 51 districts in the irrigable areas and other provinces and districts that are at risk of disaster by 2025, and other areas by 2030. Currently, no such infrastructure and facilities exist.

The multipurpose irrigation which serves irrigation water in dry season and drain flood water in raining season is expected to be fully developed to serve all irrigatable land of about 2.4 million ha though the country. In which, by 2020, most of the existing irrigation (18,067 irrigation schemes), to the extent it possible, shall be assessed and adopted the climate resilient technologies, practices and be able to irrigate water to the existing irrigated farm land (272,300 ha) adequately. Newly proposed irrigations shall deploy climate resilient technologies and practices and be able to supply irrigated water to 50% and 100% of the irrigable areas, 2.4 million ha by 2020 and 2025, respectively.

The proportion of villages that have road access was 84.51% (MPI, 2015). The access rate is far lower for the communities or villages that are prone to storms, floods and landslide. Climate resilient roads are quality paved road with adequate climate resilient technology support. They are needed to facilitate timely agriculture commodity transport and trade, to provide evacuation access in the event of disasters shall be developed and connected all communities that are at risk of disasters by 2025.

Erosion protection, greenhouse and warehouse are almost non-exist in the disaster-risk communities. By 2025, the infrastructure and facilities shall be fully developed.

Crop diversification

The Ninth (IX) Party Congress has defined the agricultural development direction to pursue an integrated agriculture development approach to ensure food security[10] (cited in MAF, 2015). Crop diversification, especially introducing the verities of crops and integrated farming systems shall be applied appropriately to increase disaster resilience, climate change adaption capacity and the net benefits by at least 20% as a value-add to the existing farming systems. The new farming systems shall be promoted to deploy crop diversification techniques to the extent it is feasible.

[9]The target was generated during BAEF

[10] From the Ninth (IX) People's Revolutionary Party Congress Resolution

4.2 Barrier analysis and possible enabling measures for livestock disease prevention and control system

4.2.1 General description of livestock disease prevention and control system

Poor husbandry, feed and animal disease have been the major constraints for livestock in Laos (Stur, 2002; FAO, 2005; Wilson, 2007; DLF, 2016). Disease outbreak causes about 20-30% of buffaloes and cattle, 15% of swine, 18% of goats and sheep and 35% of poultries dead, and economic loss of about US$ 40 million every[11]. Foot-and-Mouth Disease (FMD) outbreak only caused a loss of thousands of cattle and buffalo and in value of about USD 13.5 to US$ 102 million affecting 414 villages in 14 out of 18 provinces of Laos (Nampaya et al., 2015). Currently, extreme weather and disaster exacerbate loss and damage on livestock production. Hypothermia, for example, caused number of livestock dead worth of US$ 2.5 million in 2011 (Khounsy et al., 2012). In 2015, such extreme weather resulted in 7,162 cattle and 3,744 buffalo dead, affecting 1,384 smallholder livestock keepers in 46 districts in 6 provinces (Nampaya et al., 2015).

Effective livestock disease prevention and control, especially livestock disease epidemics surveillance and early warning system, hereafter called "the surveillance and EWS" are fundamental veterinary service for saving animals from disease epidemics. The system may include knowledge and information system about disease, detection and monitoring of disease epidemics, communication and warning, emergency response planning and vaccination. It is non-market or publicly provided technology, but private sector and livestock keepers have important roles to employ and cooperate implementation of the disease epidemics surveillance system. However, the government recognises that such system is not fully functioned and effective. This report investigated why the livestock disease epidemics surveillance and weather disasters warning system are underdeveloped and underperformed.

4.2.2 Identified barriers for livestock disease prevention and control

The barriers that hinder the effective livestock disease epidemics surveillance and early warning system, as described in Chapter 2, were identified following the barrier analysis process, which includes barriers listing, screening, decomposition and problem analysis. The literature review, key information interviews and consultations with technical working group on climate change were performed to derive longlist of barriers (Annex 7). The barrier decomposition was then conducted using decomposition matrix to categorise barriers and then investigate barriers in each categories, elements and dimension of the barriers (Annex 8). In addition, cause-effect analysis was carried out by using logical problems tree (Annex 9). The barriers prioritisation was finally made by scoring, where score 3 means very important barriers, 2 is moderate and 1 is less important. The results of the analysis were finally validated, revised and reached consensus at stakeholder consultation meetings.

As a result, it found that out of 30 longlisted barriers (Annex 7), there are 13 barriers which are important barriers preventing an effective livestock disease prevent and control. Of which, 9 of them, which were scored 3, are critical barriers. Three barriers are financial and economic and six are non-financial and

[11] It is an estimated number resulted from expert judgement by technical working group

economic barriers (Table 7). Details of the essential barriers were discussed in subsection 4.2.2.1 and 4.2.2.2.

Table 7 Barriers to effectively prevention and control of livestock disease

Barriers to effectively prevention and control of livestock disease	Score	Category
1. Inadequate budget and investment on livestock disease epidemics the surveillance and early warning system	3	Financial and economic
2. High investment and operation cost	3	Financial and economic
3. Limited capital and access to finance and financial support	3	Financial and economic
4. Inadequate human resource	3	Staff and skills
5. Inadequate basic infrastructure and facilities	3	Technical
6. Inadequate information on livestock disease, the surveillance and EWS including cost-benefits or return on investment	3	Information and awareness
7. Low awareness and ignorance about loss of livestock and not taking serious disease control	3	Awareness/Others
8. Free range and scattered livestock raising	3	Other
9. Difficult to control illegal and cross borders livestock trade especially, traditional borders	2	Legal framework/ Capacity
10. Insufficient legal framework e.g., policy on vaccination, financial incentives, and cross border disease epidemics control	2	Legal framework
11. Inadequate civil organisations and expert groups to advocate and support exchanges of knowledge and experiences	2	Organisation/Network
12. Ineffective coordination and information exchange	2	Organisation/Network
13. Ineffective human development and education system on livestock disease and vaccines	2	Organisation
Remark: *Score 3 = significant; 2 = moderate; 1 = least significant barrier*		

4.2.2.1 Financial and economic barriers

1. Inadequate financial resources and investment

Livestock disease epidemic surveillance and early warning system is underfinanced, resulting from insufficient financial resources and investment. An estimated annual budget for the surveillance and EWS, on average, was about US$ 0.85 million[12] per year between 2010 and 2015, while actual public investment was, on average, about US$ 0.10 million, and mainly spent on administration rather than vaccination. Small holder and entrepreneurs could cover only about 50% of cost vaccination, while medium to large farms could possibly cover 70 to 80% of their cost for vaccination, on average[13].

[12] Based on investment of 1US$ per large animal (cattle, pig, horse etc.) and US$ 0.3 per poultries per year.

[13] Estimate made during TNA

The financial shortfall is not only hinder development, operation and maintenance of the surveillance and EWS, it also hinders development of policy, strategy and plans, capacity, information and R&D etc. for implementing it.

The root cause of the financial shortfall is mainly because of overall public budget deficit, which possibly resulted from ineffective and inefficient earning, budgeting and leak. Secondly, the lack of capacity to defence funding for livestock disease prevention and control, especially development of financeable project proposal with comprehensive social-financial and economic analysis, cost-benefits and return on investment. A large proportion of financial support on livestock disease prevention and control comes from development partners and international organisations. However, it has been rather variable. At the same time, resource mobilisation is ineffective. Currently, DLF for example has not had resources mobilization strategy and plans is not in place, sufficient information about potential funding sources and connection, and capacity to develop financeable proposals.

2. High investment cost

The development of an effective livestock disease surveillance and EWS requires substantial financial investment as equipment and facilities for detecting, sampling and analysis, and vaccination are costly. Vaccination for example, as mentioned, at least US$ 0.3 per year is needed for poultries and US$ 1 for large animals. In addition, there are other costs such as labour, transportation etc.

Both government and private sector, especially farmers are not affordable for the cost as demonstrated by low vaccination rate as mentioned early. Previous vaccination programme, for example the vaccination programme in the north of Laos, was possible because of international support (Nampaya et al., 2015).

3. Limited capital and access to finance

It is well-known that the majority of livestock businesses and keepers are micro and production and enterprise[14]. Many small livestock holders live under poverty line. So, financial resources for production and business, including caring animal health are often limited.

Access to finance, at the same time, is problem, limiting opportunity of the business and livestock holders to expand their financial resources for upgrading production and standard. Although investing in livestock is financially and economically feasible, the high interest rate (8-12% per year) and complicated procedure have limited the farmers to access to finance. It is even harder for farmers whose livestock has disease history and is at risk of hazards.

4.2.2.2 Non-financial and economic barriers

1. Inadequate human resources

Human resources including knowledge and skills on the surveillance and EWS is insufficient. The technical staff or mobile team to monitor and go to field to take samples of disease and diagnose the

[14] Micro commercial production means production and enterprise that employ 1-5 labour, with total asset of less than 100 million LAK (US$ 12,000) and profit less than 400 million LAK (US$ 50,000) (GoL, 2017)

disease are limited and not well-organised. Although one focal point is assigned in each province and district, but this number is low considering numbers of villages they may need to work with. In addition, it is difficulty and time consuming to access villages and farms in rural area, where road access is limited, and livestock is kept free-range. There is no technical staff based at a community to coordinate this area of work. Despite a person at each village supposes to oversee the work, but they lack technical knowledge and skills to detect and handle with disease in timely manner. This shortage of staff is due to limited staff quota and difficult to maintain staff, resulting the national budget constraints, lack of equipment and incentives.

The knowledge and skills of the livestock and fishery sector including department of livestock and fishery (DLF) to effectively and sustainably develop and operate the surveillance and EWS are inadequate as list as in Annex 10. The knowledge and skills gaps are primarily caused by ineffective human resources development (HRD) system, including insufficient professional training. The professional and intensive training on the surveillance and EWS has been held on regular basis and less than once a year. Although vaccination is taught in higher education and practiced in DLF, but is only a part of the surveillance and EWS. Furthermore, there is no effective HRD system including HRD plan, staff knowledge and performance management, capacity need assessment and evaluation system of DMH in the livestock and fishery sector.

Insufficient human resources have undermined development and sustainability of the surveillance and EWS as demonstrated by underdevelopment and underperformance of the system. In addition, it also impedes development of legal framework, information and access to finance for development of the surveillance and EWS.

2. Insufficient information

Data and information about disease, the surveillance and EWS technologies including best practices and financial and economic feasibility, response capacity of local communities is shortage to plan, develop and operate a surveillance and EWS effectively. Although, 19 animal diseases including common ones such as foot-to-mouth disease (FTM) of buffaloes and cattle; fever, chronic diarrhoea and parasite of swine; bid flu, Fowl Cholera and Fox of poultries were recorded of its occurrence in Laos (DLF NAHC, 2001; ADB, 2002; OIE, 2011), but details information about characteristics of its outbreak, causes and factors, best practices for prevention and control have not been intensively studies and made available. A vaccination is perceived to be economic viable, but financial and economic feasibility of specific region, livestock and programme for expansion have not been comprehensively studies. Similarly, despite knowing that the local people have limited capacity to execute the emergency response, but to what extent and what capacity needs are have not been little known.

With the information gap, it has been hard for planning and operating the surveillance and EWS effectively and timely. Moreover, it is not easy to plan and develop financeable project to seek for funding.

The lack of information largely resulted from the lack of research, which affected by human, financial constraints and weak coordination. Financially, budget required for the research could possibly be US$ 70,000 per year, while public budget for the research has not met the needs. Although the higher

education has great potential to contribute to research and development, but it has not been optimised because of, apart from budget, the lack of coordination, for example, DLF and faculty of agriculture, NUOL and NAFRI.

3. Low awareness

Low awareness is expressed in various forms including under reporting the infected animal. For example, the animal loss due to FMD (Nampaya et al., 2015). In addition, selling and consuming infected meats, which is often reported every year, demonstrated that consciousness about disease exists. However, this happens because of not only low awareness, some infected animal may not show symptoms and hard to diagnose correctly.

This low awareness and practices are disastrous as it is hard to control. The root cause of low awareness is mainly because of insufficient decimation of information about disease, health and financial risks and impacts. In addition, education which is relatively low in rural area may be another factor involving with low awareness.

4. Inadequate reference projects and best practices

Reference projects and best practices on how to develop and operate an effective surveillance and EWS is not well-defined and sufficient. It is questionable what best methods are and how to effectively and efficiently organise and arrange the technical team, detect and report diseases outbreak, plan and implement emergency plan to cope with disease epidemics.

The lack of R&D including budget and skills are the main constraints for the development of reference projects and best practices. Although R&D plan and financial needs have not been clearly identified. It was estimated that, financially, at least US$ 1.2 million is required for piloting a surveillance and EWS including studies and employing the best practices, but the budget has not been secured. The skills and experiences to define and apply best practices are also limited. In addition, staff of especially DLF have relevant skills as outlined in Annex 10.

5. Geographical, settlement difficulties and inadequate basic infrastructure

Since more than 70% population of Laos live in rural area and large proportion of the farmers settle near rivers and in cluster of villages but far from one another. As mentioned, quite large proportion of population are not accessible to road. This is not only challenge to adequately access and receive vaccination, warning and assistance in the event of disasters.

Despite the government promotes sustainable resettlement and implement a policy to transform small and sparse villages to larger group of villages and small town in rural areas in order to increase provision and access to public services more effective, it is ineffective. The programmes encountered financial shortage. It also lacks comprehensive studies on feasibility of the programmes and best practices on resettlement. On the other hand, land for agriculture, especially fertile one is scarce elsewhere. In addition, many farmers have strong attachment and tend to prefer to live in their villages where they have located.

6. Free range grazing

The majority of livestock systems, not only cattle and goat but swine and poultries are kept free-range, and many are without fence and pen. This livestock system poses challenges to fully and effectively vaccination and disease epidemics surveillance. It is hardly possible to get all animals vaccinated and or time consuming and costly. Keeping vaccines effectively in long time in rural areas to complete vaccination is problematic since facilities and equipment to keep vaccines are lacking. In addition, monitoring and response to disease outbreak is also difficult because of disease can be spread rapidly and inadequate veterinary staff and facilities to cope with the disease outbreak. Likewise, it is hard to save the free-range animals from death resulted from extreme weather and floods.

This livestock system persists because it is inexpensive including requires lessor labour. Enforcement of law and regulation on the management of livestock and vaccination is challenge due to number of reasons including incomplete livestock land use planning and allocation. In addition, many small livestock holders are under poverty line and have not had adequate financial resources to cover vaccination, while public extension is limited due to financial and human resources constraints.

4.2.3 Identified measures

4.2.3.1 Financial and economic measures

1. Secure adequate financial resources and investment

Securing enough financial resources is fundamental measures to ensure effective and sustainable disease outbreak prevention and control. Importantly, investing in vaccination and surveillance deems financial and economic feasible, implied by the BCA analysis of Foot-to-Mouth (FMD) vaccination programme which potentially gains a return of USD 5.3 in benefits of every dollar invested (Nampanya et al., 2015) and net benefits of biannual FMD vaccination programme could be USD 22 and USD 33 for cattle and buffalo, respectively (Nampanya et al., 2013b).

To increase financial security, the public sector shall increase financial resources mobilisation and investment in funding livestock disease epidemics recovery, surveillance and response including research and laboratory facilities, human resources and veterinary services. Secondly, it needs to increase capacity and facilitate livestock holders to access to finance and insurance, by working with financial and insurance institutes to establish a mechanism to address livestock production and business loss and damage related to disease and climate risk. Actors in livestock value chain, especially livestock production and business group shall have a financial mechanism including establish and raising fund to cope with risks of livestock husbandry including disease outbreak and climate induced risks. Furthermore, it also needs to revisit feasibility studies of different livestock systems and implement non-financial measures described in the following section and 4.3.2.2.

2. Reduce investment cost on the livestock disease epidemics surveillance and EWS

Reduction or alleviation of the investment cost is necessary. The cost can be reduced or alleviated by following options:

1. Reduction or exemption of tax for importing the livestock disease surveillance and EWS. This measure would have a direct impact on the cost. However, studies about the effect or trade-off of the firs measure should be conducted so that best options can be selected.

2. Sharing investment cost between the public and private sector including farmers, and cross-border animal disease surveillance programme. Part of the cost could possibly be reduced through joint implementation and synergy of EWS activities. In addition, shifting or transferring cost could also alleviate the investment cost.

3. Implementation of a cooperation programme to access to lower or grant on the livestock disease surveillance and EWS technologies and vaccines. This is meaningful and would substantial reduce financial burden of the Lao government and livestock holders. However, improvement of cooperation and networking is needed to be enhanced.

3. Improve financial markets and capacity to access to finance

To create favourable financial markets and access, the financial and banking sector growth and competition is needed to be enhanced This means, apart from adjusting depositing mechanism, the domestic financial and banking institutes may need to increase cooperation with regional financial to access to lower rate of loan. Hence, the interest rate of loan and procedure for livestock business could be reduced and simplified. At the same time, the financial capacity of the livestock business owners and producers shall be developed to be able access to finance.

Implementation of this measure as well as increase access to finance would strengthen financial capacity of the livestock business owners and keepers to manage livestock business better including better access to vaccines and carry out disease prevention and control activities.

4.2.3.2 Non-financial and economic measures

1. Increase human resources

Human resources, especially number of the veterinarian staff and skills of the key public organisations and livestock holders listed in Annex 10 are needed to be enhanced by implementation of capacity building improvement programmes including short and long-term, internal and external assisted trainings. In addition, to be more effective and sustainable, following HRD system along with leadership and commitment for capacity building shall be improved.

1) Staff profile, capacity needs assessment and human resource and capacity development plan;
2) Develop and implement short term practical training modules and improve curriculum on livestock surveillance and EWS in higher education, especially faculty of agriculture of NUOL;
3) Increase access to financial support for capacity building,
4) Promote livestock disease expert group or think-tank including information and learning exchanges;
5) Enhance M&E of capacity building and update human resource and capacity development plan and recruitment accordingly;
6) Strengthen leadership, initiatives and commitment on capacity building including self-learning and inhouse on the job-train.

2. Upscaling livestock disease epidemics surveillance and climate early warning system

Piloting and demonstrating a showcase EWS at the communities at risk of disasters is a priority measure in order to establish a model for learning and replication. Best available and affordable technologies and suitable sites shall be studies and selected. In addition, best practices will be employed in the piloting. In any case, budget shall be secured, and skills and R&D shall be performed to support the development and extension.

3. Improve research and development for development information, reference projects and best practices

Research and development (R&D) shall be promoted to 1) improve information and 2) support development of best practices and reference projects. The information to be improved include: 1) animal disease including characteristics and patterns of epidemics, 2) risks and impacts including financial and economic loss and damage, 3) technologies or equipment for the surveillance and EWS, 4) financial needs, financial and economic return on investment including cost and benefits of the surveillance and EWS, (4) financing mechanism and insurance.

To achieve this, it requires an establishment of multi-disciplinary expert team with sufficient trainings and skills, and budget. In addition, research plan on disease surveillance and EWS shall be developed as apart from strategy or single plan to provide long term research targets and directions. EWS research think-thank and exchange platform are also needed to promote.

4. Increase awareness on livestock disease and the surveillance and EWS

Awareness of especially livestock holders on the risks, impact of disease, advantage and how the surveillance work, and roles of the livestock holders to play to prevent and control disease epidemics shall be increased by implementation of awareness raising and training programmes. Participation of the livestock holders in the programme and implementation of the surveillance and EWS shall be also promoted.

Effective implementation of the campaign and EWS programme could potentially increase awareness, change behaviour and contribution of the livestock holders to prevent and control livestock disease. However, best practices on the awareness raising and mobilisation of local people shall be studies and employed in the implementation of the awareness programme.

5. Improve basic infrastructure

Basic infrastructure such roads, telecommunication etc. shall be developed to increase access to all communities. Agriculture and Forestry (MAF) needs to work with Ministry of Public Work and Transport (MPWT), Post and Telecommunication (MPT) to implement infrastructure development plans.

To be more effective, disaster steering committee is needed to be activated and policies on DRR-oriented planning and development, integrated planning and development and land use planning for flooded land shall be developed to guide and be reference for the development of the EWS.

