LAO PEOPLE'S DEMOCRATIC REPUBLIC

TECHNOLOGY NEEDS ASSESSMENTS REPORT

CLIMATE CHANGE ADAPTATION

April 2013

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Technology Needs Assessments Report - Climate Change Adaptation

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DISCLAIMER

This document is an output of the Technology Needs Assessment project, funded by the Global Environment Facility (GEF) and implemented by the United Nations Environment Programme (UNEP) and the UNEP-Risoe Centre (URC) in collaboration with the Regional Centre Asian Institute of Technology, Bangkok for the benefit of the participating countries. The present report is the output of a fully country-led process and the views and information contained herein are a product of the National TNA team, led by the National Disaster Management and Climate Change of the Ministry of Natural Resources and Environment.

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Abbreviations and Acronyms

AIT	Asian Institute of Technology
CO2	Carbon Dioxide
DNDMCC	Department of National Disaster Management and Climate Change
EST	Environmentally Sound Technology
FNC	First National Communication on Climate Change to the UNFCCC
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
IPCC	Intergovernmental Panel on Climate Change
LDC	Least Developed Country
LUCF	Land Use Change and Forestry
MDGs	Millennium Development Goals
MAF	Ministry of Agriculture and Forestry
MEM	Ministry of Energy and Mining
MPI	Ministry of Planning and Investment
MIC	Ministry of Industry and Commerce
MONRE	Ministry of Natural Resources and Environment of Lao PDR
MPWT	Ministry of Public Work and Transport
MRC	Mekong River Commission
NAFRI	National Agriculture and Forest Research Institute
NUOL	National University of Laos
NGO	Non-governmental Organization
NTFP	Non-Timber Forest Products
REDD	Reducing Emissions from Deforestation and Forest Degradation
SNC	Second National Communication to on Climate Change the UNFCCC
TAP	Technology Action Plan
TNA	Technology Needs Assessments
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
URC	UNEP Risoe Centre

Executive Summary

The technology needs assessment for climate change adaptation includes selection of the priority sector and technologies for adaptation of greenhouse gas. The sector selection and technology prioritization was carried out through review of the status and trend of climate change vulnerability and impact in different sectors, existing adaptation technologies and stakeholders consultation together with the use of multi-criteria and scoring for prioritization. The review of the climate change vulnerability and impact status and trends including existing adaptation technologies mainly focussed on assessment and summary of the climate change vulnerability and impact and technologies described in the First and Second National Communication on Climate Change-FNC and SNC (STEA, 2000 and MoNRE, 2012), National Adaptation Programme of Action (WREA, 2009), Strategy on the Climate Change of the Lao PDR-SCC (WREA, 2010), National Socioeconomic Development Plan of the Lao PDR 2011-2015 (MPI, 2011) development plans[1] of different sector including information on the adaptation technologies elsewhere such as IPCC Assessment Report (IPCC, 2007), handbook[2] and website[3]. The stakeholder consultation particularly sector selection and technology prioritization workshops were held in February and May 2012 which were participated by public sector, research institutions, academic and international organizations. In total not less than 24 departments or organizations and 35 participants participated. The multi-criteria which wereapplied in the sector and technology prioritization are broadly divided into four main categories namely adaptation potential, economic, social and environment benefits. These criteria are mainly originated from the criteria recommended in Technology Needs Assessment (TNA) handbook (UNDP and UNFCCC, 2010) but they were edited and elaborated particularly in theselector selection and technology prioritization workshops. In the prioritization of the sector and technology, those criteria were weighted and scored based on the multi-criteria techniques (Communities and Local Government, 2009).

Through the stakeholder process involving scoring on the criteria based on expert judgments; two sectors and eight technologies are chosen as priority sectors and technologies needs for climate change adaptation respectively. The sectors are water and agriculture sector and eight technologies, four technologies each for water and agriculture sector were summarized as follows:

Adaptation technologies for water sector:

[1] For example: Water Resource Strategy to the year 2020 of the Lao PDR (WREA, 2010) and Agriculture Development to the year 2020 for agriculture sector (MAF, 2011) etc.

[2] For handbook on the Technologies for Climate Change Adaptation: the Water Sector (UNEP, 2011)

[3]For example: http://climatetechwiki.org/

Four adaptation technologies for water sector consist of Early Warning System, Disaster Impact Reduction Fund, Climate Change Oriented Irrigation and Water Supply System.

Early Warning System:

is pre-requisite for flood prevention. It involved with setting up system weather forecast, modeling of discharge, water gauges, information dissemination tools provide the information to society or community including enhancement of readiness or preparedness and recovery plan for minimizing impacts that would be caused by extreme event including flood. This technology is practiced in Laos years ago by different stakeholders but it is not systematically functioning due to shortage of financial support, knowledge and skills on the system including equipments and tools. However it is priority of the country as defined on the socioeconomic development plan 2011-2015 (MPI, 2011), Strategy on Climate Change of the Lao PDR (WREA, 2010), National Disaster Management Master Plan and so son. With system in place, it is expected that the impacts which may result from disasters particularly flood including flash flood could be minimized; leading prevention property and life of the people from losses.

Disaster Impact Reduction Fund:

To complement the early warning system, disaster management fund or impact reduction fund should be established. Previously fund for recovery after disasters were insufficient as mobilization of fund was on the ad hoc basis and lack of fund mobilization mechanism; leading the flood impacts are prolonged and or chronic. So a specific and ready fund is needed for increase effectiveness of the prevention and handling with such disaster in timely manner. The disaster fund management should include fund raising and management mechanism, responsible organizations and networks in all level, from central to village. With such fund and mechanism in place, it is expected that impacts that would result from disasters particularly flood including flash flood could be largely minimized while adaptive capacity can be enhanced.

River Basin or Watershed Management:

The river basin or watershed is of significance for environment and socioeconomic development including climate change adaptation. To sustain water resource and ensure environment and socioeconomic development, practical tools should be in place. Recently, Integrated Water Resources Management (IWRM) which embedded participatory techniques and multi-disciplinary approach is developed and perceived as a key tool for realize such sustainability including climate change adaptation. Similarly, strategy on water resources management of Laos also defined to apply IWRM for all river basin and watershed management. Till now, there are some initiatives on the application of IWRM

particularly for Nam Ngum and Nam Theun-Kading river basin. In addition, by 2015, at least 5 river basins such as Sebangfai, Sebanghieng, Sekong, Sedone and Nam Ouwill be completed its IWRM and management committee. So prioritization of this technology means support for implementation of water resources policy including food and nutrition security, pervert reduction, environmental, renewable energy development, climate change mitigation and adaptation.

Water Supply System:

The water supply system means set of water reservoir and supply system such as Nampapa and gravity water supplies including water use group and management mechanism. Currently, only 77 percent of people have access to clean water and 54 have access to sanitary toilets (MPI 2011), so to realize targets defined in the MDG, Laos needs more investment in this area and design the system in the climate change context. So prioritization of this water supply system in TNA is expected to enhance investment, management mechanism and water supply system as well as increase access to clean water of Lao people including health and sanitation improvement.

Adaptation technologies for agriculture sector:

Throughout the prioritization process particularly the scoring against criteriaand consultation of the stakeholders; four technologies which received highest scores are selected as priority technology needs for climate change adaptation in the agriculture sector. Those technologies are:

1) Livestock disease prevention and control;
2) Agricultural Development Subsidy Mechanism;
3) Climate Resilient Rural Infrastructure and
4) Crop Diversification.

Livestock disease prevention and control:

Livestock is one of foundation of socioeconomic and livelihood of farmers. Recently disease outbreak has become a challenge for Lao farmers and also government. Every year impacts caused by diseases lead to loses of productivity, income, uncertain food security and negative impacts on human health. The changes of climate are anticipated to exacerbate the situation due to increasing temperatures which can support the expansion of vector populations and thereby risk of diseases into cooler areas. Therefore, livestock disease prevention and control which covers management of livestock import and transportation, monitoring and control of diseases outbreaks, developing and improving antibiotics, vaccines and diagnostic tools, evaluation of ethnotherapeutic options, and vector control techniques including improvement of livestock health are of important for enhancement of adaptive capacity to changing

climate and ensuring productivity including minimization of economic losses, environmental and human health impacts.