6. Reduce free range and promote livestock farming systems

Reduce free-range and increase a standard livestock farming system including keeping livestock fenced is necessary for the disease prevention and control. In addition, it needs to enhance organisation of livestock production group to, apart from oversee livestock production and commercialisation, coordinate and report disease outbreak. Fulfilling this, the government may need to provide extension develop livestock feed. In addition, the government needs to implementation of integrated rural town plans to unit communities and form a small town so that it is easier to develop and increase public service access including livestock disease surveillance and EWS.

4.3 Barrier analysis and enabling measures on the agricultural development subsidy mechanism

4.3.1 General description of the agricultural subsidy mechanism

Agricultural subsidy is a financial mechanism that the government provides specific financial support for farmers and entrepreneurs, in this context, to reduce risks and enhance resilience of production to hazards (storms, floods, landslide, drought etc.), climate and market variability.

The agriculture subsidy mechanism is public provide technology. Lao government has recognised the vulnerability of agriculture sector and the needs to have such mechanism in place to assure agriculture production and industries. The law on agriculture, for example, calls for establishment of the agricultural promotion fund, but it has not been established. The government set up the government emergency fund[15] for coping with emergency issues including disasters. The fund, however, can not expand much and allocate adequate budget for disaster loss and damage reduction. This report explored why the agricultural subsidies and the government emergency fund could not be effectively developed and expanded.

4.3.2 Identification of barriers of agricultural subsidy

Barriers to agriculture subsidies, as discussed in Chapter 2, are compiled, screened, decomposed and then analysed of the subsidy problems, by literature review, key information interviews, decomposition matrix, logical problem tree analysis, scoring and stakeholder consultations. As a result, a list comprising 10 barriers was derived (Annex 7), and after screening and revising of the long-listed barriers, investigation of its elements and dimensions by decomposition (Annex 8) and analysis of the key problem using logical problem tree (Annex 9); it found that there are only 8 barriers were finally

[15] The total government emergency fund is usually 100 million LAK (US$ 12.5 million) per year, and it is used for all emergency issues, not only for disaster recovery.

considered as important obstacles to development and deployment of agriculture subsidy. Of which, there are 5 critical barriers, which were scored 3. Two of them are financial and economic and three are non-financial and economic barriers (Table 8). Details of the essential barriers were discussed in subsection 4.3.2.1 and 4.3.2.2.

Table 8 Barriers to agriculture subsidy mechanism

Barriers to agriculture subsidy mechanism	Score	Category
1. Inadequate budget for development of the agricultural development fund and subsidy	3	Financial and economic
2. Insufficient legal framework on agricultural development fund and subsidy	3	Legal framework
3. Unclear specific department and responsibility for development and management of agricultural fund and subsidy	3	Organisation
4. Inadequate knowledge and skills on the development and management of agricultural development fund and subsidy	3	Skills/Technical
5. Insufficient information on feasibility study including risks of climate change and disaster agriculture production, cost-benefits, trade-offs, impacts and sustainability of the agricultural subsidy, optimal subsidy mechanism or models	3	Skills/Information and awareness
6. Small and variable agricultural production and market	2	Market/Others
7. Incomprehensive agriculture association/think-tank for advocacy and support agriculture development including subsidy mechanism	2	Organisation/Network
8. Small, scattered and ineffective organised production groups	2	Organisation/Others
Remark: *Score 3 = significant; 2 = moderate; 1 = least significant barrier*		

4.3.2.1 Financial and economic barriers

1. Limited financial resources for subsidy

National budget shortfall is a key barrier for government to set up the agricultural development fund for subsidies. Despite aware of disasters brought about economic loss and damage of about hundred million US dollar, the government can only spare public emergency budget of about US$ 12.5 per year because of budget constraint. In addition, it is not definable how much could be allocated for agricultural subsidies.

The national budget shortage was, as mentioned earlier, unmet the financial needs due to weak income generation and management of expenditure.

2. Unclear financial and economic mechanism for subsidy

Though agricultural subsidy is needed, without a clear and convincing mechanism, it is hard to either secure financial resources for subsidy. Currently there is no financial and economic mechanism, and it is unclear what kinds of financial and economic mechanism are appropriate, how they work and effective they would be. This problem is mainly stemmed from financial and technical skills limitation.

Financially, Department of Agriculture (DoA), NAFRI and other governmental organisations have limited budget to fully implement their mandates, especially research. Normally, annual budget of DoA and NAFRI derived from public budget investment was less 0.3 million, and budget for research on this issue was not secured. In addition, foreign financial support on this area is limited. Technical skills of (DoA), NAFRI and other governmental organisations[16] on subsidy, on the other hand, are rather limited. Staff who have background and specialises on agricultural subsidy are almost none, resulting from the agricultural subsidy has not been mainstreamed in the higher education, while training and exchanges were also limited.

4.3.2.2 Non-financial and economic barriers

1. Incomplete policy on the agricultural promotion fund and subsidy

The current law on agriculture defines the development of agriculture promotion fund, but it has not been translated into specific decree or policy which define principles, procedures and guidance on how to develop, and public organisations to be in charge of the agricultural development subsidy, especially in term of disaster and climate variability risk and effects. So, it is difficult and unclear how to develop and manage such subsidy mechanism.

Incomplete policy is critical for the establishment and effectiveness of the subsidy. However, development of such policy remained challenge for Laos, especially Ministry of Agriculture and Forestry (MAF) who has limited financial and technical skills, and has to rely on external support in order to formulate appropriate and effective subsidy mechanism. The absence of the policy is because of financial and know-how which its root causes was discussed in the section 4.3.3.1 and the following section, respectively.

2. Insufficient technical knowledge and skills about agricultural subsidy

It is apparent that knowledge and skills of key stakeholders[17] on the agricultural subsidy is limited, and it is a main barrier to deploy and manage the subsidy mechanism. Knowledge and skills gaps of the key stakeholder appear on several elements and aspects of subsidy development and management, and the important ones could be summarized in the Table 20 as follow.

Deficit of skills on subsidy has been problematic since human resources development system including high education and staff skills building have been inadequate and practical. Agriculture subsidy study and research has not been mainstreamed in curriculum and research in the faculty of agriculture, forestry, economics, and agriculture and forestry research institute. In addition, key stakeholders' staff have not had adequate training in this area.

[16] Including the Economic Research Institute (ERI) of Ministry of Planning and Investment (MPI), Faculty of Economics (FoE) of National University of Laos (NUoL)

[17] Agriculture, Cooperatives and Extension, Agriculture and Forestry Research; Business Promotion; Committee for Rural Development and Poverty Reduction; Chamber of Commerce and Industry; Planning and Investment Sector at National and Local levels.

3. Insufficient and inaccurate information on the disaster risk, loss and damage

Data and information on disaster risk, loss and damage are rather insufficient for good planning and management of subsidy. Laos has a record of disaster induced losses from time to time since 1966, but there are not systematic and consistent methods to estimate direct and indirect loss and damage from disasters. In addition, risk including scale and characteristics of risks are not well documented. This is another challenge to design appropriate financing mechanism and amount of fund for disaster risk management and recovery. This data deficiency issue caused by limited financial and technical skills for research as described above.

4.3.3 Identified measures for agricultural subsidy

4.3.3.1 Financial and economic measures

1. Secure financial resources for subsidizing agricultural development

Securing adequate financial resources for subsidy is ultimate goal for agriculture sector. The important measures to achieve the goals are: 1) formulation of the decree on agricultural development fund including specific policy on subsidies, 2) study financial needs for subsidies, feasibility including cost-benefit, and impact of subsidy, 3) research and develop of effective subsidizing models or mechanism, 4) study financial sources and improve access to finance and resources mobilisation, and 5) strengthen organisational capacity for management of the subsidy system.

These measures are believed to have significant and direct effects on the development and secure financial resources for subsidies. The first measure would allow establishment of the subsidy legally and relevant. 2nd one should help convincing and committing financial resources for subsidies, and 3rd measure should help stakeholders on how to deploy and manage subsidy efficiently and effectively. The 4th measure should lead to increase financial resources for subsidies and the 5th measure should enhance effectiveness and transparency of the implementation of the subsidy mechanism. However, effective financing and implementation of subsidies is critical since national budget, and technical and financial capacity of the relevant organisations is limited. This means it would be hard operated or effective without external technical and financial support.

2. Research and develop financial and economic mechanism and policy for subsidy

Research and development is primary measure to reveal and push optimal subsidies including financial and economic mechanism. The R&D can be conducted by relevant organisations, especially join research of Department of Agriculture, Cooperatives and Extension, NAFRI of MAF; Economic Research Institute of MPI; Faculty of Agriculture and Economics of NUOL. However, based on current technical and financial capacity of the relevant organisations, it still needs external technical and financial support in order to produce comprehensive information and optimal subsidy mechanism.

Having adequate information and smart subsidy in place should be able to convince and inspire public and private investment in subsidies. However, despite good mechanism and information, it is prerequisite, and subsidies might not be operational or effectively implemented in the case of budget,

policy to enable the process, clear responsibility amongst relevant organisations and their technical skills on the development and management are not ensured. So, these factors should be created and inductive.

4.3.3.2 Non-financial and economic measures

1. Develop policy on the agricultural development subsidy mechanism

Having policy or decrees on the development of agricultural development fund and subsidy is prerequisite for development the subsidy mechanism. Once the policy in place, it, in principle, has significantly impact on the development of subsidies since it mandates and enforces concerned organisations to take actions. However, based on previous law implementation and enforcement, despite mandates of relevant organisations were stipulated in the law, it did not totally mean all the mandates were fully and effectively implemented. For example, agriculture promotion fund was defined in the agriculture law (1998), but it has not been established. So, again it depends on leadership, financial resources availability and know-how.

Development of subsidies shall be supported by researches and policy dialogues on the best practices and effects that subsidies may cause, cost and benefits. However, based on the current technical skills of the relevant organisations, policies can be formulated may need technical and financial supports from development partners and international organisations in order to accelerate and be more effective.

2. Enhance technical knowledge and skills about agricultural subsidy

Enhancement of knowledge and skills of key stakeholders[18] is a must. Overall and specific knowledge and skills outlined in the Table 15 shall be improved, and once stakeholders know how, it should be a key and has great impact on initiation including development policy and seeking financial support for operation of subsidies. In any case, know-how might not be a panacea, it needs leadership, financial resources availability and policy to support as well.

Technical skills development shall be designed for short and long-term. In short-term, practical training including on the job train shall be conducted. In long run, study on subsidy shall be mainstreamed in higher education and research in domestic education and research institutes and abroad. In addition, human resources and capacity development plan and knowledge management system of relevant bodies shall be developed to ensure effectiveness and sustainability.

The technical skills development has, however, remained a challenge for Laos and it is about certain to count on external support since there is not enough local experts in the areas of agricultural subsidies.

3. Research and develop information and database on the agriculture production, risk profile and subsidies

[18] Agriculture, Cooperatives and Extension, Agriculture and Forestry Research; Business Promotion; Committee for Rural Development and Poverty Reduction; Chamber of Commerce and Industry; Planning and Investment Sector at National and Local levels.

Data and information on agriculture production, climate and disaster risk, financial and economic and best practices on subsidies are required to developed and availability of the data should make planning and operation of subsidy mechanisms easier and more effective. R&D on such data and information, however, requires more research and financial investment in both research and capacity building. So, accomplishment this measure also require external technical and financial support.

4. Piloting subsidies

Piloting is critical measure that determines expansion of subsidies and learning process to design more proper subsidy mechanism, financing and management. The areas and products to be pilot subsidy and insurance may include dry season cash crop including cost on irrigation and electricity, organic farm production and prices, and vaccination of livestock. However, to pilot the invention, research on best practice, impact and cost-benefits of subsidies shall be proceeded to provide information and lessons for good design of subsidy schemes. In addition, products and elements to be subsidised should be also revisited so that select an appropriate one for subsidy and piloting.

Piloting calls for substantial financial investment, and based on public budget availability, it is necessary to seek for more financial support and resources mobilisation, which requires external support.

4.4 Barrier analysis and possible enabling measures for crop diversification

4.4.1 General description of crop diversification

Crop diversification refers to development and introduction of crops verities and production systems in a farming system so that it enhances, apart from value-added agriculture system and conservation of plant diversity, resilience to climate variability, hazards including pest and disease outbreak.

Crop diversification is considered as a non-market technology or publicly provided goods. However, the public sector mainly performs extension role including R&D, while the private sector including farmers have prominent role to apply and expand the technology for achieving production target including adaptive to changing climate. Crop diversification in Laos is mainly in the form of integrated and rotation farming systems, agroforestry, home garden. Currently introduction of new crop varieties such as flood and drought resistant rice verities are also practised. However, in overall, crop diversification is not effectively developed and extended. Barriers that have been constrained the deployment and diffusion of the crop diversification were analysed and discussed in the following sections.

4.4.2 Identification of barriers for crop diversification

The identification of the barriers to crop diversification follows barrier analysis process as discussed in Chapter 2. Barriers were firstly compiled, screened, decomposed and then analysed of root causes of key barriers and problems, by literature review, key information interviews, information analysis and stakeholder consultations. As a result, a list comprising 14 barriers were created (Annex 3), and after barrier decomposition (Annex 4) and analysis of the key problem using logical problem tree (Annex 5)

and screening by voting and revising; the barriers reduced from 14 to 12 as there are some similar and related barriers which can be grouped and revised, while some were not underlying barriers. Finally, prioritisation of the barriers was carried out by scoring, where, 3 is important barriers, 2 is moderate and 1 is least important barriers. Of which, there are 6 critical barriers, which were scored 3. Three of them are financial and economic and three are non-financial and economic barriers (Table 10). Details of the essential barriers were discussed in subsection 4.4.2.1 and 4.4.2.2.2.

Table 9 Barriers to crop diversification

Barriers to crop diversification	Score	Category
1. Inadequate information on optimal crop diversification for climate change adaptation and disaster resilience including cost-benefits and return on investment	3	Skills/Information/ Financial and economic
2. Inadequate knowledge and skills on crop diversification development and extension	3	Capacity/Skills
3. Limited budget and financial support from government on the promotion/extension	3	Financial and economic
4. Inadequate reference projects/models	3	Technical/Skills/Financial and economic
5. Low awareness on crop diversification	3	Information and awareness
6. Market failure and imperfection	2	Market
7. Incomplete or incomprehensive strategy and plan on crop diversification	2	Organisation/Skills/ Financial and economic
8. Limited capital and access to finance of private sector and small holder to apply crop diversification	3	Financial and economic
9. High investment on crop diversification (introduction of new varieties and systems)	2	Financial and economic
10. Ineffective network and coordination amongst stakeholders including experts	1	Organisation/Network
11. Inadequate civil organisations and expert group to advocate and support crop diversification development and deployment including exchanges knowledge and information	2	Organisation/Network
12. It is difficult, time consuming and/or costly to define the optimal crop diversification system in term of socioeconomic benefits and adaptation effectiveness	2	Others
Remark: *Score 3 = significant; 2 = moderate; 1 = least significant barrier*		

4.4.2.1 Financial and economic barriers

1. Limited public budget and investment in crop diversification extension

Public investment budget is limited, and this is the major constraint for crop diversification development. Annual public investment in the last 5 years, for instance, was only about US$ 65,000 which was less than 10% of what was needed. Meanwhile, financial support on crop diversification from development partners and international organisations remained limited and estimated to be less than US$ 100,000 per year and variable. Resources mobilisation has not had significant increase

financial resources for crop diversification. The National Adaptation Programme of Action (NAPA) 2009 aimed for access to financial support of about US$ 7.7 million for first 10 years of R&D and extension, but it has been realised. As a result, financial resources have been shortfall and inadequate for crop diversification development especially 1) R&D including assessment and identification of vulnerability and optimal crop diversification systems for climate change adaptation and livelihood improvement, 2) policy and incentives, 3) guidelines including best practices and 4) capacity building and awareness raising and 5) piloting and demonstration and 6) promotion and marketing.

The shortage of public investment in crop diversification is mainly because of national budget deficit and the deficit of about 4-5% of the GDP per year has been for a decade (MPI, 2011; 2015). Ineffective, imbalanced budgeting or lowering priority of crop diversification was also mattered. Allocation of public investment largely went to infrastructure, economic and other sector, and little budget was left for environmental and climate change including deployment of crop diversification for adaptation. Between 2011 and 2015, for example, about 2/3 of the investment in agriculture sector (US$ 2.16 billion) was spent for irrigation and road construction, and only 1/6 went for hiring experts and 1/6 for HRD, R&D and extension (DoA, 2015).

The limited and variable financial support from development partners and international could possibly resulted from internal and external factors. Internally, it is matter of low capacity, especially technical skills to financial resources. For example, access to finance for implementation of crop diversification under NAPA; either DDMCC of MoNRE or DoA of MAF have not had sufficient technical skills and did not know how to coordinate with potential partners and develop financeable proposal to access to the Adaptation and other environmental and climate related funds for implementation of the invention. Externally, pledge of the funds and mobilisation and access to financial resources of development apartments were variable and complicated.

Furthermore, limited access to finance and resource mobilisation remained a challenge since, key organisations[19], apart from limited technical skills, have not have resource mobilisation strategy and plan, adequate information about financial sources and accessibility, clear responsibilities and effective M&E for access to finance and resources mobilisation.

2. Limited financial and economic incentives on crop diversification

Financial and economic incentives, especially subsidy and tax reduction are neither clear nor committed. This is also a key barrier constraining development and expansion of crop biodiversity. The main incentives required but they are not addressed are:

1) Tax reduction, exemption or holiday for importing of equipment and inputs for production and business regarding to crop diversification,
2) Policy to promote and facilitate accessing to finance, fund, network and R&D for environmentally and ecologically practices including crop diversification.

The inexistence of those incentives was, as national revenue is concerned, due to inadequate information and mechanism for policy makers, especially information on financial and economic returns, impacts,

[19] DDMCC and EPF of MoNRE, DoA, DoCE and NAFRI of MAF

cost and benefits, and effective execution of the incentives. On the other hand, it is because of limited technical skills and financial support for R&D on the incentives.

3. Limited capital and access to finance for expansion of crop diversification

Majority of producers and entrepreneurs are small and medium with limited financial capital. Several of them even have not had enough financial resources to explore optimal production techniques and systems and invest in inputs for improvement of existing production systems. Access to finance, in the meantime, is challenged. Interest rates and requirements for borrowing of loans provided by domestic financiers are high and complicated. The producers and entrepreneurs themselves have not had concrete financial management system and capacity qualified for access to finance, especially development of bankable proposal and collateral for guarantee. In addition, financial risk management and guarantee mechanism to be introduced by government or financial institutes to address this issue have not in place. As a result, these prevent optimisation of crop diversification for income generation, adaptation and expansion.

1.4.2.2 Non-financial and economic barriers

1. Inadequate information and guidelines on optimal crop diversification systems

The information and guidelines to develop and promote robust and optimal crop diversification for climate change adaptation is inadequate. The missing information and guidelines are:1) vulnerability and resilience of existing crop varieties and production systems to changing climate and hydro-met disasters, 2) crop diversifications that suitable for different agro-ecology zones, including feasibility (financial and economic including cost and benefit, technical, farmers' choice), and 3) reference project including best practice guidelines. Without the information, it is difficult to ensure effectiveness and relevance of crop diversification development and extension for adaptation (Vernooy, 2015).

The limitation of the data and information are related with limited research including skills and budget. Primary research such as redefining and review of crop diversification practice in Laos, reference project including best practices in the country and region is incomplete. Research on vulnerability and resilience of existing crop varieties and production systems, and optimal crop diversifications for climate adaptation and hydro-met disasters resilience is very scant.
Limitation of knowledge and skills on crop diversification is undoubted since it has not been introduced in high education system; training and capacity building in relevant organisations, particularly department of agriculture (DoA) and national agriculture and forestry research institute (NAFRI) were insufficient, systemised and standardised.

Budget for research is obviously in shortage. At least, US$ 0.20 million per year is required for R&D including capacity building, while public investment in research activities of DoA and NAFRI is about US$ 50,000 per year, on average. The main causes of the budget shortage have been discussed in the early section. In addition, revenue from commercial research and reinvestment on research in Laos are not available or limited.

2. Limited knowledge and skills on crop diversification

Knowledge and skills of the key relevant organisations[20] especially to study, identify and promote suitable crop diversification systems that generate optimal socioeconomic and environmental benefits including adaptation is insufficient. Important knowledge and skill gaps are summaries in the Table 22, and these, in general, impede or caused under performance of crop diversification.

These knowledge and skill gaps derived from ineffective HRD system including learning and teaching in high education and capacity building system in the key organisations. Education and research institutes such as FoA and FoF of NUol and NAFRI have not had sufficient experts, practical curriculum, teaching and research materials and facilities, R&D and training on crop diversification. In addition, it lacks information on capacity needs for crop diversification.

DoA and NAFRI have not had effective HRD system, especially HR and capacity development plan, staff knowledge and skills mapping and management, effective recruitment, on the job train and sharing information about training and learning opportunity. Importantly, they are facing budget shortage for capacity building. Annual budget deficit for strengthening their capacity was, at least, US$ 0.15 million per year for 2011-2015, while actual budget available budget secured from public and development partners for capacity building was less than US$ 50,000 per year on average.

3. Unavailable strategy and plans for development and extension of crop diversification

Strategy and plan for development and extension of crop diversification is not clearly specified in the strategy on agriculture development to the year 2025 or forestry to the year 2020. It is not explicit what type of crop diversification systems should be adopted and promoted, or what crop variety or new species to be introduced, integrated or rotated in existing farming systems in order to enhance its adaptive capacity or resilience to climate change and disasters including its induced pest and disease. Furthermore, where to promote crop diversification or for who, when, how much and how to mobilise resources for effective intervention are not clearly identified.

The absence of the plan undoubtedly limited development of crop diversification, especially action and effectiveness of resources mobilisation and allocation for development and promotion of crop diversification. Lack of research and information, capacity, financial support and integrated land plan including land suitability maps are major constraints for the development of crop diversification development plan. The limitation of research and information, capacity and budget were as explained above, and policy issue is discussed in the following sections.

4. Existence of best practice guidelines and reference project on optimal on crop diversification

Best practice guidelines (BPG) and reference project on optimal crop diversification systems that generate high and balance socioeconomic and environmental benefits including mitigation are neither available nor defined. BPG and reference project that provide: (1) good models or examples of crop diversification systems as well as appropriate combination between trees and crops, and systems that

[20] DoA, NAFRI, DoAFE of MAF; DDMCC and NRERI of MoNRE; Faculty of Agriculture, Forestry, Eonomics of NUOL

yield maximum benefits, (2) practical guidelines and examples on how to establish, arrange inputs and finance, implement, monitor and evaluate the outcome and impacts are not available. Several crop diversifications including home gardens, agroforestry, integration cropping systems are common in Laos, but R&D including capacity to review or assess and defines optimal systems is limited. The absence of BPG and reference project is also associated with insufficient research budget.

4.4.3 Identified measures for promotion of crop diversification

4.4.3.1 Financial and economic measures

1. Secure financial support and investment for crop diversification extension

Securing financial resources and investment on crop diversification is a key objective. In which, key measure to ensure financial and investment are: (1) enhancing effectiveness of resources mobilisation, (2) increase effectiveness and efficiency of financial resources allocation and management.

To access to financial supports and resources mobilisation in effective manner; financial and investment need assessment, analysis of cost and benefit of the investment, sources of funds, resource mobilisation plan and financeable proposal shall be conducted. In addition, it also needs to survey and develop crop diversification development plan to support financial and resource mobilisation planning and implementation.

An effective financial resource management system will be developed to increase effectiveness of financial aids and public investment management. This, in general, ensures effectiveness of the public investment law, especially (1) public investment budget allocation, (2) financial support and investment record, tracking and reporting system, and (3) dialogue or platform for reflecting and planning to improve financial management effectiveness. Capacity building is needed to enable implementation of the financing and investment management measures. More details on planning, capacity and law enforcement etc. were discussed in the non-financial measures section below.

2. Research and introduce incentives for promotion of crop diversification

Study and identify suitable financial and economic incentives and mechanism for shall be conducted with involvement of all key stakeholders, especially MAF, MIC, Ministry of Planning and Investment (MPI), Finance (MoF) and PMO who ultimately make a decides on this issue. Importantly, the mechanism is needed to be enforced effectively. Therefore, it is important to also strengthen capacity on the implementation or enforcement of the incentive measures and mechanism.

2. Enhance finance access for farmers and entrepreneurs

To ensure access to finance, three main barriers should be addressed.

1) Capacity of the producers and entrepreneurs on financial management system of enterprises and preparation of financeable proposal including feasibility study, financial-economic analysis of the business;

2) Study and develop policy and mechanism to facilitate and guarantee for access to finance and risk management;
3) Improve effectiveness, efficiency and transparency of financial management including M&E, feedback scheme and database.

4.4.3.2 Non-financial and economic measures

1. Develop information and guidelines on optimal crop diversification systems

These include development of information on: 1) vulnerability and resilience of existing crop varieties and production systems to changing climate and disasters, 2) crop diversification systems that suitable for different agro-ecology zones, 3) financial and economic including cost and benefit, 3) market and 4) technical guidelines on the production. Realising these require more financial investment as discussed above and human resources as discussed in the following section.

2. Improve knowledge and skills on crop diversification

Knowledge and skills of the key relevant organisations[21] to be improved are as outlined in the Table 16. Furthermore, especially in long term, HRD system including high education and human resources development system of key organisations must be upgraded. It is important that HR and capacity development plan, staff knowledge management, effective recruitment and internal organisational learning mechanism are necessary to put in place and implemented effectively. Despite some of those capacities building activities can be done with lessor cost through self-learning; in overall, it is inevitable to seek for additional financial support from development partners.

3. Develop strategy and plans for development and extension of crop diversification

With existing capacity, the strategy and action plan for development and extension of crop diversification is developable. However, to be more comprehensive and practical, it calls for data, capacity and financially ready.

4. Research and develop best practice guidelines and reference project on optimal on crop diversification

Development of reference project and best practice guidelines is needed to convince and simulate replication and expansion of crop versification. Development of model project and practice are however required assessment of the existing project and practices including its successful and failure, and then designing model project appropriately. In addition, it also needs to choose appropriate project, practices and target groups for promotion and communication.
The best practice guidelines are also to be developed to guide the reference project formulation, implementation, and M&E. The guidelines shall be practical and user friendly. In addition, it should be an update to keep its relevance to different local contexts.

[21] DoA, NAFRI, DoAFE of MAF; DDMCC and NRERI of MoNRE; Faculty of Agriculture, Forestry, Economics of NUOL

4.5 Barrier analysis and enabling measures for climate resilient rural infrastructure

4.5.1 General description of climate resilient rural infrastructure

Rural infrastructure such as irrigations, warehouses and yards, erosion protection facilities, in-door cropping facilities, warning systems, roads and logistics system are crucial for boosting production including climate adaptation and disaster resilience, especially the ones that meet technical including engineering standards, incorporates climate and disaster resilient technologies in the development. This report focussed on irrigation, which is important facilities, amongst others.

Irrigation is publicly provided goods. However, currently, there is not adequate irrigation systems for sustaining agricultural production and commercialisation. Furthermore, number of existing facilities are low resilient to disaster since they had not been deployed and mainstreamed climate resilient technologies and practices in the planning and development. In 2011, for example, a damage and loss to irrigation including irrigation canals, weir, canal intake and gates in the value of US$ 7.9 million (18% of total economic loss) as a result of the Typhoon Haima (Lao PDR, 2011) indicated that irrigation schemes are vulnerable to floods and landslide.

4.5.2 Identification of barriers for climate resilient rural infrastructure

The barriers that prevent rural infrastructure to be fully and effective developed and resilient to floods and landslide disasters were explored by firstly compiling barriers from literature, key information interviews and consultations with technical working group on climate change (Annex 7). Then the barriers before decomposing the barriers using decomposition matrix (Annex 8). Problem analysis using logical problems tree was also performed to examine problem root causes and effects. After that the barriers were screened the obtained barriers by voting to eliminate irrelevant and unimportant and revising. So, only 11 out 14 barriers in Annex 7 are considered as important barriers (Table 14). Finally, the barriers were then prioritized by ranking and scoring, where score 3 means very important, 2 is moderate and 1 is less important barriers during stakeholder consultation meeting in May 2016. In addition, 2nd stakeholder consultation was also organised in March 2017 to validate and agree upon the analysis. As a result, only 8 barriers, which were scored 3 are critical. Three of them are financial and economic and five are non-financial and economic barriers (Table 11). Details of the 8 essential barriers were discussed in subsection 3.2.2.1 and 3.2.2.2.

Table 10 Barriers to the deployment of the climate resilient agriculture infrastructure

Barriers to fully, effectively and sustainably develop climate resilient agriculture infrastructure	Score	Category
1. High investment cost on agricultural resilient infrastructure	3	Financial and economic
2. Inadequate budget and investment from public, development partners and private/farmers	3	Financial and economic
3. Insufficient financial incentives, subsidy and fund for promotion of the agricultural resilient infrastructure	3	Financial and economic

Barriers to fully, effectively and sustainably develop climate resilient agriculture infrastructure	Score	Category
4. Insufficient legal and regulatory framework on promotion of climate resilient technology/infrastructure including mainstreaming and deployment climate resilient agricultural infrastructure	3	Legal framework
5. Ineffective enforcement of regulations and measures on the infrastructure standards	3	Legal framework
6. Limited knowledge and skills on agricultural resilient infrastructure and technologies	3	Skills
7. Inadequate information and awareness on climate variability and risks on agriculture, climate and disaster resilient infrastructure technologies, best practices, financial and economic feasibility	3	Information and awareness
8. Insufficient reference projects/models	3	Skills/Information/ Financial and economic
9. Inadequate comprehensive agricultural resilient infrastructure development plan	2	Organisation
10. Ineffective coordination amongst stakeholders on the planning and development of the agricultural resilient infrastructure	2	Organisation/ network
11. Inadequate R&D and M& agricultural resilient infrastructure	2	Skills/Financial and economic
Remark: *Score 3 = significant; 2 = moderate; 1 = least significant barrier*		

4.5.2.1 Financial and economic barriers

1. Public budget deficit

Public financial investment in irrigation is inadequate in comparison to financial needs. Total public investment in irrigation has been approximately US$ 17 million per year, while actual budget allocable is about 20% only of the needs. The budget required for maintenance of 126 irrigations between 2015 and 2016 about 37.76 billion LAK (US$ 4.55 million), but government approved budget was 20 billion LAK (US$ 2,410 million) (MPI, 2016), and actual disburse in the year was even lower or about half. The budget deficit is mainly because of small national income, which involved with macroeconomy.

Budget for maintenance of the small-scale irrigation schemes which were transferred and managed by producer groups are also problematic. A water use fee is imposed for the irrigation and farmers supposed to pay 150 kg of unmilled rice (or about US$ 38) per ha per season for irrigation maintenance. However, since the produces earned a little from irrigated rice and dry season cash crops, they could not pay for the fee, leading to many irrigations underfinanced and not well-maintained.

2. High investment cost

Investing in irrigation in Laos is normally costly because of disperse production area, geographical difficulties and difficult to access. Operation cost, for example, cost on electricity for electric pump system is relatively high since electric price for irrigation is treated as the same prices as business and manufacture. Some irrigations, especially the ones that are at risk and often damage by floods

encountered very high cost on maintenance or reconstruction. The irrigations including irrigation canals, weir, canal intake and gates that were damaged by Typhoon Haima, for example, required maintenance cost of about 7.2 to 10.9 million per year (Lao PDR, 2011).

However, it was estimated that the development of high quality irrigation including incorporating climate resilient technologies could increase start-up cost of the investment up to 30 to 40%. It may be up to 50% in case of relocation of irrigations to avoid flood is required as irrigation is rather site specific and is costly to re-site.

The high investment cost, in general, results in marginal income and in worse case, it leads to financial and economic unfeasibility, which discourage the investment. It is even harder in case of the budget shortfall and low return on investment project. So, the high cost not only causes difficulty on the decision on investment, but it may bring about failure of funding. Project unfunded although financial resources are ready and project economically feasible.

3. Low financial and economic return on investment

Overall, financial and economic feasibility including return on investment is required for public investment project, while the government may also invest a project that deem necessary and may generate other benefits such as poverty reduction and livelihood subsistence, although it is not financial and economic feasible (LNA, 2009).

Some irrigation project low rate of return on investment. A study of 15 irrigations constructed between 1998 and 2009 under ADB's support, for example, revealed that 2 irrigations had negative internal rate of return on investment (IRR), while 3 of them gained IRR great than 20% and others had IRR of 11.7%, on average (SWG-ARD, 2016).

However, although it is not definable how many irrigation projects were and will be rejected due to the low rate of return, the low financial and economic return would certainly make decision on investment difficult, variable and resulted in failure to finance a project. Hence, it is considered an important risk and obstacle for sustainable financing of irrigation.

4.5.2.2 Non-financial and economic barriers

1. Limited technical knowledge and skills to climate change adaptation and disaster resilient technologies

Insufficient knowledge and skills of relevant organisations[22] on floods, landslide and sedimentation forecast and resilient technologies is critical barrier preventing from development of resilient irrigation and optimise irrigation for adaptation. Without adequate the knowledge and skills, it is difficult to define the extent of risks and what are optimal resilient technologies to be applied for mitigation of the risks.

The knowledge and skills deficiency are largely caused by inadequate and ineffective professional learning at high education and training at work. Forecasting floods, landslide and sedimentation are not

[22] Particularly, Department of Irrigation (DoI), Meteorology and Hydrology (DMH), Disaster Management and Climate Change (DDMCC), Water Resources (DWR).

yet developed and taught in high education. Training on these skills is scanty and lack of standard training course. As a result, several irrigations were damaged and at risk of floods, landslide, and accumulation of sediment.

2. Irrigation siting

Irrigation is feasible at a specific site, otherwise it is costly for re-siting and deployment of high technologies and standards including resilient technologies, which may not financially and technically viable. Most of the previous irrigation, especially barrage and headwork are needed to build across rivers or streams, although they are at risk of floods and landslide.

4.5.3 Identified measures

4.5.3.1 Measures for Financial and economic barriers

1. Secure budget and investment in agriculture infrastructure

Public financial investment in resilient irrigation was inadequate in comparison with financial needs. Total public investment in irrigation was approximately US$ 17 million per year in last five years, which covered only half of the financial needs. Budget required for maintenance of disaster damage ranged from 7.2 to 10.9 million per year or 12.5 to 17.2 million for 2 years (Lao PDR, 2011), and for building new irrigation was about US$ 25 million in last 5 years. This means more than half of the financial needs were shortage.

Budget for maintenance of the agriculture has been shortfall since most of the small-scaled irrigation schemes were transferred and managed including paying by producer groups who earned a little from irrigated rice and dry season cash crops. The maintenance fee collection model which farmers paid 150 kg of rice (app. 38$) per ha could not secure enough money for the maintenance. However, it is critical to increase the fee since farmers' income from the production was low. Public investment focussed on medium to large schemes, but it was often inadequate.

2. Lowering investment cost

Investing in common irrigation is already costly because of geographical difficulties, scatter production area and difficult to access, and high cost on electricity and maintenance. Development of high quality irrigation including incorporating climate resilient technologies and practices could increase start-up cost of the investment up to 30 to 40%, although it is potentially cost efficient in long run. Consequently, high investment cost not only exacerbated budget shortfall, but it also marginalised income or led to financial and economic unfeasible and discouraged the investment.

4.5.3.2 Non-financial and economic barriers

1. Increase technical knowledge and skills to climate change adaptation and disaster resilient technologies

Insufficient knowledge and skills of relevant organisations[23] on floods, landslide and sedimentation forecast and resilient technologies is critical barrier preventing from development of resilient irrigation and optimise irrigation for adaptation. Without adequate the knowledge and skills, it is difficult to define the extent of risks and what are optimal resilient technologies to be applied for mitigation of the risks.

The knowledge and skills deficiency are largely caused by inadequate and ineffective professional learning at high education and training at work. Forecasting floods, landslide and sedimentation are not yet developed and taught in high education. Training on these skills is scanty and lack of standard training course. As a result, several irrigations were damaged and at risk of floods, landslide, and accumulation of sediment.

2. Develop integrated agriculture and water resources including irrigation development plan

Irrigation is feasible at a specific site, otherwise it is costly for re-siting and deployment of high technologies and standards including resilient technologies, which may not financially and technically viable. Most of the previous irrigation, especially barrage and headwork are needed to build across rivers or streams, although they are at risk of floods and landslide.

4.6 Enabling framework for overcoming the barriers in agriculture sector

Enabling framework for addressing those barriers and to effectively implement the measures (Table 11) are unexceptional needed. Some enabling framework already exists such as law on agriculture and livestock etc. In addition, to enable and accelerate the technologies development and deployment; five following frameworks shall be developed and implemented.

1. Policies on promotion of investment and development of environmentally friendly, climate adaptation and disaster resilient technologies,
2. Policies on the integrated socioeconomic planning and developments,
3. Policies on the national scientific and technological research and development,
4. Environment, climate adaptation and disaster expert network,
5. Regular Environment, climate adaptation and disaster campaign programme on media and education systems.

Table 11 Barriers and measures on the adaption technologies in the agriculture sector

Technologies/ Practices	Barriers	Measures
Livestock disease prevention and control/ Surveillance	1. Inadequate budget and investment on livestock disease surveillance	Increase budget and investment on livestock disease surveillance
	2. High cost of vaccines, vaccination, and disease epidemics surveillance	Reduce cost of vaccines, vaccination, and disease epidemics surveillance
	3. Limited access to finance for disease prevention and control	Expand access to finance for disease prevention and control
	4. Inadequate human resource	Increase human resource

[23] Particularly, Department of Irrigation (DoI), Meteorology and Hydrology (DMH), Disaster Management and Climate Change (DDMCC), Water Resources (DWR).

Technologies/ Practices	Barriers	Measures
	5. Inadequate technologies including equipment, vaccine package, laboratory, surveillance and treatments facilities	Increase technologies including equipment, vaccine package, laboratory, surveillance and treatments facilities
	6. Inadequate information on livestock disease, surveillance and treatment technologies	Increase information on livestock disease, surveillance and treatment technologies
	7. Low awareness and ignorance about livestock disease control	Increase awareness and ignorance about livestock disease control
	8. Free range and scattered livestock raising	Free range and scattered livestock raising
Agricultural development subsidy mechanism	1. Inadequate budget for subsidy	Increase budget for subsidy
	2. Insufficient legal framework	Develop legal framework
	3. Unclear responsibility for development and management of subsidy	Define clearly organisations' responsibilities s to develop and manage the subsidy
	4. Inadequate knowledge and skills	Inadequate knowledge and skills
	5. Insufficient information about the climate change and disaster subsidy mechanism	Increase information about the climate change and disaster subsidy mechanism
Climate resilient rural infrastructure	1. High investment cost on disaster resilient infrastructure	Reduce cost on disaster resilient infrastructure
	2. Inadequate budget for investment and development	Increase investment on resilient infrastructure
	3. Insufficient financial incentives for the resilient infrastructure	Increase financial and economic incentives for the resilient infrastructure
	4. Insufficient legal framework	Develop legal framework on climate resilient technologies and infrastructure
	5. Ineffective law enforcement on the infrastructure standards	Increase effectiveness of law enforcement
	6. Limited knowledge and skills on the resilient infrastructure	Increase knowledge and skills on the resilient infrastructure
	7. Inadequate information and awareness on the resilient infrastructure	Increase information and awareness on climate change, disaster resilient infrastructure including best practices
	8. Insufficient reference projects/models	Insufficient reference projects/models
Crop diversification	1. Limited budget for the extension	Increase budget for the extension
	2. Inadequate knowledge and skills on crop diversification	Increase knowledge and skills on crop diversification
	3. Inadequate information on optimal crop diversification for climate change adaptation	Increase information on optimal crop diversification for climate change adaptation and disaster resilience

Technologies/ Practices	Barriers	Measures
	4. Inadequate reference projects and best practices	Develop reference projects and best practices
	5. Low awareness on crop diversification	Increase awareness on crop diversification

Chapter 5 Conclusion

The eight important adaptation technologies and practices in the water resources and agriculture sectors namely 1) early warning system, 2) disaster risk and impact reduction fund, 3) river basin management, 4) climate resilient water supply systems, 5) livestock disease prevention and control, 6) agricultural development subsidy mechanism, 7) climate resilient agricultural infrastructure, and 8) crop diversification are non-market or publicly provided goods. This means that the government has a central role for their deployment and diffusion, which involves the promoting and generating demand, awareness raising, engaging and enabling the private sector and local communities on the development and application of the technologies and practices.