Agricultural development subsidy mechanism:

It is the fact that the key obstacle of the development in Laos associates with adequate and effective subsidy and financial support. As of now, the agriculture subsidy and insurance is not well-established or sustainable. The production under changes of climate and its related disaster can add more risks for farmers and stakeholders. So, agricultural development subsidy mechanism including insurance against crop loss and market fails is pre-requisite for agriculture development of Laos. The subsidy mechanism in this context include agricultural subsidy, development fund and or easy credits, insurance for production failure not only because of climate change, flood or drought but also due to failure of market and production technology that particularly beyond farmer's capacity to handle. Without this mechanism in place, Laos may not be able to realize its policies and targets on agriculture production, development of agricultural based industry process, improvement of people livelihood and poverty reduction timely.

Climate resilient rural infrastructure:

The agriculture development is beyond dependence on fertile land, water, weather and cultivation technologies. The infrastructure such as irrigation networks, road, warehouse, transportation, and markets system is also critical factor for the development particularly quality, durable and tolerance to changing climate and disaster. This infrastructure is insufficient and or poor conditions particularly in the rural area. Although the rural infrastructure is the priority of the government due to limited financial resource, the development is slowly going. So if investment is not taken place sufficiently and effectively, agriculture development and adapting to climate change can be at risk or ineffective; lead to loss of production as well as economics and quality of life of farmers.

Crop Diversification:

The crop diversification is fundamental for agriculture development and conservation of biodiversity. Despite it is in the initial stage of development and numbers of efforts are needed to research, develop and deploy such technology in order to effectively contribution to sustainable productivity including climate change resilience and conservation of biodiversity.

Chapter 1. Introduction

1. 1 About the TNA project

The current Global Technology Needs Assessments (TNA) project is implemented under the Poznan Strategic Program on Technology Transfer and is supporting 36 countries, and one of them is Lao PDR. The project is funded by the Global Environment Facility (GEF) and implemented by the United Nations Environment Programme and UNEP Risoe Centre (URC) and technical support is provided by the Asian Institute of Technology (AIT). The objective of the project is to help to carry out improved Technology Needs Assessments within the framework of the UNFCCC. The project is being implemented in two rounds, with 15 countries engaged in the first round and the remaining 21 countries in the second round. Lao PDR as a second round country started the project in June 2011 and scheduled to complete in February 2013. The Ministry of Natural Resources and the Environment (MoNRE) is responsible for the execution of the project in the country. However, there are number of ministries and organizations involved and Chapter 2 will dwell on the in-country institutional structure created to implement the project.

The purpose of the TNA project is to assist participant developing country Parties to identify and analyze priority technology needs, which can form the basis for a portfolio of environmentally sound technology (EST) projects and programmes to facilitate the transfer of, and access to, the ESTs and know-how in the implementation of Article 4.5 of the UNFCCC Convention. Hence TNAs are central to the work of Parties to the Convention on technology transfer and present an opportunity to track an evolving need for new equipment, techniques, practical knowledge and skills, which are necessary to mitigate GHG emissions and/or reduce the vulnerability of sectors and livelihoods to the adverse impacts of climate change. The main objectives of the project are:

- To identify and prioritize through country-driven participatory processes, technologies that can contribute to adaptation and adaptation goals of the participant countries, while meeting their national sustainable development goals and priorities (TNA);
- To identify barriers hindering the acquisition, deployment, and diffusion of prioritized technologies;

- To develop Technology Action Plans (TAP) specifying activities and enabling frameworks to overcome the barriers and facilitate the transfer, adoption, and diffusion of selected technologies in the participant countries.

1.2 Existing national policies about climate change adaptation and development priorities

Key existing national policies on climate change adaptation include the overall strategies and plan on the adaptation; specific strategies and plans on climate change adaptation of vulnerable sectors such as water resources, agriculture, health and disaster; and other relevant strategies and plans that also aim at addressing climate change impacts and or enhance adaptation capacity.

The overall strategies and plan on the adaptation include the National Adaptation Programme of Action (WREA, 2009) and the Strategy on Climate Change of the Lao PDR (WREA, 2010).

The NAPA, as a consequence of the COP 7 under UNFCCC in 2001 and recognition of Lao government on the challenge of adapting to climate change, was developed and completed in 2009 by the leading of Water Resources and Environment Administration (nowadays Ministry of Natural Resources and Environment) and support from relevant ministries and organizations. The NAPA identified 45 priority projects on climate change adaptation; covering four main sectors namely agriculture, forestry, water and water resources, and public health. Of which 13 projects are under the agriculture sector; 14 projects are under forestry sector, 10 projects are under water sector and 8 projects in the public health sector. Out of 45 priority projects; 12project proposals were categorized as first priority and the rest 33 projects are in the priority two. The priority projects are as in the annex 2.

The Strategy on Climate Change of the Lao PDR (SCC) is the key policy which specifically aims to provide guidance for climate change adaptation and mitigation of the country in a way that promotes sustainable development. It was developed with the leading of Ministry of Natural Resources and Environment (MONRE) and endorsed by Prime Ministers' Office in 2010. This strategy defined directions and specific measures for seven sectors on climate change adaptation and six sectors on climate change mitigation. Those adaptation sectors are (1) agriculture and food security, (2) forestry and land use change, (3) water resources, (4) energy and transport, (5) industry, (6) urban development and (7) public health while mitigation excluded health sector. The key measures include:

- Mainstreaming climate change into the 7th National Socio-Economic Development Plan (NSEDP) 2011-2015 (Lao PDR, 2010) as well as sectoral strategies, programmes and projects;
- Strengthen international partnerships and network for capacity building and development and transfer of technology to support the adaptation and low-carbon growth;
- Enhance capacity as a priority for government agencies, technical institutions, the private sector and local communities to be able to carry out appropriately climate change mitigation and adaptation;
- Enhance synergy and complement in development and implementation of mitigation and adaptation in order to maximize benefits;
- Build the innovative financial mechanism that lead ensure financial support and investment for implementation of mitigation and adaptation action plans;
- Increase awareness, education and community participation in order to mobilize and realize effective climate change mitigation and adaptation.

Recently there are some specific climate change adaptation strategies of vulnerable sector such as climate change adaptation strategy of health sector and disaster master plan. However, to great extend, the agriculture, water resources and forestry sectoral strategies included directions and measures on climate change adaptation.

Climate change adaptation in health sector formulated in 2009 recognizes the risk and challenges to overcome health risks associates with changing climate. Therefore, it identified 6 main objectives and strategies to address such risks and challenges. Those objectives and strategies are:

1. **Conduct research on human health in light of climate change:** this includes identification of a scope of research/study, data and Information development and management;
2. **Control of water, food, vector, rodent borne diseases and health care waste management:** by provision of safe drinking water and improve sanitation, strengthen food sanitation, control malaria, dengue and rodent, promotion of hygiene practices and strengthen health care waste management;
3. **Strengthen health education and communication, and empower people to take actions to reduce individual and community vulnerability to climate changes:** this links with the objective and strategies 1 but more emphasis on education and awareness raising;
4. **Establish, improve, and maintain mechanisms for surveillance and monitoring of climate-related illness, vulnerabilities, protective factors, and adaptive capacities:** includes identification of vulnerable people and health risk, establishment of plan/warning system,

monitoring system including surveillance of vector populations, monitoring & reporting of diseases incidences including skin and eye incidences, improve post-disaster surveillance and health promotion;

5. **Improve the medical intervention:** especially adjust work schedules to avoid heat-stress exposure, establish emergency response plans during heat waves (e.g. by increasing staff & beds in hospitals), improve and maintain public health preparedness and emergency response including tools for local public health facilities to provide rapid health needs, preparation of vaccines and drugs, offering immunization programs and provision of healthcare professionals with information and tools to assist people at risk;
6. **Work in partnership with other agencies for infrastructure development:** especially maintain standards of health service systems, laboratory diagnosis facilities, increase shaded areas in cities and public places, provide accessible public drinking fountains in outdoor public places and accessible air conditioned public facilities and shelters.