Although the government has made efforts to develop the mentioned technologies for years, the progress levels on the development and deployment for adaptation and disaster resilience varies. Technologies that are further along and mature in their development include the water supply systems, early warning system, river basin management, livestock disease prevention and control, while others are still in the early stages and are underdeveloped.

The barrier analysis found several barriers that impede the effective development, mainstreaming and application of climate adaptation and disaster-resilient technologies and practices. Both the water and agriculture sectors are faced with financial and economic barriers due to insufficient financial resources. The underlying issues involved in the financial and economic barriers are 1) pubic budget deficit, 2) variability of external funding, and 3) high investment cost.

There are also non-financial and economic barriers such as insufficient capacity for technology development, and for streamlining and deploying climate and disaster-resilient technologies. There are also insufficient technical skills, a lack of organisation and coordination, poor reporting and inaccurate information, a lack of development technologies and plans, limited reference projects and best practices, poor policy framework, and ineffective law enforcement.

To address the financial and economic barriers, the following actions shall be taken: 1) Improve access to finance, facilitate resource mobilisation, and enforce transparency in finance management and resource allocation. 2) Enhance R&D on financial and economic data and information, and devise best practices and models for financing climate adaptation and disaster resilient technologies. Such data and information could be utilized to justify and support decision making on the investment of technology development.

The following shall be implemented to address the non-financial and economic barriers in order to create enabling environments: 1) Improve technical knowledge and skills, 2) Enhance R&D, acquire technology development technologies and plans, implement additional reference projects to derive best practices, and improve the policy framework to help define and provide legal references for the technologies development, and 3) pilot interventions and promote learnings and expansion.

Implementing measures that have an overall impact and create an enabling environment for technology development, streamlining and deployment is crucial. These measures include: 1) Ensuring national economic growth, while mainstreaming the adaptation technologies in the national and provincial socioeconomic development plans. 2) Developing and enforcing policies on integrated planning, developments and good governance. 3) Maintaining and enhancing international cooperation. 4) Implementing policies on promotion of investment and development of environmentally friendly, climate adaptation and disaster resilient technologies, 5) Enhancing environment, climate adaptation and disaster expert network, 6) Conducting regular environment, climate adaptation and disaster campaign programme on media and education systems and promoting public participation in the development and deployment of climate change adaptation and hazard resilient technologies, and 7) Enhancing international cooperation on financial and technical support including transfer of technologies.

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2	Mr. Syamphone Sengchandala	DCC, MONRE	Deputy Director General	
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9	Mr. Soukphavanh Sawathvong	REDD Office, Department of Forestry, MAF	Technical Official	WG/WS
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25	Mr. ThaKhonmixay	Dep. of Water Resources, MoNRE	Technical Official	WG/WS
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43	Mr. Bounlueth Louangprasuet	Construction and renewable energy company	Director	INT
44	Ms. Sengdaovone	Secret of organic agriculture association, LNCCI	Head of secretariats	INT
45	Mr.Dethoudome	Agriculture development bank	Director of account division	INT
46	Mr.Phouvanh	Nayobay bank	Director of credits division	INT

Remark: WG=working group. PT=project team. WS=workshop attendant. INT=interview

Annex 2: Key reviewed literature and checklist questions

Main literature reviewed		
Water Resources Sector		
Technologies	**Specific Literature**	**General literature**
Early warning system	- National progress report on the implementation of the Hyogo Framework for Action (2013-2015) (2015). - (draft) Standard operation guidelines for early warning system (2012) - Flood management and early warning systems in the Lower Mekong Basin (2016) - Country Assessment Report for Lao PDR. Strengthening of Hydrometeorological Services in Southeast Asia (ISDR et al., 2012).	Natural resources and environment strategy to 2025 and Vision to the Year 2030(2015) Water resources strategy to 2025 and Vision to the Year 2030(2015)
Disaster risk and impact reduction fund	- Law on water resources - (Draft) law on disaster and climate change - Decree on the establishment of national and provincial committee for disaster prevention and control - Decree on environmental protection fund	
River basin management-IWRM	- Law on water resources, environment protection, electricity, irrigation - Decree on environmental impact assessment	
Climate resilient water supply systems	- Water Supply and Sanitation Sector Review (2010) - Service Delivery Assessment. Water Supply and Sanitation in Lao PDR. Turning Finance into Services for the Future (2014) - Lao People's Democratic Republic Strengthening Water Supply, Sanitation and Hygiene Sector Coordination in Lao PDR Supporting Sector Reform for Scaling Up Rural Sanitation-Synthesis Report (2015)	
Agriculture Sector		
Technologies	**Specific Literature**	**General literature**
Livestock disease prevention and control	- (draft) Strategy on livestock and fishery (2016) - Significant mortality of large ruminant due to hypothermia in northern and central Lao PDR (2014) - Review of the Livestock Sector in the Lao People's Democratic Republic (2002)	Agriculture Development Strategy to 2025 and Vision to the Year 2030(2015)
Agricultural development subsidy mechanism		
Climate resilient infrastructure	- Completion Report. Lao People's Democratic Republic: Northern Community-Managed Irrigation Sector Project (2011).	
Crop diversification	- Effective implementation of crop diversification strategies for Cambodia, Lao PDR and Vietnam: Insights from past experiences and ideas for new research (2015)	
Checklist questions used in the interview and discussion:		
(1) What is the status of deployment and diffusion of the technologies in the water resource and agriculture sectors?		

(2) What impedes or what are the key barriers or gaps to fully, effectively and sustainably develop the technologies? Any financial-economic, policy, capacity, technical barriers etc. and what are they?

(3) Do these impediments really hinder development or what are their effects? Would the technologies be fully, effectively and sustainably developed if such barriers are addressed?

(4) What have we learned from previous measures and management approaches? Are financial-economic, policy, capacity, technical measures etc. efficient and effective, and what are the gaps?

(5) How to ensure effective or sustainable solutions, and what is the process to addressing the barriers?

Annex 3: Long-list of barriers of technologies in water sector

1. Floods early warning system (EWS) development gaps and barriers

Barriers on the development, effectiveness and sustainability of EWS	Category
1. Inadequate budget and investment from public, private and development partners on EWS (1. Hazards and risk knowledge, 2. Floods monitoring and forecast including technologies, tools and facilities, 3. Warnings, dissemination and communication, 4. Development of preparedness or response plans, and 5. Organisational and capacity improvement)	Financial and economic
2. Inadequate financial and economic information/feasibility on EWS such as financial needs, cost and benefit or return on investment of EWS	Information/ Financial and economic
3. Inadequate capacity, how to develop effective EWS	Capacity/Skills
4. Incomplete law and regulation on disaster management and EWS	Legal framework
5. Inadequate tools and facilities (radar, satellite receiver, weather station, water gauges and modelling software) to forecast floods, landslide and storms accurately and timely, interpret and apply regional forest results/products for effective and timely warning	Technical
6. Inadequate telecommunication quality (speed, functional, clearness) and quantity, and access to information by local areas, especially areas that are at risk of hazards	Technical
7. Overlaps or unclear responsibilities and ineffective coordination amongst stakeholders (Department of hydrology and meteorology, water resources, disaster management and climate change of the ministry of natural resources and environment; department of disaster relief of the ministry of labour and social welfare, at national and local levels and Mekong River Commission and Lao National Committee for Mekong) on the development and management of EWS	Organisation
8. Incomplete and incomprehensive strategy and plan on EWS development	Organisation
9. Inadequate information and awareness about floods, landslide and storms characteristics, patterns, risks and vulnerability and EWS	Information and awareness
10. Complex organisation arrangement and elements of EWS is operated by different stakeholders and ineffective coordination	Organisation
11. Inadequate knowledge and skills use tools and models to forecast floods, landslide and storms accurately and timely	Capacity/Skills
12. Incomplete SOP for EWS (Floods monitoring and forecast, warnings, dissemination and communication, and response)	Legal framework
13. Lack of EWS operation centre that are directly and specifically responsible for implementation including mediating EWS at the central and local levels including community at risk of floods, landslide and storms	Organisation
14. Inadequate skills and tools to research and apply effective and best practice guidelines on organisation arrangement, forecast and monitoring, communication tools and mechanism for warning and facilitating response	Capacity/Skills
15. Inadequate skills and models/tools to study about floods, landslide and storms characteristics, patterns, risks and vulnerability	Capacity/Skills
16. Ignorance and unconfident about warnings, concerned about assets and not taking seriously to response to floods, landslide and storms warning	Others

Barriers on the development, effectiveness and sustainability of EWS	Category
17. Planning and developments (e.g., town, hydropower projects) have not sufficiently mainstreamed/considered climate change, disaster risk and EWS	Others
18. Inadequate capacity, how to mobilise sufficient resources for EWS	Capacity/Skills
19. Lack of expert group to support disaster management and development of EWS including knowledge and information exchange	Networking/ organisation
20. Limited information and extension of best practices including local knowledge about disaster warning/alarming and response	Information and awareness
21. Complexity and difficult to develop and apply technologies and models to forecast floods, landslide and storms accurately	Technical/ Others
22. Incomplete and incomprehensive education and training on EWS	Capacity/Skills
23. Some communities and assets have lied in hazard risk areas and limited options and/or unwilling to be resettled, which are difficult or challenge for effective response	Others

2. River basin management including IWRM

Barriers to effectively develop and sustain river basin and watershed management for climate change adaptation	Category
1. Inadequate budget and investment on the promotion and development of river basin/watershed including application of integrated water resources management (IWRM)	Financial and economic
2. Lack of financial models on sustainable financing river basin/watershed development and management	Financial and economic
3. Incomplete economic mechanism to increase revenues and reinvestment in river basin/watershed management	Financial and economic
4. Ineffective promotion/extension of the river basin/watershed development and management including application of IWRM	Technical
5. Incomplete agreement amongst stakeholders/provinces and regulation on watershed management	Legal framework/ Organisation
6. Incomplete and incomprehensive watershed development strategies and plans for sustainable development and adaptation	Organisation
7. Incomplete policy and regulation on resources uses and tax including benefits sharing	Legal framework
8. Limited knowledge and skills to develop and sustain on river basin/ watershed for adaptation	Capacity/Skills
9. Lack of knowledge and skills on R&D effective and best practices on sustainable and climate resilient river basin/watershed development and management	Capacity/Skills
10. No policy on integrated planning and developments including strategic environmental assessment to ensure developments in watershed are implemented in coordinated manner and relevant to watershed development agreement, strategy/plans	Legal framework
11. Inconsistency amongst laws and policies on the management resources in the watershed	Legal framework

Barriers to effectively develop and sustain river basin and watershed management for climate change adaptation	Category
12. Lack of river basin/watershed including application of integrated water resources management (IWRM) performance review	Legal framework
13. Incomplete or not inclusive working group on water resources management	Organisation
14. Complex organisation arrangement and overlaps or unclear responsibilities on river basin/watershed development and management	Organisation
15. Ineffective coordination and communication amongst stakeholder in a basin and watershed	Organisation/ networking
16. Inadequate guidelines including best practice guidelines on integrated watershed management	Technical
17. Lack of information and sharing information on land, resources and planned developments in the river basin and watershed	Information and awareness/Others
18. Lack of awareness on the socioeconomic and environmental benefits of integrated river basin/watershed including application of integrated water resources management (IWRM)	Information and awareness
19. Lack successful and effective integrated river basin/watershed including application of integrated water resources management (IWRM)	Technical/ Information and awareness
20. Complexity of watershed/IWRM (multi-disciplinary approach)	Technical
21. Socioeconomic development based on governance administration boundary rather than river basin/watershed boundary	Others
22. Conflicts of interest and lack of consensus on water and other resources using in the river basin and watershed	Others

3. Disaster impact reduction fund

Barriers on the development and sustainability of disaster reduction fund	Category
1. Inadequate budget for establishment of disaster reduction fund	Financial and economic
2. Incomplete policy and regulation on disaster management and risk reduction and disaster reduction fund	Financial and economic
3. Unclear roles and responsibilities of stakeholder and unit in charge of development and management of disaster reduction fund	Organisation
4. Limited knowledge and skills on the development and management of disaster reduction fund	Capacity/Skills
5. Limited skills to mobilise resources for disaster reduction fund	Capacity/Skills
6. Inadequate skills on R&D about feasibility, effective and successful disaster reduction fund and financing mechanism and models	Capacity/Skills
7. Lack of information about feasibility, effective and successful disaster reduction fund and financing mechanism and models	Information and awareness
8. Ineffective coordination and exchange with environmental and natural resources management funds	Organisation/ Information

4. Climate resilient water supply system

Barriers on the development and sustainability of climate resilient water supply system	Category
1. Inadequate budget and investment on climate resilient and quality water supply system	Financial and economic
2. High investment cost for climate resilient technologies	Financial and economic
3. Inadequate financial and economic incentives for climate resilient technologies	Financial and economic
4. Inadequate promotion/extension of climate resilient technologies in water supply system construction	Technical
5. Incomplete policy and regulation on climate resilient technologies /infrastructure	Legal framework
6. Limited knowledge and skills to design, develop and apply sustainable and climate resilient urban/town including water supply system planning	Capacity/Skills
7. Lack of guidelines and ineffective climate resilient mainstreaming in water supply system construction standard	Technical
8. Inadequate information about climate and water hazards and its risk and impact on water sector and infrastructure including water supply system	Information and awareness
9. Inadequate information about climate change climate resilient water supply system technologies/equipment including successful models/reference project	Information and awareness
10. Ineffective quality assurance and control of water supply system	Technical
11. Incomplete policy on sustainable and integrated urban/town and land use planning and developments including climate resilience mainstreaming	Legal framework
12. Lack of sustainable and integrated urban/town and land use planning and developments including climate resilience mainstreaming	Technical
13. Incomplete identification and conservation of water sources for water supply and strategy to develop climate resilient water supply system	Organisation
14. Lack of information and technology for mapping, selecting and drilling ground water resources for water supply	Information
15. Lack of skills and tools for monitoring quality of water, especially biological including bacteriological testing	Skills/Technical
16. Economic unviable water supply system	Financial and economic
17. Scattered population and settlement and difficult access	Others
18. Incomplete or not inclusive working group to support and exchange climate resilient technologies /infrastructure	Organisation
19. Lack of R&D skills and information about climate change impact and climate resilient infrastructure including water supply system	Skills/ Information and awareness
20. Inadequate skills to estimate water demands and supply in associated with changing climate, developments and increase of population	Skills/Others
21. Inappropriate settlement and limited water sources	Others

Annex 4: Decomposition of barriers to adaptation technologies in water resources sector

1. Decomposition of barriers on EWS

Broad categories of barriers	Barriers within a category	Elements of Barriers	Dimension of Barrier elements
Economic and financial	Inadequate and variable and difficult to secure budget and investment from public, private and development partners on EWS	Inadequate budget for hazard mapping including R&D about water related disaster	Storms and flood risk maps exist for whole country and provincial level, but no downscaled and detailed maps and about US$ 0.75 million shortage for downscaled and detailed mapping and US$ 0.08 per year for updating
		Inadequate budget for monitoring and forecast water related disaster including facilities and technologies (hydro-met station including telemetry and automate water gauges, radar and satellite receiver, forecasting models) and SOP	- 17 Hydro-met stations, but no automatic telemetry system - Water gauges are only available the Mekong, and mina rivers, but inexistent and cover tributary river, watershed and catchment. Automate telemetry water gauge is not in use - Only one radar and satellite in and cover only Vientiane capital, and available and cover the north and south provinces - Lack of forecasting models including WNM, river and flash flood, erosion and landslide model etc. - At least US$ 10.93 million is required for stand-alone EWS system and 18.98 million regional integrated EWS. About 95% of the budget shortage to complete the system
		Inadequate budget for warnings communication and dissemination facilities and technologies (high speed internet, telephone and fax, mobile phone, TV and radio, speaker system network) and SOP	- 40% of the population access to internet, only 5% access to high speed internet, and very limited access for remote, rural and disaster risk areas - 70% of the population to telephone, but only 35% of remote, rural and disaster risk population are accessible or covered - 70% of the population to mobile phone, but only 25% of remote, rural and disaster risk population are accessible or covered

Broad categories of barriers	Barriers within a category	Elements of Barriers	Dimension of Barrier elements
			- 74% of the population to TV, but only 45% of remote, rural and disaster risk population are accessible or covered - 80% of the population to radio, but only 50% of remote, rural and disaster risk population are accessible or covered - 54% of the population are accessible or covered by local speaker system, but only 15% of remote, rural and disaster risk population are accessible or covered - No siren system at any disaster risk areas - At least US$ 33 million is required for establish basic infrastructure for disaster risk areas/communities. About 90% of the budget shortage to complete the basic infrastructure
		Inadequate budget for enhancing response capacity including infrastructure and facilities (preparedness assessment and response planning, signage system, road, vehicle, evacuation area, warehouse/storage, life safety equipment etc.)	At least US$ 23 million is required for establish basic infrastructure for disaster risk areas/communities and US$ 0.10 million per year for operation and maintenance. About 90% of the budget shortage to complete the system
		Inadequate budget for organisational improvement (EWS centre and mobile or volunteer) including facilities (vehicle, communication tools, life safety equipment etc.)	EWS centre and mobile or volunteer is not established and equipped. At least US$ US$ 0.04 million per year shortage for organisational improvement
	Inadequate feasibility study of EWS, which are difficult to justify and convince investment in EWS	Inadequate feasibility study including financial and economic analysis and/or low cost-benefit ratio or return on investment on EWS	- Only overall cost-benefit ratio (CBR) was estimated and it ranked from 1:5.2 to 1:8.7, which is, in general, worth investing compare to the CBR set by WMO, 1:7.
		Inadequate R&D of effective and appropriate and technical and engineering feasibility study	

Broad categories of barriers	Barriers within a category	Elements of Barriers	Dimension of Barrier elements
		of monitoring and forecast of water related disaster, communication and response technologies/equipment	- Specific feasibility and CBR for each area and EWS activity have not been estimated and lack of the information for determining EWS investment. - At least US$ 1.2 million is required for FS. About 95% of the budget shortage to complete the study
	Ineffective and insufficient resources mobilisation for EWS	Ineffective and insufficient resources mobilisation for hazard mapping, forecast, communication and response	Less than 50% of potential financial support was tapped
		No resources mobilisation plan for EWS	About US$ 1 million shortage for capacity building, research and facilitation to more effective resources mobilisation.
		No potential donners/financial sources directory and access feasibility study	
		Limited financeable project proposal and examples	
		No resources mobilisation M&E system	
Market failures and imperfection	Ineffective promotion/ extension and push demand/needs for development of EWS	Inadequate practical the best practice guidelines and successful EWS models	About US$ 0.5 million per year shortage for more effective promotion/extension of EWS
		Inadequate information on feasibility, financial and economic information such as CBR on EWS	
		Limited knowledge and skills on EWS and extension affairs	
Policy, legal and regulatory	Incomplete and inconsistent law or decree on disaster management and risk reduction	A draft of law on disaster was completed in 2012, but has not been updated and approved	At least US$ 0.1 million per year shortage for improvement of legal framework including capacity building
		Overlaps or unclear responsibilities and inconsistent laws of relevant organisations	

Broad categories of barriers	Barriers within a category	Elements of Barriers	Dimension of Barrier elements
		(Dep. of hydrology and meteorology, water resources, disaster management and climate change of MoNRE; dep. of disaster relief of the ministry of labour and social welfare, at national and local levels and Lao National Mekong River Committee) on disaster and EWS management	
	Incomplete decree or regulation on EWS including standard operation procedure (SOP)	A draft of SOP was completed in 2012, but has not been updated and legalised	
Network failures	No specific expert group on EWS	Small number of EWS experts and lack of platform for exchanges	About US$ 0.05 million shortage per year for enhancement of coordination and networking.
	Ineffective coordination amongst stakeholders, especially with regional and local levels	1. Only few staff of DMH involve in coordination with regional EWS network 2. Lack of coordination/cooperation plan	
Institutional and organisational capacity and human skills	Incomplete organisational management systems	No EWS centres at national and local levels including ones at disaster risk communities	About US$ 2.5 million shortage for establishment of centres and US$ 0.05 per year for operation
		No EWS expert group/association	
	Ineffective organizational planning, M&E and reporting system	Incomplete and incomprehensive strategy and plan on EWS development, M&E and reporting system at national and local levels	US$ 0.75 million shortage for development of strategy, planning, M&E and reporting

Broad categories of barriers	Barriers within a category	Elements of Barriers	Dimension of Barrier elements
	Ineffective coordination amongst stakeholders	Limited formal and informal exchange platform/ communication channel amongst stakeholders on EWS	About US$ 0.02 million per year shortage for improving coordination, including dialogue and exchange
	Insufficient technical capacity and skills on EWS	Insufficient skills on organisational and HRD and system (e.g., HRD plan, capacity needs assessment, staff knowledge management, effective recruitment and staffing, management of HR demand and supply side	About US$ 0.15 million per year shortage for capacity building for enhancing and maintaining human resource development system
		Insufficient technical skills on EWS, including skills on all aspects (technical, financial and economic, social and policy) of EWS)	About US$ 0.2 million per year shortage for development of technical skills on EWS and extension
	Insufficient resource materials on EWS	Inadequate handbook, guidelines and best practices on all aspects of EWS	About US$ 0.03 million per year shortage for handbook, guidelines and best practice
Information and awareness	Little information and awareness on EWS	Inadequate EWS guidelines, especially best practice guidelines, and reference projects	About US$ 2 million for development of model EWS and US$ 0.10 per year shortage for extension and R&D on best practice guidelines and reference projects
		Insufficient information on (1) villages/communities at risk, (2) suitable EWS and its elements, and (3) financial and economics e.g., CBR and IRR in EWS, and models	About US$ 0.07 million per year shortage for research and technical information on EWS
	Ineffective information dissemination and awareness raising	Inadequate information dissemination and awareness raising	About US$ 0.07 million per year shortage for extensive and effective dissemination of information on EWS including R&D
		Inadequate best practice and effective information and awareness raising tools and R&D	

Broad categories of barriers	Barriers within a category	Elements of Barriers	Dimension of Barrier elements
Technical	Complexity and difficult to develop and apply technologies and models to forecast floods, landslide and storms accurately, especially in changing climate		About US$ 0.09 million per year shortage for EWS technology R&D
Others	Some communities and assets have lied in hazard risk areas and limited options and/or unwilling to be resettled		About US$ 7 million per year shortage for relocation and sustainable or town resilient planning and development

2. Decomposition of barriers on river basin and watershed management/IWRM

Broad categories of barriers	Barriers within a category	Elements of Barriers	Dimension of Barrier elements
Economic and financial	Inadequate and variable budget and investment on the promotion and development of river basin (WB/WSM) including IWRM	National budget deficit so that WB/WSM including IWRM was insufficiently financed	National budget deficit was 4.98% (US$ 0.27 billion) for 2005-2010 and 4.07% (US$ 0.38 billion) for 2011-2014. Budget demand for establishment of EWS was about US$ 8.4-13.8 million for 2011-2014. Only about 5% of the required budget secured and 95% shortage.
		Ineffective and imbalanced public investment prioritisation and budget allocation	The public investment 2011 and 2015 were economic sector (30%), infrastructure (35%), education (17%), health (9%) and the rest were for other sectors including natural resource and environment.
		Variable financial support and actual disbursement from development partners and international organisations	- Support from financial support from development partners and international organisations on EWS was very variable or ranged from million US$ during 2005-2010 and hundred thousand US$ 2011-2015. - In overall, 80-90% of financial support from development partners and international organisations were disbursable.
	Inadequate capacity to conduct feasibility study including financial and economic analysis e.g., cost-benefit ratio of the application of IWRM in each watershed	Inadequate capacity, R&D on feasibility study including financial and economic analysis and/or low cost-benefit ratio or return on investment on EWS, which are difficult to justify and convince investment in EWS	Only overall cost-benefit ratio (CBR) was estimated and it ranked from 1:5.2 to 1:8.7, which is, in general, worth investing compare to the CBR set by WMO, 1:7. Specific feasibility and CBR for each area and EWS activity have not been estimated and lack of the information for determining EWS investment.

Broad categories of barriers	Barriers within a category	Elements of Barriers	Dimension of Barrier elements
	Ineffective and insufficient resources mobilisation for WB/WSM including IWRM	No resources mobilisation plan for WB/WSM including IWRM	Less than 50% of international (excluding ones under agreement or cooperation with development partners or overseas development assistance-ODA) and domestic private sector potential financial support were tapped About US$ 0.15 million per year shortage for capacity building, research and facilitation to more effective resources mobilisation.
		Limited capacity to research and identify financial sources and feasibility to access	
		Limited capacity to develop financeable project proposal including financial and economic analysis e.g., cost-benefit ratio or return on investment	
Market failures and imperfection	Ineffective promotion/ extension and push demand/needs for WB/WSM including IWRM	Inadequate practical the best practice guidelines and successful WB/WSM including IWRM models	About US$ 0.20 million per year shortage for more effective promotion/extension of WB/WSM including IWRM
		Inadequate information on feasibility, financial and economic information such as CBR on EWS	
		Limited knowledge and skills for effective and sustainable including extension for WB/WSM including IWRM adaptation	
Policy, legal and regulatory	Incomplete and inconsistent law or decree on water resources management including decree or regulation on WB/WSM including IWRM adaptation	Incomplete definition, principles, procedures for planning and management, organisational responsibility for WB/WSM including IWRM adaptation	At least US$ 0.08 million per year shortage for improvement of legal framework including capacity building
		Lack of policy on WB/WSM-based governance and socioeconomic development	
		Incomplete policy and regulation on the utilization of resources in the basin/watershed and tax, and benefits sharing	
Network failures	No specific expert group on WB/WSM including IWRM adaptation	Small number of WB/WSM including IWRM adaptation experts and lack of platform for exchanges	About US$ 0.05 million shortage per year for enhancement of coordination and networking.
	Ineffective coordination amongst stakeholders,	1. Benefit-based coordination/cooperation 2. Taking personality	

Broad categories of barriers	Barriers within a category	Elements of Barriers	Dimension of Barrier elements
	especially with regional and local levels	**3.** Low awareness on the coordination and communication	
Institutional and organisational capacity and human skills	Ineffective organizational planning, M&E and reporting system	Incomplete and incomprehensive watershed development strategies and plans for sustainable development and adaptation	US$ 0.10 million per year shortage for development of strategy, planning, M&E and reporting
	Limited knowledge and skills to develop and sustain on river basin/ watershed for adaptation	Insufficient skills on organisational and HRD and system (e.g., HRD plan, capacity needs assessment, staff knowledge management, effective recruitment and staffing, management of HR demand and supply side	About US$ 0.35 million per year shortage for technical capacity
		Insufficient technical skills on integrated land use in the river basin and watershed	
		Insufficient technical skills to assess the climate change impact on the river basin and watershed hydrology and dynamics	
		Insufficient technical skills to develop and apply best or effective practice on floods early warning	
		Lack of knowledge and skills on water resilience technologies and infrastructure	
		Insufficient technical skills to water governance and conflict solutions	
Information and awareness	Lack successful model on effective RB/WSM including IWRM for socioeconomic development and environmental protection including adaptation	Lack successful model or effective models of RB/WSM including IWRM that enhance or contribute to socioeconomic development and environmental protection including adaptation	About US$ 1.8 million for development of WB/WSM including IWRM adaptation model and US$ 0.12 per year shortage for extension and R&D on best practice guidelines and reference projects

Broad categories of barriers	Barriers within a category	Elements of Barriers	Dimension of Barrier elements
Others	Administrative boundary-based socioeconomic development and conflict of interest		See policy section

3. Decomposition of key barriers on disaster reduction fund

Broad categories of barriers	Barriers within a category	Elements of Barriers	Dimension of Barrier elements
Economic and financial	Inadequate budget for establishment of disaster reduction fund	National budget deficit, resulting small amount of budget allocated for disaster management	National budget deficit was 4.98% (US$ 0.27 billion) for 2005-2010 and 4.07% (US$ 0.38 billion) for 2011-2014. Budget demand for disaster management including risk reduction and recovery was about US$ 88 million per year during 2010-2015. Only about 30% of the required budget secured and 70% shortage.
		Ineffective and imbalanced public investment prioritisation and budget allocation	The public investment 2011 and 2015 were economic sector (30%), infrastructure (35%), education (17%), health (9%) and the rest were for other sectors including natural resource and environment.
		Little or no financial support on the development of disaster fund from bilateral and multilateral funding, development partners, international organisations and private sector	Law on disaster and decree on disaster fund is incomplete. At least 30-40% of the disaster reduction fund should be contributed by these sources
	Inadequate capacity to conduct feasibility study including financial and	Inadequate capacity, R&D on feasibility study including financial and economic analysis and/or low cost-benefit ratio or return on investment on the disaster reduction	Only overall cost-benefit ratio (CBR) was estimated and it ranked from 1:5.2 to 1:8.7, which is, in general, worth investing compare to the CBR set by WMO, 1:7.

Broad categories of barriers	Barriers within a category	Elements of Barriers	Dimension of Barrier elements
	economic analysis of disaster reduction fund	fund, which are difficult to justify and convince investment in the disaster reduction fund	Specific feasibility of the disaster reduction fund is not conducted
	Ineffective and insufficient resources mobilisation for the disaster reduction fund	No resources mobilisation plan for the disaster reduction fund	Little or no fund is mobilised or allocated from environmental protection fund (EPF) to establish the disaster reduction fund. At least 5-15% of the disaster reduction fund should be derived from mobilisation
		Limited capacity to research and identify financial sources and feasibility to access	
		Limited capacity to develop financeable project proposal including financial and economic analysis e.g., cost-benefit ratio or return on investment	
Market failures and imperfection	Ineffective promotion/ extension and push demand/needs for establishment of the disaster reduction fund	Lack of legal framework on the disaster reduction fund	About US$ 0.25 million per year shortage for more effective promotion/extension of the disaster reduction fund
		Inadequate successful fund management model and practical guidelines including best practices	
		Inadequate information on feasibility, financial and economic information such as CBR on the disaster reduction fund	
Policy, legal and regulatory	Incomplete law or decree on disaster and disaster reduction fund	A draft of law on disaster was completed in 2012, but has not been updated and approved	At least US$ 0.25 million shortage for improvement of legal framework including capacity building
		Decree on the disaster reduction fund is not even drafted	
Institutional and organisational capacity and human skills	Unclear roles and responsibilities of stakeholder and unit in charge of development and management of disaster reduction fund	Incomplete law or decree on disaster and disaster reduction fund	At least US$ 0.04 million per year shortage for improvement organisation and system
	Limited knowledge and skills to develop and	Insufficient skills to study financial needs for disaster management and feasibility of disaster reduction fund	About US$ 0.30 million per year shortage for technical capacity

Broad categories of barriers	Barriers within a category	Elements of Barriers	Dimension of Barrier elements
	sustain disaster reduction fund	Insufficient technical skills on resources mobilisation indulging development of resources mobilisation plan, assessment of available and potential fund sources and feasibility of access, development of financeable project	
		Insufficient skills to study and develop effective organisation and management schemes for an effective and sustainable management of disaster fund	

4. Decomposition of the key barriers for development and sustainability of climate resilient water supply system

Broad categories of barriers	Barriers within a category	Elements of Barriers	Dimension of Barrier elements
Economic and financial	Inadequate budget and investment on the promotion and development and management of climate resilient water supply system	Inadequate budget and investment in development new water supply system	More than 50% of budget was shortage
		Inadequate budget and investment in maintenance existing and damage water supply system	
		Inadequate budget and investment in extension/ promotion, marketing and awareness	
		Inadequate budget and investment in development of policy, strategy and plan	
		Inadequate budget and investment in climate resilient water supply technologies/equipment	Additional budget, at least 15-30% is needed for climate resilient technologies/equipment compare to normal water supply system equipment
	Difficult to secure budget and investment from public budget	National budget deficit so that climate resilient water supply system was insufficiently financed	- **National budget deficit was 4.98% (US$ 0.27 billion) for 2005-2010 and 4.07% (US$ 0.38 billion) for 2011-2014.**

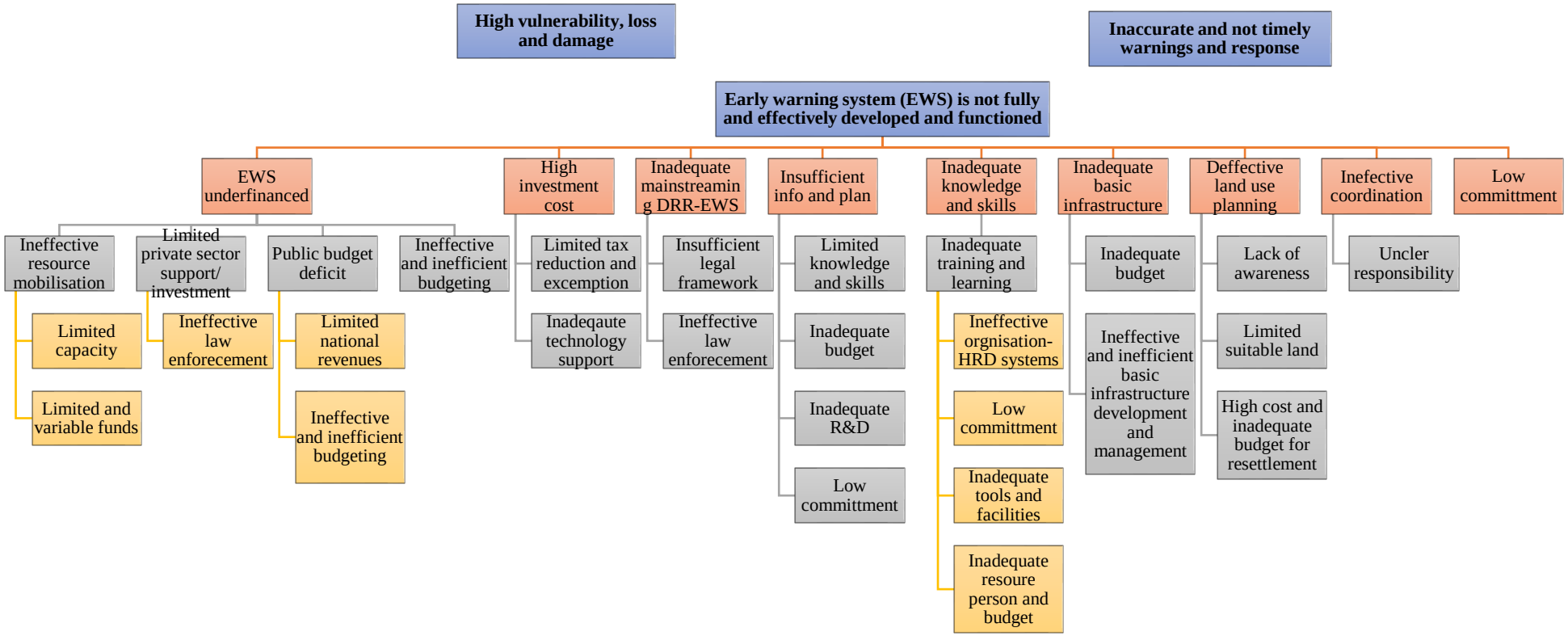
Broad categories of barriers	Barriers within a category	Elements of Barriers	Dimension of Barrier elements
			- **Annual budget required for rural water supply was about US$ 30.4 million for 2012-2015. US$ 21.9 million was underfinanced.** - **Annual budget required for urban water supply was about US$ 36.7 million for 2012-2015. US$ 14.9 million was underfinanced.**
		Variable financial support from development partners and international organisations, especially rural water supply system	Support from financial support from development partners and international organisations on EWS was very variable or ranged from million US$ during 2005-2010 and hundred thousand US$ 2011-2015.
	Inadequate feasibility study including financial and economic analysis e.g., cost-benefit ratio or return on investment of all water supply system	Inadequate assessment or review of financial and economic analysis e.g., cost-benefit ratio or return on investment of existing water supply system	Only private and state enterprise carries out financial and economic assessment. None of public funding water supply systems including rural water supply do. About US$ 0.10 million per year shortage for M&E indulging capacity building
		Inadequate feasibility study of financial and economic analysis e.g., cost-benefit ratio or return on investment of new water supply system which adopted climate resilience	
	Ineffective and insufficient resources mobilisation for climate resilient water supply system	No resources mobilisation plan for climate resilient water supply system	About US$ 0.15 million per year shortage for capacity building, research and facilitation to more effective resources mobilisation.
		Limited capacity to research and identify financial sources and feasibility to access	
		Limited capacity to develop financeable project proposal including financial and economic analysis e.g., cost-benefit ratio or return on investment	

Broad categories of barriers	Barriers within a category	Elements of Barriers	Dimension of Barrier elements
	High investment cost for climate resilient technologies	High investment cost for climate resilient equipment, imported tax, capacity or consultancy	Additional budget, at least 15-30% is needed for climate resilient technologies/equipment compare to normal water supply system equipment
Market failures and imperfection	Ineffective promotion/ extension and push demand/needs for climate resilient water supply system	Inadequate reference project and models on successful climate resilient water supply system	About US$ 2 million shortage for reference project and models on successful climate resilient water supply system and US$ 0.20 million per year shortage for extension including development guidelines
		Inadequate information on feasibility, financial and economic information such as CBR on climate resilient water supply system	
		Inadequate guidelines for climate resilient water supply system	
Policy, legal and regulatory	Incomplete policy on climate resilient infrastructure including water supply system	Incomplete policy on climate resilient infrastructure including water supply system equipment	At least US$ 0.09 million per year shortage for improvement of legal framework including capacity building
		Incomplete policy on financial and economic incentives and subsidy for promotion of climate resilient infrastructure including water supply system	
		Incomplete policy on mainstreaming climate resilient and disaster risks in infrastructure including water supply system development	
Network failures	No specific expert group on climate resilient infrastructure including water supply system	Small number of climate resilient infrastructure including water supply system experts and lack of platform for exchanges	About US$ 0.05 million shortage per year for enhancement of coordination and networking.
Institutional and	Incomplete strategy and plan to develop climate	Incomplete identification and conservation of water sources needs and supply capacity	US$ 0.08 million per year shortage for development of strategy, planning, M&E and reporting