The National Strategic Plan for Disaster Risk Management to 2020, formulated in 2003, defined four strategies and six specific objectives for disaster management. Those strategies are (1) safeguarding sustainable development and reducing the impacts and damages caused by natural and manmade disasters; (2) shifting the focus from relief to mitigation of disaster impacts on communities, society and the economy to preparedness and post recovery with emphasis on hazards such as floods, drought, landslides and fires; (3) ensuring that disaster management is a joint responsibility of both the Government and the people, through building of community capacities; and (4) promoting sustainable protection of the environment and the country's natural wealth, including forests, land and water resources.

The specific objectives and actions are described as below:

(1) Ensuring that disaster risk reduction is a national and local priority. by(a) Formulate policies and legislation in support of disaster risk reduction; (b) Create and strengthen a national disaster risk reduction coordination mechanism or platform; (c) Integrate disaster risk reduction into national development policies and planning such as NSEDP; and (d) Allocate appropriate resources for DRR at the national, provincial and community levels.

(2) Strengthening sub-national and community-based disaster risk management. by (a)Decentralizing responsibilities and resources for DRR; (b) Promoting implementation of community-based DRR programmes; and (c) Developing a National Disaster Management Plan that supports activities at provincial, district and village levels.

(3) Identifying, assessing and monitoring hazard risks and enhance early warning. by (a) Conducting periodic national and local risk assessments to ensure that timely response mechanisms are developed; (b) Establishing and maintaining a disaster management information system; (c) Developing and maintaining a multi-hazard early warning system; (d) Collaborating with international and regional disaster risk reduction stakeholders; and (e) Establishing and operationalizing Emergency Operations Centres at national and sub-national levels.

(4) Using innovative knowledge and education to build a culture of safety and resilience. by (a) Establishing mechanisms for information exchange and networking; (b) Promoting disaster risk management education and training; (c) Promoting gender and cultural sensitivity training as integral components of disaster risk management; (d) Undertaking DRR technical and scientific research; and (e) promoting public awareness of hazards, risks and mitigation strategies.

(5) Mainstreaming DRR strategies into policies and programmes of relevant Government Ministries. by (a) Promoting food security to enhance community resilience; (b) Integrating DRR and response preparedness planning into all sectors of relevant Government Ministries; (c) Promoting appropriate structural and non-structural mitigation measures into national building codes; and (d) Developing innovative financial instruments for addressing disaster risks.

(6) Strengthen disaster preparedness for effective response at all levels. by (a) Strengthening national and sub-national capacities for preparedness and response; (b) Developing coordinated regional operational mechanisms for emergencies exceeding national coping capacities; (c) Preparing and periodically updating disaster preparedness and contingency planning; and (d) Establishing emergency funds at national and local levels.

Furthermore, there are other relevant strategies and plans that also covers the climate change adaption such as Environment Strategy to 2020 and Action Plan 2011-2015(STEA, 2004) and The Forestry Strategy to the year 2020 of the Lao PDR (MAF, 2005).

The National Environment Strategy until 2020 and Action Plan 2006-2010 (NES-AP) was formulated in 2004.This strategy focused on overall environmental management and sustainability which is a fundamental for climate change adaptation. The key areas of focused included (1) sustainable management and utilization of natural resources; (2) promotion and enforcement of environmental and social impact assessments; (3) institutional and capacity building; (4) private sector involvement in environmental protection, restoration, and sustainable use of natural resources; (5) promotion of investment in and establishment of financial mechanisms for environmental protection and management; (6) strengthening of regional and international cooperation.

The Forestry Strategy to the year 2020 of the Lao PDR(MAF,2005), endorsed in 2005, aims at promoting sustainable forest resource management and use which is also a means for climate change adaptation. The defined vision in the strategy envisaged to comprise extensive and scientifically well-managed forests and forest resources, managed with the wider participation of society and international cooperation. Such resources would provide socioeconomic benefits to local communities; enhance environmental quality; and promote biodiversity, ecosystem and water resources conservation, as well as sustainable growth of the agriculture, industrial, ecotourism and hydropower sectors. In line with this, nine key programmes of action were proposed:

1) Land and forest use;
2) Production forest;
3) Non-timber forest products;
4) Tree plantation development;
5) Harvest/logging plans and royalties;
6) Wood processing industry;
7) Biodiversity conservation;
8) Protection forest and watershed management;
9) Village land and forest management.

Implementing these programmes effectively is expected to stabilize forest cover at about 70 percent of total land by 2020; to ensure a sustainable flow of forest products for domestic consumption and export; to preserve important biodiversity and unique habitats; to conserve the environment, including soil, watersheds and climate; and ultimately, to contribute to improved livelihoods, revenue and foreign exchange earnings, thereby increasing direct and indirect employment.

Chapter2. Institutional arrangement for the TNA and the stakeholders' involvement

The organizations involved with the implementation of the TNA project can be divided into five main groups;1) steering committee, 2) project management team, 3) technical working group, 4) partners and technical advisor and 5) other stakeholders. The groups' arrangement structure is as shown in the Figure1; the roles and responsibilities of each group are described in the section 2.1anddetail of engagement process is in the section 2.2 respectively.

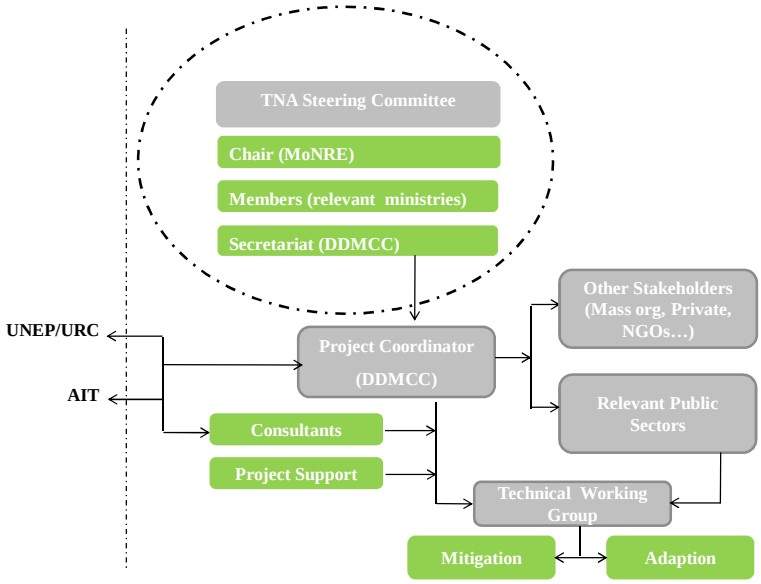

Figure 1 Organization arrangement structure for TNA project implementation.

AIT	*Asian Institute of Technology*
DDMCC	*Department of Disaster Management and Climate Change*
Mass Org	*Mass Organizations*
MoNRE	*Ministry of Natural Resource and Environment*
NGO	*Non-Government Organization*
TNA	*Technology Needs Assessments*
UNDP	*United Nations Development Programme*
UNEP	*United Nations Environment Programme*
URC	*UNEP Risoe Centre*

2.1 National TNA team

As mentioned earlier the TNA project team included project steering committee, project management team, technical working group, partner and advisory, and other stakeholders.

The steering committee is a group of senior and decision making staffs members who were officially nominated for overseeing the project. The committee is chaired by Vice Minister of MONRE and most of committee members are from public organizations particularly MONRE, relevant ministries which mainly were former committee for development of the strategy on climate change and second national communication on climate change (SNC). The main roles and responsibilities of this committee is to overall oversee the implementation of the project, policy alignment and advice, approval the TNA reports including the prioritized sectors and technologies.

The project management team, in general, is Department of National Disaster Management and Climate Change (NDMCC), MoNRE and the overall role and responsibility of this team is to coordinate, implement the TNA project and reporting to the steering committee and UNEP Risoe Centre. The members of the team include the project director, coordination, support staff and consultants who assigned and recruited by the MONRE. The project director is the director of the NDMCC whom main role is to supervises the team. The coordinator is senior staff of the NDMCC and IPCC focal point, responsible for both technical and administrative tasks on daily basis on the facilitation and implementation of the project including working with consultants and coordination with UNEP-Risoe Centre, the Asian Institute of Technology (AIT) and Technical Working Group and Stakeholders. The support staff are administrative staff of the NDMCC responsible for administrative and financial including arrangements of the workshop while the consultant, who was recruited based on selection procedures of MONRE including consultation process with key member of the steering committee and partners, is taking roles and responsibilities on the provision the TNA teams with the process-related and methodological/technical advisory services and facilitation including research, analysis and synthesis needed for the project.