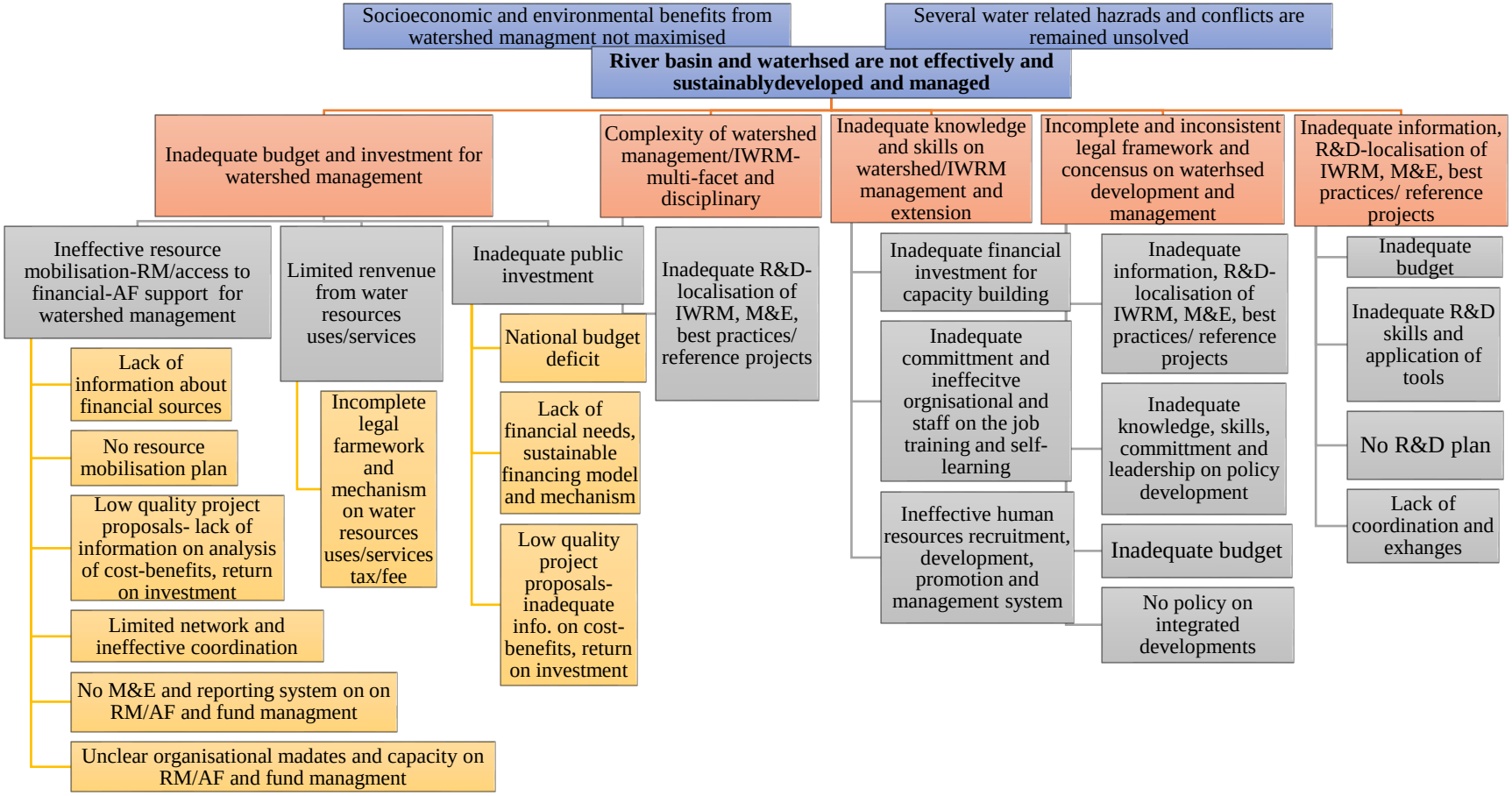
Broad categories of barriers	Barriers within a category	Elements of Barriers	Dimension of Barrier elements
organisational capacity and human skills	resilient water supply system	Inadequate information about climate and water hazards and its risk and impact on water sector and infrastructure including water supply system	
	Limited knowledge and skills to design, develop and apply sustainable and climate resilient urban/town including water supply system planning	Insufficient skills on organisational and HRD and system	About US$ 0.35 million per year shortage for technical capacity
		Insufficient technical skills to design, develop and apply sustainable and climate resilient urban/town including water supply system planning	
		Insufficient technical skills to develop policy and regulation on climate resilient technologies /infrastructure	
		Insufficient technical skills to study climate and water hazards and its risk and impact on water sector and infrastructure including water supply system	
		Insufficient technical skills on R&D of climate resilient technologies /infrastructure	
		Insufficient technical skills on construction standard, inspection, quality assurance and control	
Information and awareness	Inadequate information on climate and water hazards and its risk and impact on water sector and infrastructure including water supply system		About US$ 0.08 million shortage for R&D and information
Others	Lack of sustainable and integrated urban/town and land use planning and developments including climate resilience mainstreaming		About US$ 0.15 million shortage for sustainable and integrated as well as resilient urban/town and land use planning

Annex 5: Problems and solutions trees of technologies in water sector

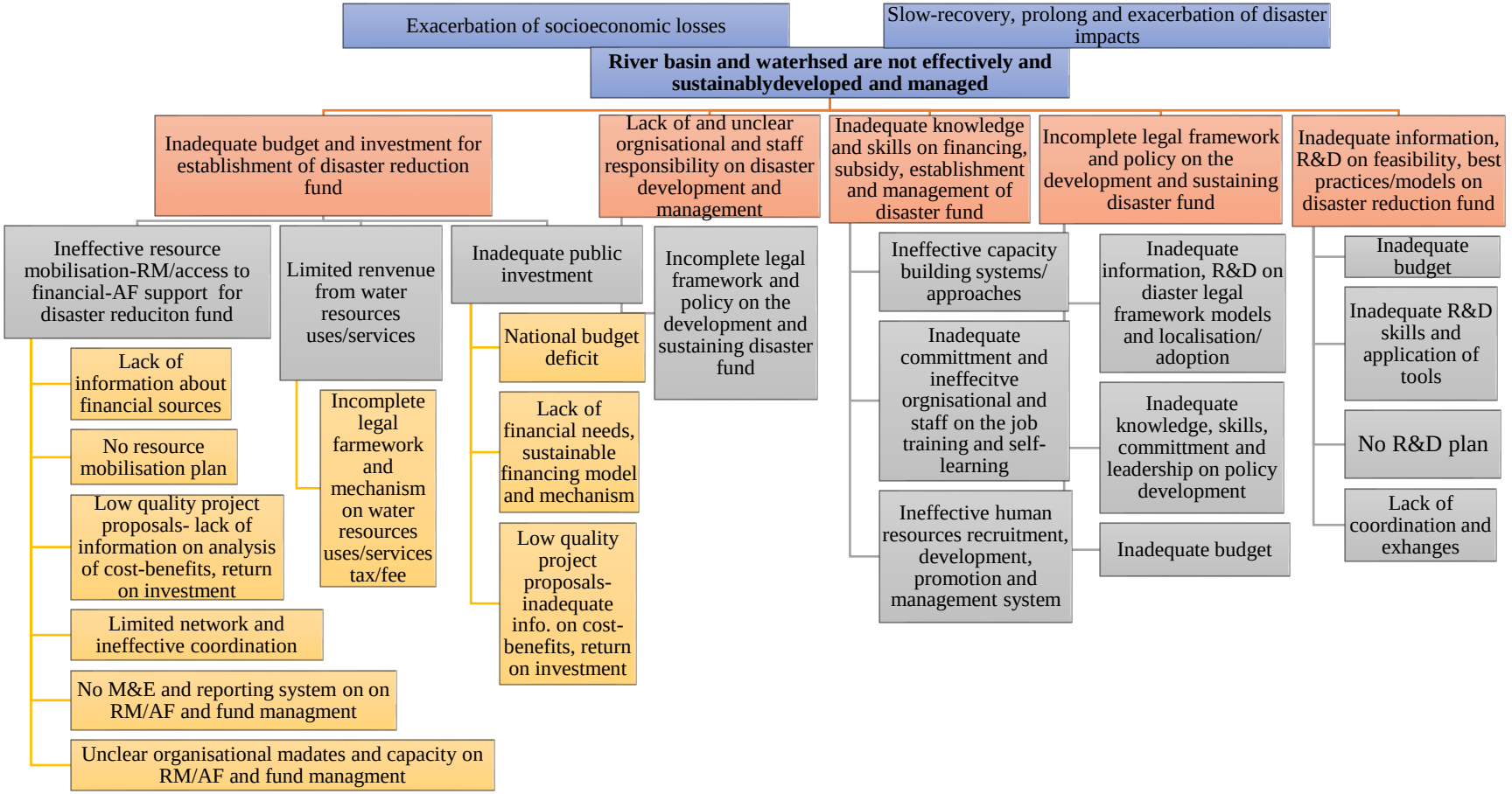
1. Early warning system (floods, landslide and storms)-EWS



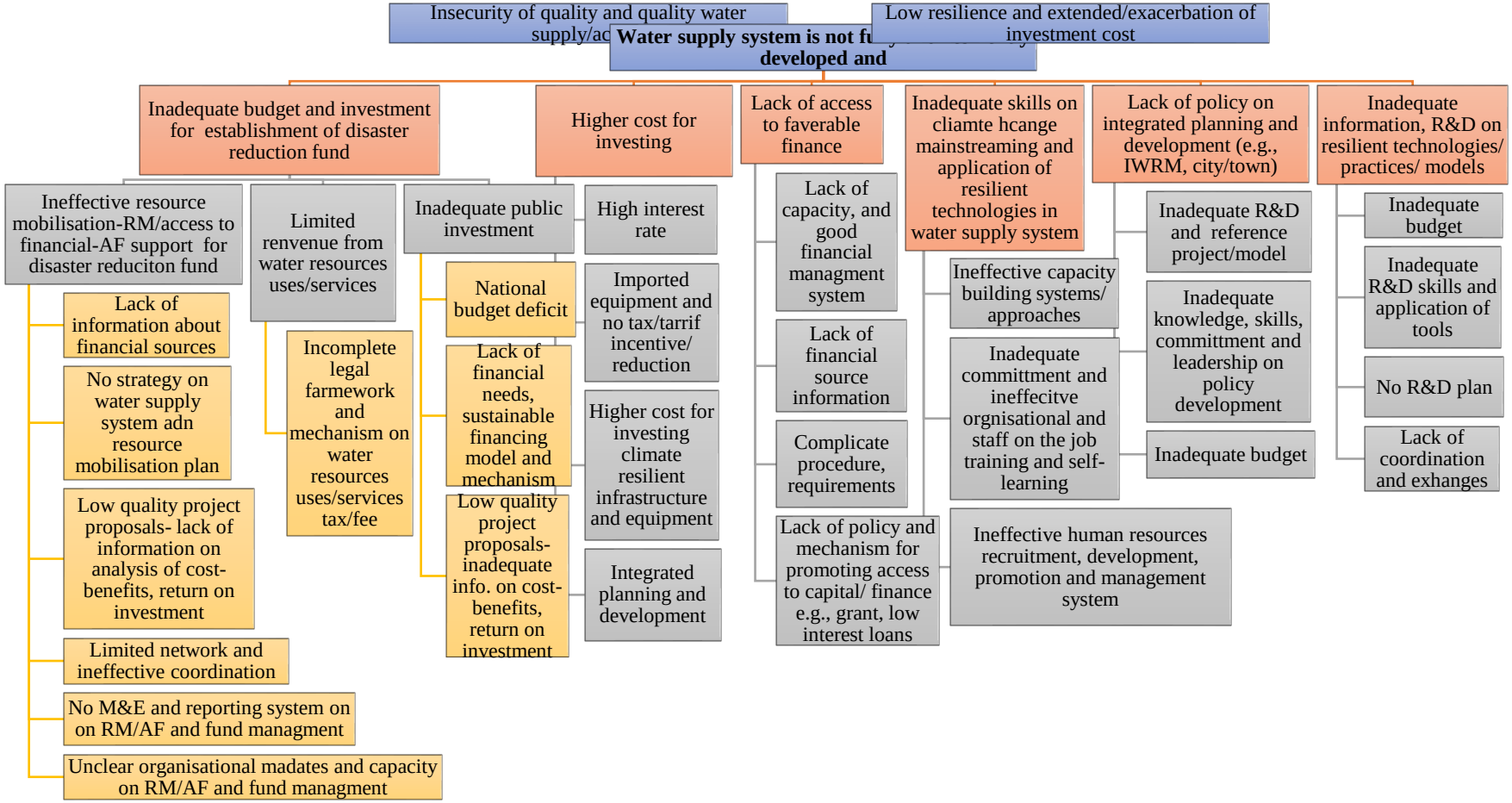
2. River basin and watershed management



3. Disaster reduction fund



4. Climate resilient water supply system



Annex 6 Key knowledge and skills gaps on the adaptation technologies in water resources sector

1. Knowledge and skills gaps on EWS

No	EWS components	Capacity gaps
1	**Risk knowledge**	Inadequate knowledge and skills to: - Identify pattern and dynamics, risks and impacts of floods, landslide, and storms - Do hazard and risk mapping including identification of villages and assets at risk of floods, landslide, and storms - Carry out vulnerability and readiness assessment
2	**Monitoring and forecast of floods, landslide, storms and extreme weather**	Inadequate skills and experiences to develop and apply: - Numerical weather forecast and newscasting - Gauge-to-gauge correlation models to forecast riverine flood - Flash flood and landslide modelling/simulation - Interpretation of the results generated from regional hazard forecast and warnings - SOP and best practice guidelines for monitoring and forecast
3	**Communication and dissemination of warning message**	Inadequate knowledge and skills to: - Research and develop effective and best practice on the warning communication and dissemination channel, methods, message and tools/materials for different hazards, risks and communities - Develop SOP and best practice guidelines for communication
4	**Response capacity**	Limited knowledge and skills to: - Develop, simulation and implement preparedness or response plans and design structural measures - Assess preparedness or response capacity, - Develop SOP and best practice guidelines for response.
5	**Institutional arrangements**	Limited knowledge and skills to research and develop effective and sustainable organisation set up and operation and committee for disaster management
Other knowledge and skills		
1	**Financial and economic**	- Feasibility study including financial and economic analysis such as cost and benefit or return on investment in EWS - Bankable proposal - Identification and analysis of financial or funding sources - Resources mobilisation planning - Effective and efficient public budgeting - Financial aids management including M&E
2	**Organisational, planning and management**	- HR and capacity development planning - Strategic and integrated planning (socioeconomic, land use, urban, watershed) - Sustainable resettlement - Cooperation and coordination - Leadership
3	**Legal**	- R&D of Disaster and climate change law, policy and regulation including its impact - R&D and deployment of best practice on law enforcement

2. Key knowledge, skills and legal gaps on effective and sustainable watershed management

No	**Categories**	**Elements of knowledge and skills**
1	Financial and economic	Inadequate knowledge and skills to assess (1) financial needs, (2) feasibility including cost-benefit and return on investment, and (3) research and develop of effective financing and investing models for watershed management including IWRM
2	Technical	Inadequate knowledge and skills on: - Adoption or localisation of IWRM to suit national context - R&D and application of best practices on IWRM for adaptation and sustainable development - Water resources valuation and financial and economic analysis of investment in water resources - Monitoring environmental changes in river basins - Assessment of water demand and supply - Assessment and identification of minimum water attraction and discharge - Environmental and water tax - Study climate change impact on water sector including watershed and its adaptive capacity - Water related disasters (storms, floods and drought) risk management and reduction including forecast and early warnings - Water resources governance, leadership and effective organisation - Effective law enforcement including R&D of best practices - Integrated planning including integrated spatial, land use planning and strategic environment assessment
3	Policy	Inadequate knowledge and skills to research and develop water resources policy, especially: - Policy and agreement on integrated and participatory development planning policy (spatial integrated land use, resources, urban and rural town planning) - Policy and agreement on equitable resources use, benefit sharing, contribution and conflicts solving - Policy and agreement on minimum water discharge - Policy and agreement on water related disaster management - Policy on watershed based-socioeconomic development
4	Organisation	Inadequate skills to carry out: - Organisational analysis or review, - Research and develop effective organisation structure and arrangement for effective management
5	Strategic planning and management	Inadequate skills on the application of strategic and spatial integration planning, sustainable land use, urban and rural town planning and resettlement
6	Resources mobilisation	Inadequate skills to develop: - Bankable proposal - Identification and analysis of financial or funding sources and feasibility - Establish financial aid M&E system

7	Extension/promotion and marketing	Inadequate skills to research and develop mechanism and methods for effective awareness raising on the important and advantage of IWRM

No	Main areas of ineffective law enforcement or implementation	Status and Gaps
I	Law on water resources (revised 2014)	
	1) Register of water resources use and medium and large-scale water resources use permits	No register system in place. No permit is enforced. Specific decree is required, but not yet developed
	2) Supply of water data and information by water users	Specific decree is required, but not yet developed
	3) Sector plans is required to align with river basin management plan	Unenforceable since majority of river basins have not been assessed its water resources and had management plan in place
	4) Specific regulation and review of river basin management plan	Specific decree is required, but not yet developed. Majority of river basins has not had management plan in place
	5) Determination and enforcement of minimum and maximum water attraction, flow and discharge including permits	Incomplete or not yet implemented
	6) Water resource tax	Incomplete or not yet implemented
	7) Cooperation for management of transboundary water resources	Cooperation agreement for all river basin is incomplete or not implemented
	8) Wetland development, management and conservation	Only some wetlands completed resources assessments. Study on impact and perennials of existing wetlands on climate change adaptation, and management plan have not been developed.
	9) Ground water development, management and conservation	Ground resources assessments including study on impact and potentials of groundwater on climate change adaptation and its management plan have not been developed.
	10) Water hazards and risk reduction and management including early warning	- Only few river basins have floods mapping in place. Overall hazard profile exists, but not downscaled to river basin and sub-basin level. - Most of river basins have not been assessed its vulnerability and adaptive capacity to changing climate and disasters, and have not been equipped with EWS including response plans. - No policy on the promotion of development of water resources for drought and flood including climate resilient and adaptation technologies
II	Decree on Conservation Forest (2015)	

No	Main areas of ineffective law enforcement or implementation	Status and Gaps
	1) Contribution of water related business including hydropower for river basin management including forest management in the river basin	Either lack M&E and reporting, or ineffective enforcement and implementation. In addition, it lacks standard practices
	2) Offset of forest in the river basin	Not well defined in the decree. No specific regulation and ineffective enforcement or implementation
II	Decree on EA (2010) and MoNRE's EIA and IEE Instruction (2013)	
	1) Contribution of water related business including hydropower for river basin management including forest management in the river basin	Majority of international financing projects considered and followed these requirements, but somehow generic or ineffective. Majority of private and public investment projects have not had sufficient mainstreaming, implementation or enforcement of these areas.
	2) Offset of forest in the river basin	
	3) Determination of minimum and maximum water flow and discharge including permits	
	4) Valuation of water resources and identification of appropriate measures	
	5) Forecast/predict water hazards, feasibility study and deification of risk reduction and management including early warning to mainstreaming in development project planning and development	

3. Key knowledge and skills gaps on the development and sustainability of fund for disaster risk and impact reduction

No	Categories	Sub-categories or specific elements of skills
1	Financial and economic	Knowledge and skills about mechanisms for financing climate and disaster risk reduction and management including (1) financial needs assessment, (2) feasibility including cost-benefit and return on investment, and (3) research and develop of effective financing mechanism including insurance
2	Policy	Inadequate knowledge and skills to research and develop policy on climate and disaster financing, insurance and subsidy
3	Organisation	Inadequate skills to review, research and develop effective organisation structure and arrangement for effective management and operation of climate and disaster fund, insurance and subsidy
4	Resources mobilisation and access to finance	Inadequate skills to develop: - Bankable proposal including financial and economic as well as CBR and IRR analysis - Identification and analysis of financial or funding sources and feasibility

		- Establish financial aid M&E system - Extension/promotion and marketing including to research and develop mechanism and methods for effective awareness raising on the important and advantage of disaster reduction fund - Access to finance e.g., contingent credit

4. Knowledge and skills gaps for deployment and diffusion of climate and disaster resilient water supply technologies

No	Main Areas of Skills	Insufficient Skills
1	Risk knowledge	- Assess risks, impacts and resilience of existing and future water supply systems to floods, landslide and drought on water supply system - Assess and identify climate and disaster resilient equipment/technology such as
2	Technology knowledge and skills for application	Analysis and apply disaster and climate resilient or proof equipment such as - Structural design to prevent erosion and landslide in water supply system, - Water leak detection and repair, - Pressure system to increase or maintain water flow in pipe system, - Portable water filtering and purification devices, - Man-made pond and water storage for drought adaptation - Rain water harvest system, - Water proof deep boreholes,
3	Financial and economic	- Financial and economic analysis including CBR and IRR
4	Resources mobilisation	- Develop bankable project proposal including financial and economic analysis - Identify and analysis financial or funding sources and feasibility - Establish financial aids M&E system
5	Policy	- Policy on the promotion of environmentally friendly climate resilient technologies including financing and subsiding, taxation and exception, incentives
6	Human resources development system	- Organisational development including analysis and performance assessment, human resources and capacity building development planning, self-capacity needs assessments and staff knowledge management, HRD M&E

Annex 7: Long-list barriers of technologies in agriculture sector

1. Livestock disease prevention and control

Barriers to effectively prevention and control of livestock disease	Category
1. Inadequate knowledge about livestock disease including climate and disaster induced disease and treatments skills including vaccines effectiveness and efficiency	Capacity/Skills
2. Livestock cross borders especially, traditional borders without inspection and inadequate livestock quarantine facilities at borders	Technical/Financial and economic
3. Majority is free range and scattered livestock raising which is difficult or costly for disease outbreak monitoring, control and treatments	Technical/Financial and economic
4. Ineffective disease outbreak warnings (risk knowledge, monitoring, information dissemination, response capacity)	Technical
5. Inadequate mobile team equipped with vehicle, equipment, vaccine and information package for information dissemination and disease control and treatments including vaccination	Organisation/ Financial and economic
6. Inadequate budget and investment on livestock disease management (prevention, control and treatments including vaccination and R&D)	Financial and economic
7. Limited knowledge and skills on livestock sanitary and quarantine	Capacity/Skills
8. Limited knowledge and research skills on livestock nutrients for healthy and climate resilience	Capacity/Skills
9. Limited knowledge and research skills on biological improvement for healthy and climate resilient livestock	Capacity/Skills
10. High cost of vaccines and vaccination	Financial and economic
11. Inadequate farm standard, livestock facilities and hygiene	Technical/Financial and economic
12. Incomplete livestock raising zoning	Technical/Financial and economic
13. Incomplete legal and regulatory framework e.g., regulation and policy on livestock raising and vaccination including vaccines management	Legal framework
14. Ineffective law and regulation enforcement on livestock raising and vaccination including vaccines management	Legal framework
15. Inadequate and ineffective livestock disease information dissemination, extension and exchanges	Information and awareness
16. Lack of feasibility skills and information on cost-benefits or return on investment of disease management (prevention, control and treatments including vaccination)	Skills/Information and awareness
17. Inadequate disease and vaccines research laboratory	Technical/Skills/ Financial and economic
18. Inadequate knowledge and research skills on biotechnology and genetics for development of healthy and climate resilient livestock	Technical/Skills
19. Ignorance, concerned about loss of livestock and not taking serious disease control	Awareness/Others

Barriers to effectively prevention and control of livestock disease	Category
20. Lack of feasibility of financial incentives and mechanism to finance or subsidy livestock raising including vaccination	Financial and economic/Skills
21. Limited access to finance/capital for livestock raising including disease control	Financial and economic/Skills
22. Lack of (feasibility) study and implement livestock business insurance	Financial and economic/Skills
23. Incomplete legal and regulatory framework e.g., policy on financial incentives, subsidy, agricultural including livestock development fund and insurance	Legal framework
24. Incomplete legal and regulatory framework e.g., policy and regulation on cross border livestock movements	Legal framework
25. No specific expert group and platform for exchanges knowledge and experiences on livestock prevention and control	Organisation/Network
26. Ineffective coordination and information exchange with regional network on livestock disease outbreak, prevention and control	Organisation/Network
27. Ineffective human development and education system on livestock disease and vaccines	Organisation
28. Lack of knowledge and skills on livestock development financial incentives, subsidy and insurance	Skills
29. Limited information and awareness on livestock disease and vaccines, and climate induced disease outbreak	Information and awareness
30. Inadequate information on feed/forage and nutrient improvements for healthy and climate resilient livestock	Information and awareness

2. Agriculture development fund and subsidy

Barriers	Category
1. Inadequate budget for development of the agricultural development fund and subsidy	Financial and economic
2. Incomplete policy and regulation on agricultural development fund and subsidy	Legal framework
3. Unclear specific department and responsibility for development and management of agricultural fund and subsidy	Organisation
4. Inadequate knowledge and skills on the development and management of agricultural development fund and subsidy	Skills/Technical
5. Lack of development fund and subsidy mechanism or models and feasibility study	Skills/Information and awareness
6. Lack of study and information on cost-benefits, trade-offs, impacts and sustainability of the agricultural development fund and subsidy	Skills/Information and awareness
7. Inadequate information about risks of agriculture production and products related with climate change, disaster and others	Information and awareness
8. Small and variable agricultural production and market	Market/Others
9. Incomprehensive agriculture association/think-tank for advocacy and support agriculture development including subsidy mechanism	Organisation/Network
10. Small, scattered and ineffective organised production groups	Organisation/Others

3. Crop diversification

Barriers	Category
1. Inadequate study and information on optimal crop diversification (introduction of new varieties and systems) for climate change adaptation or resilience and cost-benefits and return on investment of each crop diversification system	Skills/Information/ Financial and economic
2. Inadequate knowledge and skills on crop diversification development and extension	Capacity/Skills
3. Limited budget and financial support from government on the promotion/extension	Financial and economic
4. Lack of reference projects/models	Technical/Skills/Financial and economic
5. Lack of awareness on crop diversification	Information and awareness
6. Incomplete or incomprehensive strategy and plan on crop diversification	Organisation/Skills/ Financial and economic
7. Limited capital for investment of private sector and small holder to apply crop diversification	Financial and economic
8. High investment on crop diversification (introduction of new varieties and systems)	Financial and economic
9. Ineffective network and lack of coordination amongst stakeholders including experts	Organisation/Network
10. Ineffective or lack of expert and platform for exchanges knowledge and information on crop diversification	Organisation/Network
11. Ineffective organizational planning, evaluation and reporting system on the crop diversification	Organisation/Skills
12. Ineffective human development and education system on the crop diversification	Organisation/Skills
13. Inadequate knowledge and skills on R&D on the crop diversification	Skills/Technical/ Financial and economic
14. It is difficult, time consuming and/or costly to define the optimal crop diversification system in term of socioeconomic benefits and adaptation effectiveness	Others

4. Rural and agricultural climate resilient infrastructure

Barriers to fully, effectively and sustainably develop climate resilient agriculture infrastructure	Category
1. High investment cost on agricultural resilient infrastructure	Financial and economic
2. Inadequate budget and investment from public, development partners and private/farmers	Financial and economic
3. Lack of financial incentives, subsidy and fund for promotion of the agricultural resilient infrastructure	Financial and economic
4. Incomplete legal and regulatory framework on promotion of climate resilient technology/infrastructure including mainstreaming climate resilient agricultural infrastructure	Legal framework
5. Ineffective enforcement of regulations and measures on the infrastructure standards	Legal framework

Barriers to fully, effectively and sustainably develop climate resilient agriculture infrastructure	Category
6. Limited knowledge and skills on agricultural resilient infrastructure and technologies	Skills
7. Difficult, time consuming and costly to forecast climate phenomena and disaster and design proper agricultural resilient infrastructure including standards and best practices	Skills/Financial and economic/Others
8. Lack of information and awareness on agricultural resilient infrastructure technologies, standards, guidelines and best practices	Information and awareness
9. Lack of reference projects/models	Skills/Information/
10. Lack of feasibility study and information and awareness on agricultural resilient infrastructure cost and benefits	Skills/Information and awareness/
11. Inadequate study and information about effects, risks and financial needs for climate resilient agricultural infrastructure	Information and awareness
12. Incomplete agricultural resilient infrastructure development plan	Organisation
13. Ineffective coordination amongst stakeholders on the planning and development of the agricultural resilient infrastructure	Organisation/ network
14. Inadequate R&D and M&E of agricultural resilient infrastructure	Skills/Financial and economic

Annex 8 Decomposition of barrier to adaptation technologies in agriculture sector

1. Decomposition of the key barriers on early warning system on climate variations and livestock disease outbreak

Broad categories of barriers	Barriers within a category	Elements of barriers	Dimension of Barrier elements
Economic and financial	Limited budget and financial support from government on the promotion/extension	Limited budget and financial support on: - **R&D including piloting/demonstration** - **Development guidelines including best practices** - **Information dissemination and awareness raising** - **Development strategy and plan** - **Policy for promotion/extension** - **HRD as well as knowledge and skills for promotion/extension** - **Review, M&E**	US$ 0.25 million per year shortage for investing in crop diversification
Policy, legal and regulatory	Incomplete legal and regulatory framework	No decree or regulation on crop diversification to provide clear definition, principles and procedures for promotion and management for climate change adaptation	About US$ 0.07 million per year shortage for formulation of the degree or regulation and US$ 0.08 million per year for M&E of the degree or regulation implementation
		Lack of comprehensive policy on financial incentives, subsidy or fund for agriculture technology including crop diversification	About US$ 0.05 million per year shortage for formulation and implementation of the policy
Institutional and organisational	Ineffective coordination between education, research and partitioning organisations (HR demand and supply)	Uncoordinated education and research crop diversification and application	About US$ 0.08 million was shortage for formulation of the strategy and plans, and US$ 0.06 million per year for M&E of strategies and plans implementation including staffing and capacity building

Broad categories of barriers	Barriers within a category	Elements of barriers	Dimension of Barrier elements
capacity and human skills	Lack of crop diversification development strategy, M&E and reporting systems		
	Limited technical capacity and skills	Limited skills on HRD systems including (1) HDR planning, (2) capacity needs assessment, (3) staff information and knowledge map/management, (4) effective recruitment and staffing, and (5) management of human resources demand and supply	About US$ 0.05 million per year has been shortage for development of efficient skills on HRD
		Lack of technical skills on the development of crop diversification systems, especially (1) R&D on optimal systems including tree-crops components for generation of optimum economic and adaptation, (2) financial and economic models including entrepreneurship and (3) marketing of products and service	About US$ 0.07 million per year has been shortage for the development of skills on optimal crop diversification systems and business including marketing
	Lack of resource materials on crop diversification	Handbook and guidelines including best practices on different types of crop diversification systems	About US$ 0.035 million per year has been shortage for the development and facilitation of the application of the handbook and guidelines including best practices
Information and awareness	Insufficient information on crop diversification	Insufficient information on (1) existing crop diversification systems and performance, (2) optimal or suitable systems including land/soil- tree-crops components or combination, (3) cost-benefits and return on investment of each system, (4) adaptation potential or capacity of each system	About US$ 0.07 million per year has been shortage for information R&D including capacity building
	Inadequate and ineffective and information dissemination and awareness raising	Inadequate and ineffective and information dissemination and awareness raising about crop diversification best practices/methods/technologies, models and guidelines	About US$ 0.06 million per year has been shortage for R&D of best practices/methods and materials for effective awareness raising

Broad categories of barriers	Barriers within a category	Elements of barriers	Dimension of Barrier elements
Technical	Difficult to define and evaluation the effects of optimal crop diversification systems	It is difficult, time consuming and costly for defining and evaluating optimal crop diversification systems, especially trade off and adaptation capacity amongst crop diversification systems	About US$ 0.08 million per year has been shortage for R&D and capacity building on R&D and evaluation of optimal systems including financial, economic and mitigation trade off amongst crop diversification systems
Other			

2. Decomposition of the key barriers on climate risk and resilient agriculture subsidy

Broad categories of barriers	Barriers within a category	Elements of Barriers	Dimension of Barrier elements
Economic and financial	Inadequate budget for establishment and extension of agriculture subsidy	National budget deficit	- **National budget deficit was 4.98% (US$ 0.27 billion) for 2005-2010 and 4.07% (US$ 0.38 billion) for 2011-2014.** - **Budget demand for subsidy was about US$ 18 million per year during 2010-2015, but no subsidy was allocated.**
	Ineffective and imbalanced investment prioritisation and budget allocation	Ineffective and imbalanced public investment prioritisation and budget allocation	The public investment 2011 and 2015 were economic sector (30%), infrastructure (35%), education (17%), health (9%) and the rest were for other sectors including natural resource and environment.
		Agricultural loans by agricultural and Nayobai bank went to medium class and better off and none-climate risk farmers rather than poor and climate risk farmers	Perhaps 70% of loans went to medium class and better off and none-climate risk farmers and 30% was accessible by poor and climate risk farmers
	Inadequate capacity to conduct feasibility study	Inadequate capacity, R&D on feasibility study including crops to be subsidised, financial needs and sources, analysis of	No specific feasibility of agriculture subsidy

Broad categories of barriers	Barriers within a category	Elements of Barriers	Dimension of Barrier elements
	including financial and economic analysis of agriculture subsidy	financial and economic e.g., cost-benefit, impact and sustainability of agriculture subsidy, which are difficult to make decision on agriculture subsidy	
	High cost of climate resilient technologies	High cost of climate resilient technologies: - **Infrastructure and facilities e.g., irrigations, warehouse, greenhouse/shadehouse and road** - **Processing and drying facilities and equipment**	At least US$ 4.7 million per year is required for subsidy climate resilient technologies or 25-40% to be subsidised for initial stage (1-4 years)
Policy, legal and regulatory	Incomplete policy, decree and regulation on agricultural development fund and subsidy	Lack of definition, principles, procedures, types and sources of funds for subsidy, criteria, organisation and policy measures for agricultural subsidy	At least US$ 0.35 million shortage for improvement of legal framework including capacity building
Institutional and organisational capacity and human skills	Unclear responsibility amongst relevant organisations and departments on development and management of agricultural subsidy as a result of climate induced loss and damage	Unclear responsibility amongst DDMCC of MoNRE, department of agriculture of MAF and disaster relief of MoLSW on development and management of agricultural subsidy as a result of climate induced loss and damage	At least US$ 0.04 million per year shortage for improvement organisation and system
		Department of agriculture of MAF has not has specific division to be responsible for development and management of agricultural fund and subsidy	
	Inadequate knowledge and skills on the development and management of agricultural development fund and subsidy	Inadequate capacity, R&D on feasibility study including crops to be subsidised, financial needs and sources, analysis of financial and economic e.g., cost-benefit, impact and sustainability and models for agriculture subsidy, crops insurance	About US$ 0.30 million per year shortage for technical capacity
		Insufficient skills on the development of policy for management of agricultural development fund and subsidy	

Broad categories of barriers	Barriers within a category	Elements of Barriers	Dimension of Barrier elements
		Insufficient skills to study risks of agriculture production and products related with climate change, disaster and others in order to support design appropriate subsidy schemes	
Technical	Lack of agriculture subsidy models/reference project		About US$ 2.7 million shortage for piloting including R&D and capacity building
Information and awareness	Inadequate information about risks of agriculture production and products related with climate change, disaster and others		About US$ 0.12 million per year shortage for research, information and awareness raising on climate change and disaster impact on agriculture sector
	Lack of information about agriculture subsidy practice, models, cost-benefit, impact and sustainability and models for agriculture subsidy, crops insurance		

3. Decomposition of the key barriers on crop diversification

Broad categories of barriers	Barriers within a category	Elements of barriers	Dimension of Barrier elements
Economic and financial	Limited budget and financial support from government on the promotion/extension	Limited budget and financial support on: - **R&D including piloting/demonstration** - **Development guidelines including best practices** - **Information dissemination and awareness raising** - **Development strategy and plan** - **Policy for promotion/extension** - **HRD as well as knowledge and skills for promotion/extension** - **Review, M&E**	US$ 0.25 million per year shortage for investing in crop diversification

Broad categories of barriers	Barriers within a category	Elements of barriers	Dimension of Barrier elements
Policy, legal and regulatory	Incomplete legal and regulatory framework	No decree or regulation on crop diversification to provide clear definition, principles and procedures for promotion and management for climate change adaptation	About US$ 0.07 million per year shortage for formulation of the degree or regulation and US$ 0.08 million per year for M&E of the degree or regulation implementation
		Lack of comprehensive policy on financial incentives, subsidy or fund for agriculture technology including crop diversification	About US$ 0.05 million per year shortage for formulation and implementation of the policy
Institutional and organisational capacity and human skills	Ineffective coordination between education, research and partitioning organisations (HR demand and supply)	Uncoordinated education and research crop diversification and application	About US$ 0.08 million was shortage for formulation of the strategy and plans, and US$ 0.06 million per year for M&E of strategies and plans implementation including staffing and capacity building
	Lack of crop diversification development strategy, M&E and reporting systems		
	Limited technical capacity and skills	Limited skills on HRD systems including (1) HDR planning, (2) capacity needs assessment, (3) staff information and knowledge map/management, (4) effective recruitment and staffing, and (5) management of human resources demand and supply	About US$ 0.05 million per year has been shortage for development of efficient skills on HRD
		Lack of technical skills on the development of crop diversification systems, especially (1) R&D on optimal systems including tree-crops components for generation of optimum economic and adaptation, (2) financial and economic models including entrepreneurship and (3) marketing of products and service	About US$ 0.07 million per year has been shortage for the development of skills on optimal crop diversification systems and business including marketing

Broad categories of barriers	Barriers within a category	Elements of barriers	Dimension of Barrier elements
	Lack of resource materials on crop diversification	Handbook and guidelines including best practices on different types of crop diversification systems	About US$ 0.035 million per year has been shortage for the development and facilitation of the application of the handbook and guidelines including best practices
Information and awareness	Insufficient information on crop diversification	Insufficient information on (1) existing crop diversification systems and performance, (2) optimal or suitable systems including land/soil- tree-crops components or combination, (3) cost-benefits and return on investment of each system, (4) adaptation potential or capacity of each system	About US$ 0.07 million per year has been shortage for information R&D including capacity building
	Inadequate and ineffective and information dissemination and awareness raising	Inadequate and ineffective and information dissemination and awareness raising about crop diversification best practices/methods/technologies, models and guidelines	About US$ 0.06 million per year has been shortage for R&D of best practices/methods and materials for effective awareness raising
Technical	Difficult to define and evaluation the effects of optimal crop diversification systems	It is difficult, time consuming and costly for defining and evaluating optimal crop diversification systems, especially trade off and adaptation capacity amongst crop diversification systems	About US$ 0.08 million per year has been shortage for R&D and capacity building on R&D and evaluation of optimal systems including financial, economic and mitigation trade off amongst crop diversification systems
Other			

4. Decomposition of the key barriers on climate resilient agricultural infrastructure

Broad categories of barriers	Barriers within a category	Elements of Barriers	Dimension of Barrier elements
Economic and financial	Inadequate budget and investment on the	Inadequate budget and investment in development new climate resilient agriculture infrastructure	More than 50% of budget was shortage

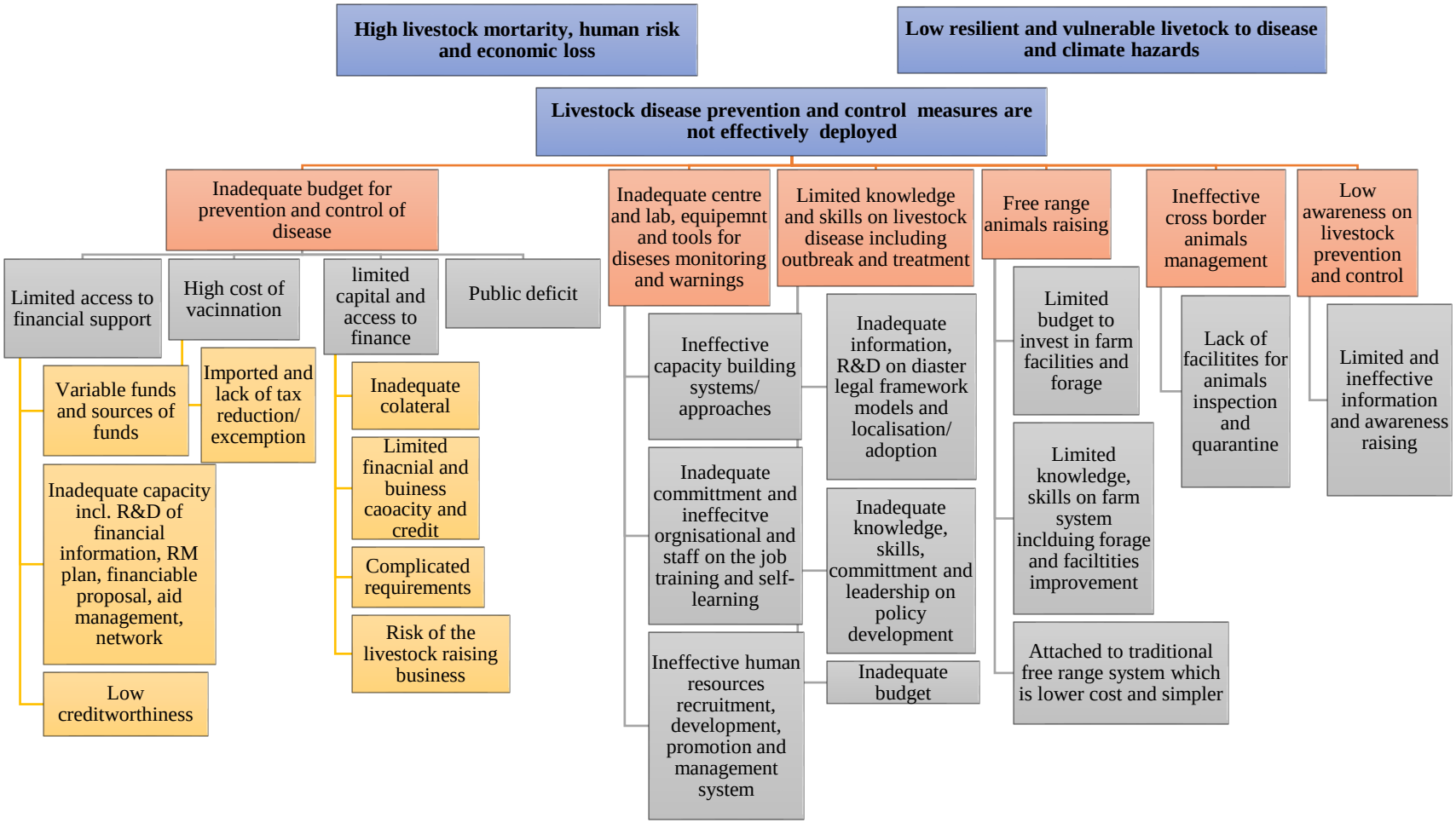
Broad categories of barriers	Barriers within a category	Elements of Barriers	Dimension of Barrier elements
	promotion, development and management of climate resilient agriculture infrastructure	Inadequate budget and investment in maintenance agriculture infrastructure	
		Inadequate budget and investment in development of policy, strategy and plan	
		Inadequate budget and investment in extension/ promotion, marketing and awareness and mainstreaming climate resilient agriculture infrastructure	Additional budget, at least 15-30% is needed for climate resilient technologies/equipment compare to normal agriculture infrastructure
	Difficult to secure budget and investment from public budget	National budget deficit so that climate resilient water supply system was insufficiently financed	- **National budget deficit was 4.98% (US$ 0.27 billion) for 2005-2010 and 4.07% (US$ 0.38 billion) for 2011-2014.** - **Annual budget required for agriculture infrastructure was about US$ 40 million for 2011-2015. About US$ 30 million was underfinanced.** - **Annual budget required for climate resilient agriculture infrastructure or integration was about US$ 10 million for 2011-2015, and none was financed.**
		Limited financial support from development partners and international organisations	Few projects climate resilient agriculture infrastructure were just funded recently
	Inadequate feasibility study including financial and economic analysis e.g., cost-benefit ratio or return on investment of all climate resilient agriculture infrastructure	Inadequate assessment or review of financial and economic analysis e.g., cost-benefit ratio or return on investment of existing agriculture infrastructure	Most of the agriculture infrastructure have not been reviewed or evaluated its climate resilience and cost. About US$ 0.15 million per year shortage for review and evaluation including capacity building, research
		Inadequate feasibility study of financial and economic analysis e.g., cost-benefit ratio or return on investment of new climate resilient agriculture infrastructure	
	Ineffective and insufficient resources	No resources mobilisation plan for climate resilient agriculture infrastructure	