The established technical working group is mainly from same sectors with the steering committees. The roles and responsibilities of the group are to provide technical support particularly ensuring alignment between the prioritized sectors and technologies and their sectoral strategies and or plans, assistance in collecting and providing data relevant to their sectors including technical review and feedback on the TNA reports.

The UNEP-Risoe Centre and Asian Institute of Technology (AIT) is technical advisory body who provides technical support including training, revision and quality control of the TNA report in order to meet the report requirements of the UNEP as well as GEF.

Other stakeholders consist of wide range of organizations, international organizations, private, educational and research institutes and NGO. This group are involved in the project based on their relevance, requirements of MONRE/TNA project and also voluntary. This group is engaged to share the experiences, data, advices and feedbacks including on decision on the sector and technology prioritization.

Annex 1 provides the list of project teams and their belonged ministries and organization.

2.2 Stakeholder Engagement Process followed in TNA – Overall assessment

The stakeholder engagement is key element of the TNA project's success. However, engagement of all stakeholders may not possible or ineffective and inefficient. So this project focused on engagement of only key stakeholders and stakeholder arrangement in project's activity implementation.

The key stakeholders were identified based on their relevance, influence, impacts, voluntary and performance on climate change mitigation, adaptation including mitigation, adaptation technology. As a result, there were 36 organizations; from public, private, international organizations, projects and individual participated in the project. Detail of stakeholders was in the Annex 1. Their participation in the project included project planning, implementation and reporting. During the planning phase, the stakeholders were taking part in particularly inception workshop which project's activity plan was presented, discussed and validated. During project implementation, the stakeholders particularly participated in the prioritisation of the sector and technology on climate change mitigation and adaptation. During reporting the stakeholders involved with report review and validation.

Picture 1: Inception and sector selection workshop in February 2012

Picture 2: Technology prioritization workshop in May 2012

Chapter3. Sector selection

In overall the selection of sector for climate change adaptations was also conducted through literature review of climate change vulnerability and impacts on different sectors in the country, initial sector identification and then selection of sectors through consultation with stakeholders.

The review of climate change vulnerability and impacts was mainly conducted by consultant with support from the project management team. The review, based on the available and accessible data, covered review of the climate change vulnerability and impact in Laos in order to gain insight about the expected climate and vulnerable sectors which helps initial identification of priority sector for adaptation. Detail of the expected climate change in Laos and vulnerable sectors are presented in the section 3.1.

The initial sector identification was similarly conducted by consultant with consultation and support from the project management team. This initial sector identification is to scope or screen critical sector that is susceptive to changing climate and required immediate adaptation. The identification based on the results of the review presented in the section 3.1 and focussed on the key sectors required for climate change adaptation that recommended in national climate change policies, plans of Laos and IPCC. The initial identified sectors were partly described in the section 3.1.4 and used as reference for stakeholder consultation and decision on sector selection in the TNA inception and sector selection workshop which described in the section 3.2.

The selection of sectors was taken place in the TNA inception and sector selection workshop and employed multi-criteria and scoring including expert judgement for assessment and selection of the key sector for climate change adaptation respectively. Detail of process and criteria including result of the sector selection is described in the section 3.2

3.1 An Overview of expected climate change, vulnerability and impacts

Currently, there is limited research on climate change, vulnerability and impacts in Laos. This is due to lack of historical climatic data, financial and human resources for research. However, previous study and assessment such as by Southeast Asia START (SEA START) (2005), Kiem et al (2008), World Food Programme (2007) including observation in the NAPA (2009), Strategy to Climate Change of the Lao PDR and SNC (2012) indicated some aspects of climate change, vulnerability and impacts.

The SEA START (2005) predicted that future temperature change in the LMB region will vary from baseline condition within the range of 1 ºC ~ 2ºC;the region will have longer summer periods with shorter winters. The precipitation is on the rising trend between 10% and 30% throughout the region, with the highest increase in the eastern and southern part of the Lao PDR. Climate variability tends to be more extreme with wider differences in precipitation between dry and wet years, especially in the Lao PDR. In

addition, such as SEA START study also predicted climate change impact on agriculture with the use of Conformal Cubic Atmospheric Model (CCAM) and Decision Support System for Agro Technology Transfers (DSSAT version 4.0) crop modeling software and a result indicated that 10 percent of productivity would be lost in Savanakhet province under CO2 concentration of 540 ppm scenarios.

Kiem et al, (2008) reported that the result of the use of Japan Meteorological Agency atmospheric general circulation model (JMA AGCM) for production of climate scenarios in the Mekong River basin showed that the annual mean precipitation will increase in the 21st century (2080–2099) by 4.2 percent averaged across the basin, with the majority of this increase occurring over the northern MRB (i.e. China). Annual mean temperatures are also projected to increase by approximately 2.6 ºC(averaged across the MRB), leading to significant changes in the hydrology of the Mekong River basin. In addition, all Mekong River basin sub-basins will experience an increase in the number of wet days in the 'future', magnitude and frequency of extreme events such as flood while there is likelihood of reduction of droughts/low flow periods though water extraction would be at a sustainable level.

A study by World Food Program (2007) predicted that 46 percent of the rural population in Lao PDR are vulnerable to drought, most of whom are located in the lowlands, especially in the Southern regions and in the provinces of Xayabury and Luangprabang. Of which, most households vulnerable to drought are farmers or (agricultural)unskilled laborers, 12 percent of agro-pastoralists are also considered vulnerable to drought; leading 2 percent of the population were already chronically food insecure.

According to the Joint Study Team including MAF,WREA, IUCN, ADPC and PAFO, climate change is likely to enhance the severity and frequency of flood and drought in the future. Floods will increase during the rainy season and drought will increase during the dry season (Report of the Joint Study Team including MAF, STEA, IUCN, ADPC,PAFO of Attapeu, January 2005).

According to the data recorded, Lao PDR has already faced the impacts of climate change, particularly from floods, droughts and human health. Basically, over 80 percent of Lao people depend closely on the agriculture practice and natural forest resources sectors for their livelihoods. However, the data reviewed has shown that from 1966 to 2005, climate change causing floods and drought, which affect extreme economics, food security and background infrastructure, example, houses, roads and irrigations value in millions of USD (UNDP 2009). Flooding disaster impacted the central and southern parts of Laos, especially in year 2005, with losses amounting to more than 10 million UA$ in Vientiane (UNDP 2009). Furthermore, the areas of rain-fed rice fields destroyed by flooding were over 65,937 ha in 1995, 67,500

ha in 1996, 42,900 in 2000, 42,223 ha in 2001, and 57,300 ha in 2005. In 2005 and 2006, paddy rice field irrigation systems damaged by flooding costed over 5 million USD. The climate change affecting to flood and drought in Laos not only impacts to the economics of Lao people, but it is also affected directly for rice production shortage and increasing hunger and poverty to Lao people, some detailed data for floods and drought are shown in Table 1.

The climate change impacts not only the Lao economy, agriculture products and livelihoods, but it also creates a public health hazard for both direct and indirect ways to people. For the indirect way, floods and drought which causing from climate change impact to the human health by spreading diseases through dirty water flooded and drought to the people, especially from the people up stream to lower stream. The diseases that usually occur are small pox, malaria, diarrhoea, dysentery, dengue fever and pneumonia. The UNDP report in 2009 stated that in year 2005 there were more than 10,000 cases of diseases were recorded causing by the climate change causing for flash flooding and droughts (Table 2).

Table 1: Rain-fed rice fields impacted by flood (1996-2005) in hectares (ha). Severe drought occurred in 1998 to 2003

Regions	**1996**	**1997**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Northern	1,215	255	161	20	240	1,810	207	357	620
Central	42,350	26,370	4,792	29,420	30,193	24,151	607	13,078	44,120
Southern	23,981	6,750	3,549	13,460	11,790	8,103	-	960	9,900
Total:	**67,546**	**33,375**	**8,502**	**42,900**	**42,223**	**34,064**	**814**	**14,395**	**54,640**

Source: modified from NAPA, 2009

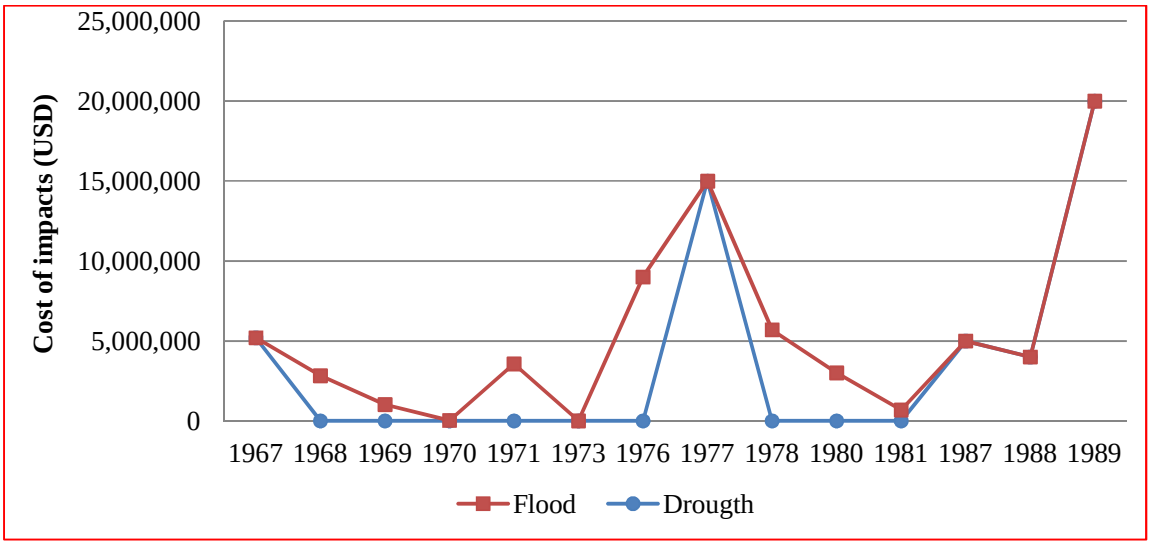

Figure 2: Impacts of floods and drought in Lao PDR from 1966 to 1995 (modified from NAPA, 2009)

Table 2: Climate change impacting human health from 2001 to 2005

Disease	2001		2002		2003		2004		2005	
	Case	Death	Case	Death	Case	Death	Case	Death	Case	Death
unidentified dysentery	899	0	959	1	790	1	879	0	-	-
Diarrhoea	2,941	15	2,042	3	1,572	7	1,761	10	-	-
dengue fever	3,968	3	9,176	21	19,638	63	3,414	10	5,471	13
malaria	246,844	244	267,454	195	274,911	187	53,808	105	30,341	77
pneumonia	2,431	142	2,645	133	2,798	160	3,206	185	3,809	154
smallpox	1,361	20	1,237	0	1,278	0	1,846	7	-	-

Modified from (NAPA, 2009)

A study in relation to the vulnerability to climate change in Laos for Second National Communication (2012) was developed by aggregating indices for vulnerability and adaptive capacity which are called Sensitivity and Exposure index (SEI) and Adaptive Capacity Index (ACI). These aggregated indices are used to reflect the vulnerability and adaptive capacity levels of villages in Laos, the higher the SEI, the more vulnerable the village (MoNRE, 2012).

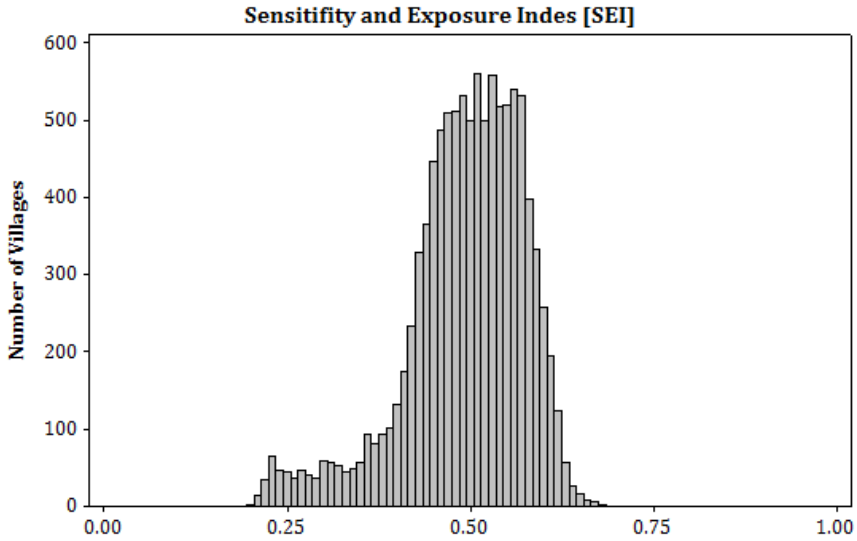

Figure 3: Histogram of Sensitivity and Exposure Index (SEI) of the Lao PDR (MoNRE, 2012)

The result shows high vulnerability to the change of climate. As shown in Figure 3, nearly all provinces of Laos have more than one-fourth of villages that are highly sensitive and expose to extreme climate. Only Champasak and Vientiane capital have small proportion of villages having exposed to the change. Moreover, over 75 percent of Lao villages and provinces have low adaptive capacity to climate change and low capacity to cope with related disasters.

Agriculture and health are the key sectors exposed to the impact of the change, especially, flood, drought and disease epidemic. In agriculture sector, the areas of rain-fed rice fields were destroyed by flood in average over 45,000 ha each year between 1995 and 2005. In 2005 and 2006, irrigated paddy field was damaged by flooding with losses over 5 million USD. These negatively affected the rice production causing shortage of rice, increasing hunger and poverty to Lao people (NAPA, 2009).

Health sector is one of major concerns to the change of climate. Lao Heath has identified seven significant health concerns related to climate change and shown in Table below:

Table 3: Climate change and health risks

No	Impact of Climate change	Risk	Adaptive capacity
1	Increases in average temperature	Population with heart problem, asthma, the elderly, young and homeless.	No preparation to cope with unexpected heat. No health-care records of heat-related health effects.
2	Extreme weather events such as flood and drought	Death, injure, deceases and mental disorder, water born and vector maborne disease	
3	Change in average temperature and rainfall	Vector borne and rodent borne diseases such as malaria, dengue, tick borne, and encephalitis	72% of population are covered by Anti-malaria programs 83.8% of population are protected by impregnated bed nets. But 90% of villages claim malaria as a major health problem.
4	Heavier rainfall events and higher temperatures	-Waterborne diseases such as E.coli, giardiasis and cryptosporidiosis-Contamination of drinking water from Flushing bacteria, sewage, fertilizers and other organic waste into water ways and aquifers.	
5	Increase in temperatures in summer	Flood born diseases causing diarrhea, illnesses and deaths especially amongst mothers and children	Limited report and research in food born diseases. Limited surveillances of food contamination,
6	Air pollution	Respiratory infection	
7	UV radiation	Exposure to Solar UV can cause cataracts, growth of pterygium, macular degeneration, and eyelid cancers	

Sources: modified from Climate Change and Health Adaptation Strategy in Laos (2009)

Malalia, Dengue fever and Diarrahea remain problems for Laos from 2001 to 2005 as shown in Table below:

Table 4: Climate change impacting for human health from 2001 to 2005

Disease	2001		2002		2003		2004		2005	
	Case	Death	Case	Death	Case	Death	Case	Death	Case	Death
Unidentified dysentery	899	0	959	1	790	1	879	0	-	-
Diarrhoea	2,941	15	2,042	3	1,572	7	1,761	10	-	-
Dengue fever	3,968	3	9,176	21	19,638	63	3,414	10	5471	13
Malaria	246,844	244	267,454	195	274,911	187	53,808	105	30,341	77
Pneumonia	2,431	142	2,645	133	2,798	160	3,206	185	3,809	154
Smallpox	1,361	20	1,237	0	1,278	0	1,846	7	-	-

3.2 Process, criteria and results of sector selection

As stated in the earlier of the Chapter 3; the overall sector selection process included the review of the climate change vulnerability and impact in different sectors, initial sector selection and selection of the sector with the use of multi-criteria and expert judgement in the TNA inception and sector selection workshop. However, as the review of the climate change vulnerability and impact in different sectors, initial sector selection was already mentioned in the sector 3.1 before; this section focused on initial sector section, the TNA inception and sector selection workshop and applied multi-criteria, scoring including the results of the sector selection.