Broad categories of barriers	Barriers within a category	Elements of Barriers	Dimension of Barrier elements
	mobilisation for climate resilient agriculture infrastructure	Limited capacity to research and identify financial sources and feasibility to access	About US$ 0.15 million per year shortage for capacity building, research and facilitation to more effective resources mobilisation.
		Limited capacity to develop financeable project proposal including financial and economic analysis e.g., cost-benefit ratio or return on investment	
	High investment cost for climate resilient technologies	High investment cost for climate resilient equipment, imported tax, capacity or consultancy	Additional budget, at least 15-30% is needed for climate resilient technologies/equipment compare to normal water supply system equipment
Market failures and imperfection	Ineffective promotion/ extension and push demand/needs for climate resilient agriculture infrastructure	Inadequate reference project and models on successful climate resilient agriculture infrastructure	About US$ 2 million shortage for reference project and models on successful climate resilient agriculture infrastructure and US$ 0.20 million per year shortage for extension including development guidelines
		Inadequate information on feasibility, financial and economic information such as CBR on climate resilient agriculture infrastructure	
		Inadequate guidelines for climate resilient agriculture infrastructure	
Policy, legal and regulatory	Incomplete policy on climate resilient infrastructure and technology including agricultural infrastructure and technology	Lack of definition, principles, procedures and measures, and organisation responsibility for development and management of climate resilient agriculture infrastructure	At least US$ 0.09 million per year shortage for improvement of legal framework including capacity building
		Incomplete policy on the promotion including financial and economic incentives and subsidy on climate resilient agriculture infrastructure	
Network failures	No specific expert group on climate resilient infrastructure	Small number of climate resilient infrastructure including agriculture experts and lack of platform for exchanges	About US$ 0.05 million shortage per year for enhancement of coordination and networking.
Institutional and	Incomplete strategy and plan to develop climate	Lack of systematic review of agriculture sector and resilient infrastructure and technologies	US$ 0.08 million per year shortage for development of strategy, planning, M&E and reporting

Broad categories of barriers	Barriers within a category	Elements of Barriers	Dimension of Barrier elements
organisational capacity and human skills	resilient agriculture infrastructure	Inadequate information on climate impact (technical and socioeconomic and environment) on and resilience capacity of agriculture infrastructure	
		Inadequate information, knowledge and skills analyse and promote suitable climate resilient technologies/equipment	
	Limited knowledge and skills to design, develop and apply sustainable and climate resilient agriculture infrastructure	Insufficient skills on organisational and HRD and system on climate resilient agriculture including infrastructure and technologies	About US$ 0.35 million per year shortage for technical capacity
		Insufficient technical skills to design, develop and apply sustainable and climate resilient agriculture including infrastructure and technologies	
		Insufficient technical skills to develop policy and regulation on climate resilient technologies /infrastructure	
		Insufficient technical skills to study climate and disasters risk and impact on agriculture sector and including infrastructure and technologies	
		Insufficient technical skills on R&D of climate resilient technologies /infrastructure	
		Insufficient technical skills on construction standard, inspection, quality assurance and control of agriculture infrastructure and technologies	
Information and awareness	Inadequate information and maps of climate and disasters risk and impact on agriculture sector and including infrastructure and technologies		About US$ 0.08 million shortage for R&D and information

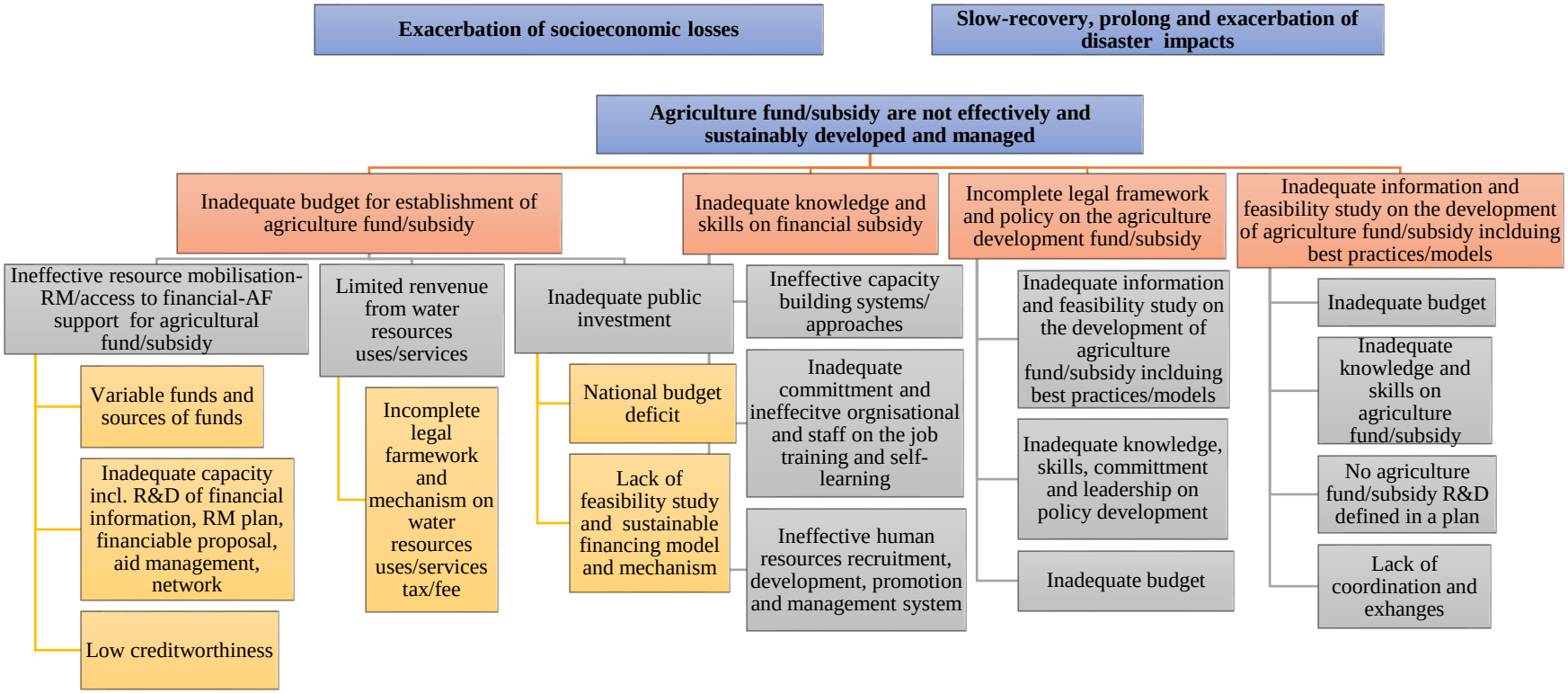
Annex 9 Problem trees of adaptation technologies in agriculture sector

1. Prevention and control of livestock disease

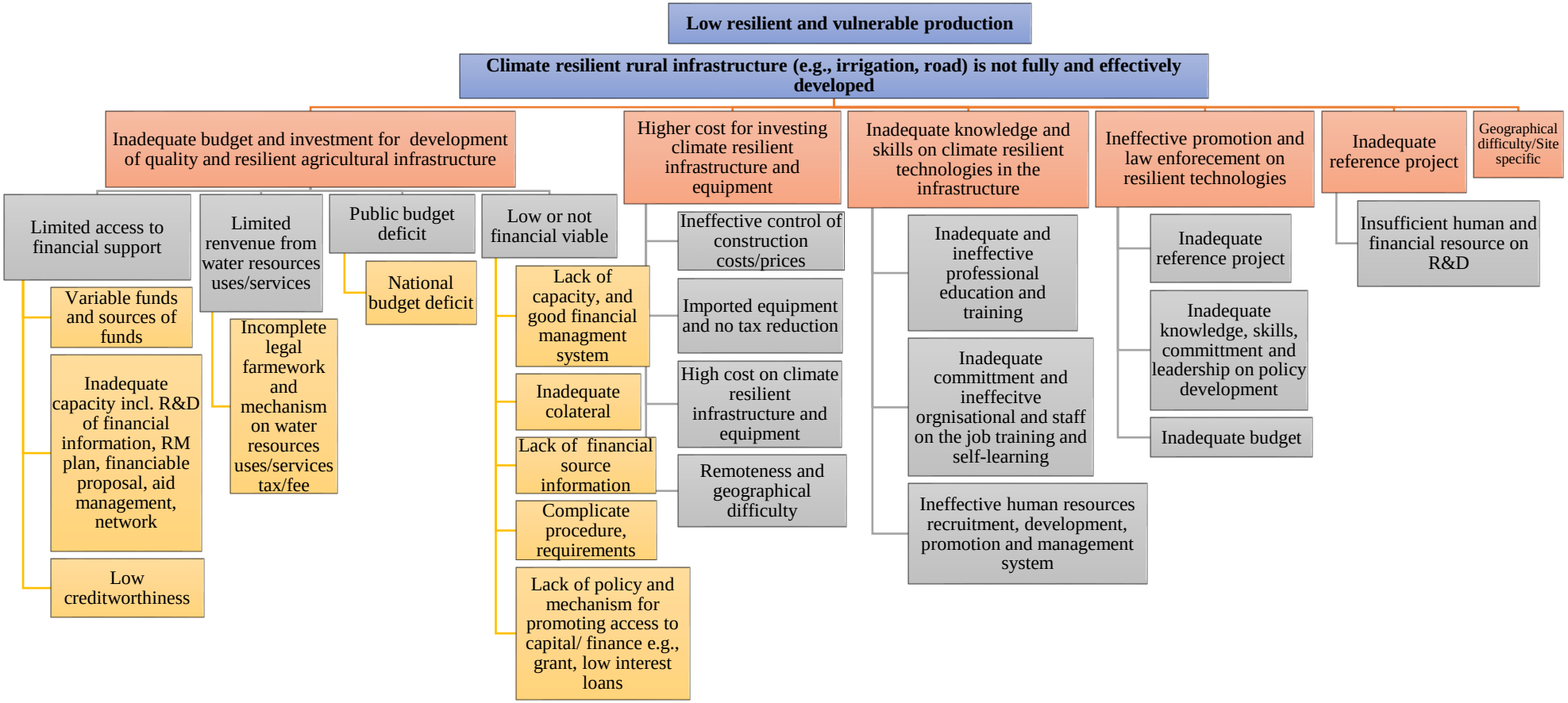


Low

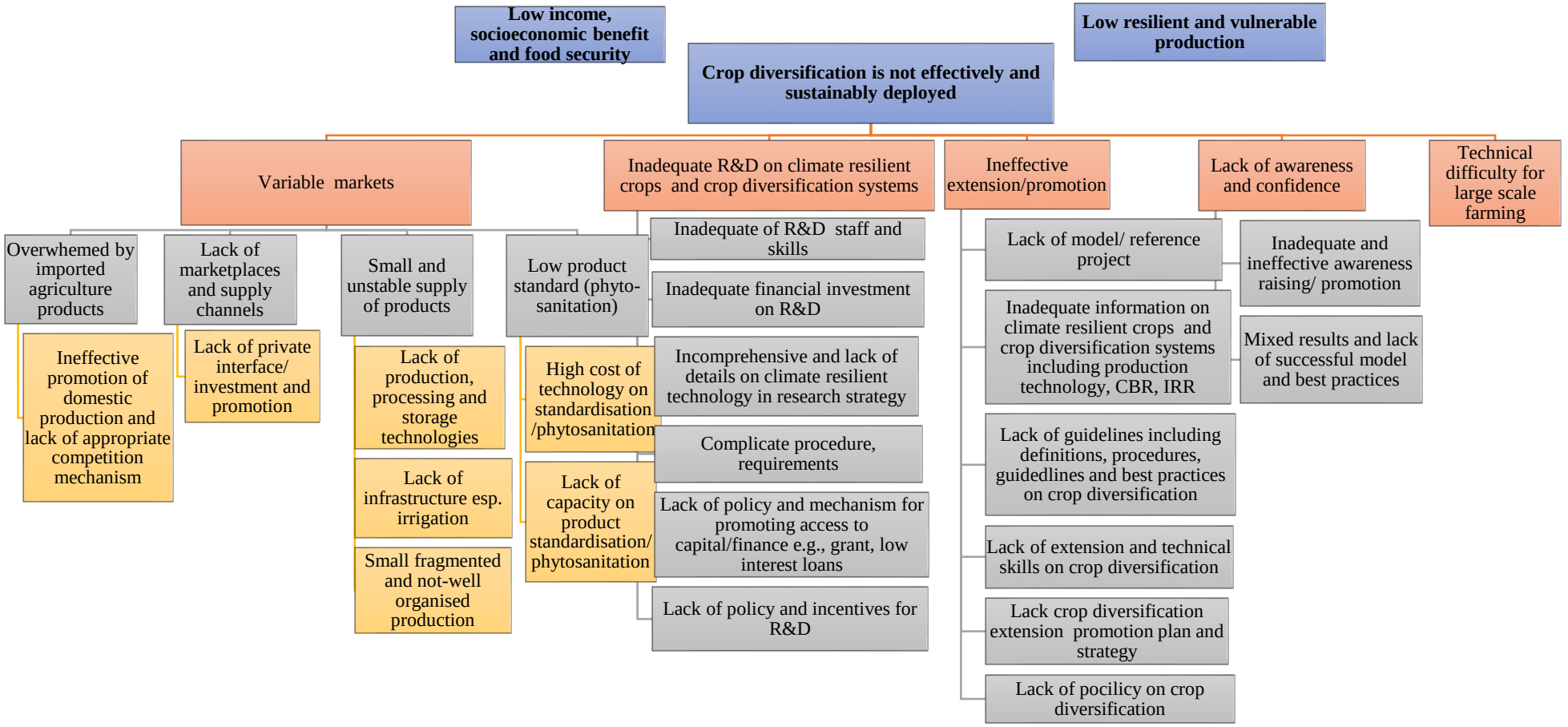
2. Agriculture development fund/subsidy



3. Rural and agricultural climate resilient infrastructure



4. Crop diversification



Annex 10 Knowledge and skills gaps on adaptation technologies in agriculture sector

1. Key knowledge and skills on the development of animal disease surveillance and early warning systems

I	Surveillance and EWS components	Capacity gaps
1	Risk knowledge	Inadequate knowledge and skills to identify of disease, pattern and characteristics of epidemics, risks and impacts including economic and health impacts
2	Monitoring and detection of disease	Inadequate skills and experiences to develop and apply technologies for assessment of climate-sensitive disease hotspots mapping and outbreak.
3	Communication and dissemination of warning message	Inadequate knowledge and skills to: - Research and develop effective and best practice on the communication and reporting - Develop SOP and best practice guidelines for communication
4	Response capacity	Limited knowledge and skills to: - Develop and implement preparedness or response plans - Assess preparedness or response capacity, - Develop SOP and best practice guidelines for response.
5	Institutional arrangements	Limited knowledge and skills to research and develop effective coordination mechanism among stakeholders
II	**Other management skills**	**Capacity gaps**
1	Extension/promotion and marketing	- Feasibility study including financial and economic analysis such as cost and benefit or return on investment - R&D of practical guidelines including best practices on disease surveillance and EWS - Research and develop mechanism and methods for effective awareness raising on the important and advantage of the disease surveillance and EWS
2	Planning and management	- Strategic and integrated planning (socioeconomic, land use, urban, watershed) - HRD system and capacity development planning - Disease surveillance and EWS review and M&E
3	Resources mobilisation	- Bankable proposal - Identification and analysis of financial or funding sources and feasibility - Establish financial aid M&E system
4	Policy	- R&D of Disaster and climate change law and regulation including its impact - R&D of regulation or policy on disease surveillance and EWS including its impact - R&D of policy on integrated planning (for mainstreaming disaster and climate change in the development planning)
5	Cooperation and coordination to create enabling environment for EWS	- Cooperation and coordination planning - Stakeholder engagement - Leadership

2. Knowledge and skills gaps on agricultural subsidy

No	Main categories	Specific elements and aspects of subsidy skills
1	Financial and economic/access to finance and resources mobilisation	- Inadequate knowledge and skills assess (1) financial needs for subsidy, (2) feasibility (financial, economic and policy) including cost-benefit, (3) research and develop of effective subsidizing models or mechanism, and (4) impact or trade-off of subsidies - Inadequate skills to mobilise resources, especially development of financeable proposal, identification and analysis of financial or funding sources and feasibility and establish subsidy M&E system
2	Technical	- Inadequate skills to study and identify agricultural products, crops and livestock suitable to be subsidized and how or what principle, procedure, criteria and guidelines are needed for subsidizing - Inadequate skills to research and develop effective mechanism and methods for raising awareness about subsidy
3	Policy	Inadequate knowledge and skills to research and develop policy on agriculture subsidy (e.g., principle, procedure, criteria and guidelines for subsidizing)
4	Organisational	Inadequate skills to review, research and develop effective organisation structure and arrangement for effective management and operation of the subsidy mechanism

3. knowledge and skill gaps on crop diversification

No	Categories	Elements of knowledge and skills
1	Financial and economic	Inadequate knowledge and skills to assess (1) feasibility including cost-benefit and return on investment, and (2) financial needs for adaptation or enhancing resilience of each crop diversification systems
2	Technical	Inadequate knowledge and skills to 1) assess vulnerability and adaptive capacity or resilience of existing crop diversification systems, 2) R&D of effective or best practices crop diversification systems for adaptation, 3) agro-ecology and hazard mapping, 4) develop curriculum or training module on crop diversification for adaptation, and 5) biotechnological skills for improvement of climate resilience crop variety
3	Policy	Inadequate knowledge and skills to research and develop policy on the promotion of environmentally friendly and climate change adaptation technology including crop diversification in agriculture sector and activities
4	Resources mobilisation	Inadequate skills to develop: - Bankable proposal - Identification and analysis of financial or funding sources and feasibility - Establish financial aid M&E system
5	Extension/promotion and marketing	Inadequate skills to research and develop mechanism and methods for effective awareness raising on the importance and advantage of environmentally friendly and climate change adaptation technology including crop diversification