As mentioned, the initial sector identification mainly based on key climate change vulnerable sectors that were recommended in national climate change policies, plans of Laos and by IPCC and it is pre-selection of sectors in order for stakeholder to discuss and make judgement in the TNA inception and sector selection workshop. So the initial sector selection was conducted through review and summary of the climate change vulnerable or adaptation sectors that identified in the National Adaptation Programme of Action (WREA, 2009), the Strategy on Climate Change of the Lao PRD (WREA, 2010), Second National Communication on Climate Change of the Lao PDR-SNC (MoNRE, 2012) including Fourth IPCC report (IPCC, 2007). Those identified sectors consisted of agriculture, water resources, public health, forestry, industry, energy, transportation, urban and residential including their infrastructure.

The TNA inception and sector selection consultation workshop was held on 17th February 2012 and participated by 36 participants representing18 organizations including public, private and international organizations(Annex 3).Prior to the workshop; the stakeholders were informed about the climate change vulnerability and impacts of different sectors in Laos as described in the section 3.1;during the workshop, the stakeholders discussed vulnerable or adaptation sectors defined in the NAPA, SCC, SNC and IPCC AR4 as well as initial identified sectors mentioned above. In addition, the stakeholders were also consulted about steps and methodologies for sector selection particularly multi-criteria and application of the criteria for the selection including judgment of the results.The multi-criteria applied in the prioritization of the sectors were basically developed and agreed amongst stakeholders with reference of the criteria recommended in the TNA guidebook (UNDP and UNFCCC, 2010). These criteria cover four main areas: contribution to GDP, GHGs reduction and sequestration, environmental and social improvement. Below is the detail of criteria and its description.

Table 5: The criteria for technology prioritization

Category	**Criteria**		**Description**
Cost/investment	Cost/investment		Sounds cost and preferable technology which also priority for investment.
Adaptation potential	Adaptation potential		Potential for adaptation including reduction of vulnerability and impacts while enhancement of adaptive capacity.
Development	Economic benefits	Yield/Income	Enhance economic growth particularly GDP and stability including create income and increase.
		SMEs/MSMEs	Enhance SMEs/MSMEs, growth and diversification particularly environmentally and social responsibility enterprise.
	Environmental benefits	Reduce environmental negative impacts and pollution	Covers reduction of environmental negative impacts, pollution while contribution to environment protection such as protection of land, water, biodiversity resources and ecosystem.
	Social benefits	Employment	Creation of new jobs and employment opportunities including working conditions such as learning and safety.
		Gender equality	Addressing gender gaps and contribution to gender equality particularly opportunities for gender such as income generation, , capacity building and employment.
		Enhance adaptive capacity	Particularly health safety, infrastructure, education and organization strengthening

In the selection, based on sector performances, the scores were given to each sector against criteria. The score ranks from 1 to 5; of which 1 is the least preferred while 5is most preferred. With this, in principle, the sector that obtains highest score would be selected as priority sector for adaptation. As a result of stakeholder judgement and scoring; the scores of each sector against criteria can be shown as in theTable 6below.

Table 6: Result of the sector selection

Sectors/Criteria	Contribution to GDP	Most Vulnerable	Environment/ Ecosystem	Contribute Poverty Reduction/ Livelihoods	Employment	Existing /Initiative	Social Benefits	Total Score	Priority
Water	5	5	5	5	4	4	5	33	1
Agriculture	5	5	3	5	5	5	5	33	1
Health	3	4	3	4	3	4	5	26	3
Forestry	5	3	5	4	4	3	5	29	2
Industry	4	3	2	3	4	2	3	21	5
Energy	4	4	3	3	4	3	4	25	4

According to the scores in the criteria; the agriculture and water sector were chosen as priority for climate change adaptation. On the other view, these sectors were selected because of its vulnerability, priority and significance for the socioeconomic development and environment preservation.

As mentioned, the agriculture sector is a top vulnerable sector which is directly and indirectly affected by the changes of climate including disasters caused by climate change. While this sector is fundamental sector for socioeconomic development of Laos and the key employment sector as the majority of Lao lives in rural area and relies on agriculture and natural resources (UNDP, 2010). For past six years, this sector contributed about 30 percent of the GDP for the period of 2006to 2010 and it expected that this level of contribution will continue until 2011-2015 (MPI, 2011).In addition, enhancing climate resilience of agriculture sector means support implementation of the national strategies and policies as well as ensuring poverty eradication, food security, rural development, promotion of commercialization of products, decentralization.

Water sector is also among the key climate change vulnerable sector while it is crucial resource and critical sector for development of socioeconomics, environment conservation including support development other sectors. Water resources can be directly and indirectly affected by the changes of climate such as change of hydrological cycle and ecosystem; leading flood and drought including water and water resources supply. Impact of the water sector means impact on the socioeconomic development as Laos's economy and livelihood are more dependence on water resources such as hydropower,

irrigation, water supply, aquatic resources and tourism. Enhance adaptive capacity of this sector would help ensure economic growth, poverty reduction, livelihood improvement and conservation of ecosystem.

Chapter 4. Technology prioritization for water sector

Similar to sector section process, in overall, the prioritization of adaptation technologies for water sector were carried out through the review of vulnerability and impact of climate change; identification existing adaptation technologies in the water sector; initial assessment and selection of technology options; and then prioritization.

The review of the vulnerability, impact of climate change in the water sector included the literature review of the vulnerability, impacts from previous studies and assessment such as study and assessment of climate change and impact in the Mekong region of SEA START, in the First and Second National Communication-FNC and SNC(STEA, 2000; MoNRE, 2012), National Adaptation Programme of Action (WREA, 2010), Strategy on Climate Change of the Lao PDR–SCC (MoNRE, 2010),Water Resources Strategy to the year 2020 of the Lao PDR (WREA, 2011) and Master Plan on Disaster Prevention (MLSF, 2009). In addition, it also included review of the climate change impact elsewhere such as IPCC annual report 2007 as reference. Detail and results of the review of the climate change vulnerability, impact are as described in section 4.1.

The identification and edition of existing adaption technology in the water sector included the review of existing technologies recommended policies, plans and reports that mentioned in the above. In addition, the existing technologies were also identified and edited in the technology prioritization workshop. Detail of edited existing adaptation technologies is as described in section 4.2.

The initial assessment of the technology options is a pre-requisite for technology prioritization. This assessment included categorization of the edited existing and recommended technology, which based on its scale of application and availability. The section of the technology options is the identification of the technology option based on benefits of technology and alignment with national policies. Both the initial assessment and selection was initially conducted by consultant with consultation and support from the project management team. It is then justified and validated in the technology prioritization workshop by stakeholders. The results of the initial assessment are described briefly in the section 4.3: overview of possible adaptation technology options in the water sector.

The technology prioritization was conducted in the technology prioritization workshop which was held in May2012. It was attended by 37 participants from 24departments of relevant ministries and organizations (Annex 4).The workshop technology employed multi-criteria, scoring and sensitivity analysis for assessment of the technology options and expert judgement for prioritization of the technology. Detail of the workshop and prioritization were as described in Section 4.3 following.

4.1 The vulnerability and impacts of the climate change on the water sector

The vulnerability and impact of the climate change can be assessed and viewed in various aspects and sectors. However, according to available information; this report just provided overview of risk and impacts of flood, drought and water bone disease.

As mentioned in the section 3.1; one of the main impacts of climate change is on hydrological cycle and increase of magnitude and frequency of such events including flood and drought. According to SEA START study (2005), the precipitation is on the rising trend between 10% and 30% throughout Mekong region and Kiem et al, (2008) also projected that the number of wet day would increase in future. In addition, WREA (2010) also provided observation that the dry season is becoming longer, droughts are more frequent and more severe, unusual and extreme flood events are escalating.

It is fact thatLaos is at risk of flood and drought. The north faced the flash flood while the middle and south region experienced river flood. In addition, the extreme events such storms already exacerbated the flood situation and it is anticipated Laos would experience increase of magnitude and frequency of such events including flood and drought. Based on ten years flood record, between 1995 to 2005, the areas of rain-fed rice fields destroyed by flooding were over 65,937 ha in 1995, 67,500 ha in 1996, 42,900 in 2000, 42,223 ha in 2001, and 57,300 ha in 2005. In 2005 and 2006, paddy rice field irrigation systems damaged by flooding costed over 5 million USD. For flooding disaster, in the central and southern parts of Laos especially in year 2005, Vientiane was losses amounted to more than 10 million UA$ (UNDP 2009).

4.2 Existing adaptation technologies in the water sector

Based on review of existing technologies particularly those recommended in the NAPA (WREA, 2010), SCC (MoNRE, 2010), SNC (MoNRE, 2012), Water Resources Strategy to the year 2020 of the Lao PDR (WREA, 2011) and Master Plan on Disaster Prevention (MLSF, 2009), IPCC annual report 2007, TNA Guidebooks and Climate Techwiki together with technology identification and edition by stakeholders during technology prioritization workshop; the existing technology in water sector can be summarized as in the table 7 below.

Table 7: Edited existing technology and categorization

No	Category/ Sub-sector	Key adaptation technology options	Scale of application	Availability
1	Water sources and supply management	1. Watershed management (IWRM)	Medium to large scale	Short to medium term
		2. Ground water pump	Small scale	Short term
		3. Multi-purpose hydropower dam	Small to large scale	Short to medium term
		4. Irrigation	Small to medium scale	Short term
		5. Borehole/Tube wells	Small scale	Short term
		6. Rain water harvesting	Small scale	Short term
		7. Water safety plan		
2	Water quality management	1. Water quality monitoring	Medium scale	Short to medium term
		2. Effective law enforcement	Medium to large scale	Short term
		3. Water treatment plants	Medium to large scale	Short to medium term
		4. Water recycle	Small to medium scale	Short to medium term
		5. Water drainage system	Medium to large scale	Short to medium term
		6. Household Drinking Water Treatment and Safe Storage	Small to medium scale	Short to medium term
		7. River bank protection	Medium to large scale	Short to medium term
3	Flood and drought management	1. Early warning system	Medium to large scale	Short to medium term
		2. Flood and drought hazard mapping	Medium to large scale	Short to medium term
		3. Flood and drought monitoring	Medium scale	Short to medium term
		4. Improve weather forecast system	Medium to large scale	Short to medium term
		5. Regulation of water discharge (from dam)		

		6. Preservation of wetland	Small to medium scale	Short to medium term
4	Promote water use efficiency	Water resources awareness and education	Small to medium scale	Short to medium term
5	Strengthen water sector administration	Water use group	Small to medium scale	Short to medium term

River basin/Watershed management:

This refers to the river basin or watershed management that applies Integrated Water Resources Management (IWRM) techniques for the planning and management. The IWRM covers application of participatory techniques, multi-disciplinary and organization to realize sustainable water resource and environment with balance of socioeconomic development in the hydrological boundaries. Usually the IWRM process includes institutional arrangement and engagement, selection of critical river basin or watershed, creating consultation dialogues, assessment of the watershed function, creating action plan, implementation of action plan, monitoring and evaluation.

Lao PDR is in the Mekong River Basin and occupies number of important Mekong River tributaries and river basins. Based on the strategy on water resources to the year 2020, government expected to apply IWRM for all river basin and watershed. However, to date, only two river basins namely Nam Ngum and Nam Thuen-Nam Kading that completed basic steps of IWEM such as organization of management committee and in the process of planning for sustainable river basin management.

Water Supply System:

Water supply system is key water storage and conveyance for consumption and useof water in society. There are two main types of systems: pumping and gravity system or Napapa and Namlin which usually applied for urban and rural community respectively. The pumping systems consist of head pump which is usually electricity pump while gravity usually relies on head dam and water reservoir in higher area. The pumping system sometimes requires dam and reservoir as well. These two systems similarly equipped with water storage and treatment, pipe and control system.

The water supply system has been introduced in Laos for centuries. Currently 77 percent of total population access to clean water (MPI, 2011). The system doest cover all area yet, some are inadequate

water particular in dry season due to drying of water sources and or leakage including insufficiency of water use. Therefore; in the changing climate, water supply system development should consider climate resilience, the construction standard, proper and regularly maintenance and management including water sources or catchment conservation and cost effectiveness.

Irrigation

It is a group of technologies for irrigating rice and other crops. In addition, it is also constructed to preserve water for the use in the dry season and drainage system during rainy season or flood. There are several types of irrigations: concrete and earthen dam, weir and stone pocket weir. It also includes pumping and gravity system; irrigation and dripping or sprinkle system. Usually the irrigation system consists of head pump, water reservoir, canal, dripping and or sprinkle system. However, the concrete dam and canal is the most preferable as it can be more resilient to flood and more effective in drainage or irrigating the water.

The irrigation has been introduced in Laos for more than 40 years and in 2010, the irrigated rice is 108, 410 ha or around 15 percent of the total rice area of the country (MPI, 2011). However, recently numbers of irrigation were broken or use of use because of flood, low of maintenance and low quality of construction. In addition, many are of use due to lack of water and or high cost for electrical pump system. Therefore; future irrigation development should consider climate resilience, meeting the construction standard, proper and regularly maintenance and management including water sources or catchment conservation and cost effective irrigation.

Water pump:

It is a technology that involves drilling into ground and extracting water from ground water for use. This technology is mainly used in sub urban and rural area where access to river and other water sources is limited. The technology consists of drilling, inserting a tube to protect the erosion, and a hand or electrical pump. In addition, concrete floor around the pump or wet area and roof to keep shade. There are several sizes of pump but on average, in case ground water is sufficient, it can be used to cover water supply for a cluster of village or community or about 100 households. Average cost is approximately $US 3,000 for construction of a pump system including water quality testing. Water from the well can use directly for other use but is encouraged to boil for the drinking.

This type of pump has been introduced in Laos for decade and currently, quite a lot of families or households in sub-urban and rural area are still using the water pump. The construction of pump is not so

costly but the issue is quality and quantity of ground water. In some areas, manganese and cyanide are higher than acceptable levels; some are facing dry out of ground water. It also associates with knowledge and information about the ground water which is usually limited. In addition, there is a problem break down of pump and low maintenance of pump. So regular monitoring of water quality, quantity and maintenance of the pump is necessary.

Borehole/Tube Well:

It is traditional technology that used for centuries and majority is in the rural areas. Borehole well is for getting cleaner ground water and water from nearby river through soil filtration. The technology involves with digging the hole particularly in the area that near river, ground water table. Tube is sometimes used to protect erosion in the well and it is also usually covered by a roof to prevent from leaves, dusts into the well. It is a low cost and not required high kills and knowledge including save cost for paying water. Water from the well can use directly for use but is encouraged to boil for the drinking. Because it is close to river or water sources, for flood prone area, this type of well is often affected and out of use during flooding and or some heavy raining period. Often the maintenance and cleaning of well is taken every year and usually after raining season or flooding. Sometimes, the sour stone is used for clarify the water and sedimentation particularly in the first few days after digging or cleaning.

Currently, several families or households in rural areas are still using the borehole well. The construction of borehole well is though low cost and affordable by poor and local people, however, this boreholes well can be risk sources of water in the changing climate, flood prone and ground water high contamination area. In addition, the use of sour stone can cause health effect. So water proofed well with regular monitoring of water quality and awareness raising should be the option for improvement of boreholes well.

Rain water harvest from roof:

It is also a traditional technology that used for centuries and majority is in the rural areas. It is for collection of water in rainy season and for use in the dry season and or save water from other sources including reduction of payment for Nampapa water. It is a low cost and does not require high kills and knowledge. The technology involves with roof drainage system, pipe, filter and water container. Water from the well can be used directly for other use but not encouraged for drinking as water is usually contaminated due to rusty, dirty roof and precipitation particularly the first rain. However, some practices used the first rain water in rainy season as liquid of battery.

Currently, there is no statistic about the number of households are still using this technology. However, it is only practical for small scale and use collected water for other purpose rather than drinking. Ad mentioned, other issues of the harvesting water from roof are contamination of rusty and dust including particles or elements in the air and precipitation. In addition, filtration of treatment can be costly compare to access water from other sources. This means rain harvest can be only practical for certain purpose, area and cases.

Multi-purpose dam:

It refers to the dam that, apart from electricity production, includes function of flood reduction, irrigation system, fishery, and tourism and environment conservation in the watershed. Lao PDR's total hydropower potential is estimated to be more than 30,000MW. The dam or hydro power dam has been introduced in Laos since 1975 and it is also estimated that by 2011 installed capacity will increase the four-fold from the current 624 MW to 2,735 MW and the net revenues could grow 20-fold from relatively little today (US$17 million) to approximately US$350 million by the year 2020 and could exceed $700 million by 2025 (WB, 2010). It is one of largest income sources and significantly contribution to socioeconomic development of the county, however, many cited that the development of hydropower, despite it is clean energy, but it cause lots of damage to environment, ecosystem including community. In addition, the hydropower was not designed and implemented effectively for other function such as flood regulation, irrigation, tourism, conservation of water resources and environment in the watershed. So; multi-purpose hydropower dam construction should be considered as option for future hydropower dam development.

Water safety plan:

Water Safety Plans (WSPs) are described collectively as a systematic and integrated approach to water supply management based on assessment and control of various factors that pose a threat to the safety of drinking water. WSPs enable identification of threats to water safety during any and all steps in the catchment, transport, treatment and distribution of drinking water. This approach is fundamentally different from those traditionally adopted by water suppliers, which rely on treatment and end-product testing to ensure water safety. When implemented successfully, the WSP approach can ensure that water quality is maintained in almost any context. Framework for safe drinking water WSPs contribute to climate change adaptation at the catchment level primarily through increased resilience to water quality degradation. The WSP approach allows for water suppliers to be flexible and responsive to changing input parameters. This means that the monitoring, management and feedback components of a successful WSP naturally absorb the acute impacts of climate change. The WSP approach can also be modified to

adapt to long-term climate change and slow-onset hazards by recognizing how the water supply system may be affected by specific climate change effects, by factoring these effects into the risk assessment, and by identifying appropriate control measures.

Household Drinking Water Treatment and Safe Storage (HWTS):

The drinking water treatment and safe storage is for improving the quality and safety drinking water by treating it in the home. Common technologies include ultraviolet disinfection processes, biological sand filters, combined products with both coagulant and disinfectant (e.g. Procter and Gamble PUR product), and solar disinfection (SODIS).These technologies have been used for decade but still in small scale due to poor people may face high of cost for modern technology e.g PUR, ultraviolet disinfection while majority of urban people already access to Nampapa. However, this technology is important particularly in the flood area which access to safe drinking water is difficult.

Water treatment plants and facilities:

This is for water recycles and maintenance water to be available for use in long run. The water treatment plants include one for treatment of waste water from urban, industry, landfill and sewage. In Laos, recently there is no waste water treatment plant for addressing waste water from urban and residential, landfill and sewage. Although industrial factories and manufacturing equipped with this facilities but only large one does. Law on industry, decree on environmental impact and social assessment, water quality and environmental standards are in place, but the implementation is less effective. In addition, capacity on the design and maintenance of such plants and facilities is limited. So it is important to the treatment plants in place for recycle of water, reduce impact on environment and health including GHGs emissions.

Early warning system:

is a technology for flood prevention. It associates with setting up system weather forecast, modeling of discharge, water gauges, information dissemination tools that provide the information to society or community including enhancement of readiness or preparedness and recovery plan for minimizing impacts that would be caused by extreme event including flood. This technology is practiced in Laos years ago and mainly by MRC, department of meteorology and hydrology of MONRE, center for flood prevention in Asia pacific, disaster prevention office of ministry of social welfare and projects funded world food programme and Lao Red Cross. However, the approach or technologies employed by these organizations were various and not yet systematically functioned. MRC focused on the river flood and used water gauge including computer-based modeling for flood monitoring and prevention. Department of meteorology and hydrology focused on the regular prediction and provision of the precipitation and

river discharge information for society and communities. While the rest focused on preparedness and flood recovery. This means, early warning system was not implemented systematically. This issue caused by lacks of equipments, capacity including financial resources. So improvement of this system and implemented effective is expected to realize or ensure flood prevention and impact minimization.

4.3 An overview of possible adaptation technology options in water sector

There are several adaptation technology options in the water sector recommended in the policies, plans and reports particularly NAPA (WREA, 2009), Water Resources Strategy to the year 2020 of the Lao PDR (WREA, 2011), Strategy on Climate Change of the Lao PDR (WREA,2010) and Second National Communication on Climate Change (MoNRE, 2012), IPCC fourth report (2007), TNA handbook on water sector and Climate Tecwiki including ones identified in the edited and categorized technology mentioned in section 4.2. However, based on technology performance potential, and benefits including beneficial groups coverage justified and judged by stakeholders particularly in the technology prioritization workshop in May 2012, the technologies in the Table 8 below are considered as adaptation technology options.

Table 8: the adaptation technology options in water sector

No	Category/ Sub-sector	Key adaptation technology options
1	Water sources and supply management	1. Watershed management (IWRM)
		2. Ground water pump
		3. Multi-purpose hydropower dam
		4. Irrigation
		5. Borehole/Tube wells
		6. Rain water harvesting
		7. Water safety plan
2	Water quality management	1. Water quality monitoring
		2. Effective law enforcement
		3. Water treatment plants
		4. Water recycle
		5. Water drainage system
		6. Household Drinking Water Treatment and Safe Storage

		7. River bank protection
3	Flood and drought management	1. Early warning system
		2. Flood and drought hazard mapping
		3. Flood and drought monitoring
		4. Improve weather forecast system
		5. Regulation of water discharge (from dam)
		6. Preservation of wetland
4	Promote water use efficiency	1. Water resources awareness and education 2. Research
5	Strengthen water sector administration	3. Flood and drought operation center 4. Water use group 5. Flood relief subsidy mechanism

4.4 Process, criteria of technology prioritization in the water sector

As mentioned earlier, the technology prioritization was conducted through the process of reviewing status of climate change vulnerability and impact and identification of existing adaptation technologies in water sector; initial assessment and section or screening technology options and prioritization of the technology in the technology prioritization workshop with the use of multi-criteria and expert judgement. The status of climate change vulnerability and impact and existing adaptation technologies were as described in the section 4.1 and 4.2 respectively. The initial assessment and selection of the technology options was as in 4.3. So following focussed on the technology prioritization in the workshop which was organized in May 2012.

37 participants representing 24 departments or organizations of government, academic, research institutes, private, international organizations and projects attended the technology prioritization workshop organized in May 2012. The list of the participants is in the Annex4. Pre-workshop the stakeholders were informed about the vulnerability and impacts of the climate change in the water sector as in section 4.1 and adaptation technologies and options particularly ones that were mentioned in the section 4.2. During the workshop, the stakeholders were introduced and discussed on the steps and methodologies particularly validating technology options, criteria and application of the multi-criteria and scoring techniques for assessment and prioritization of four technologies. As a result of expert judgement and validation; top ten

technology options that perceived as key the technology for adaptation were selected for further prioritization. Those top ten technologies are as presented in the Table 9 below.

Table 9: Ten Technology Options

No	Ten Technology Options
1	Flood risk mapping
2	Early warning
3	Multi-purpose water reservoir and storage
4	Optimal water supply system
5	Disaster impact reduction fund
6	Climate change oriented irrigation
7	Effective water sources and basin management
8	Flood and drought operation center
9	Groundwater management
10	Hydrological monitoring

For prioritization of four priority technology; in overall, the top ten technologies were assessed with the use of multi-criteria and scoring techniques including sensitivity analysis. The criteria for the prioritization consisted of technology performance, adaptation potential, and contribution to sustainable development as well as benefiting economic, environmental and social development. These criteria were elaborated, edited and agreed by the stakeholders with reference to the criteria recommended in the TNA guidebook (UNDP and UNFCCC, 2010). Prior to the prioritization of the technologies, the criteria were weighted by stakeholders based on its significance and technologies were scored against the criteria. The applied criteria and weighing is presented in the Table 10 and Figure 4 below.

Table 10: The criteria for technology prioritization

Category	Criteria	Description
Cost/ Investment	Cost or investment	Cost or investment in the development, application or operation and maintenance of the technology.
Reduction of impact and vulnerability	Reduction of impact and vulnerability while enhancement of adaptive capacity	Reduction of impact and vulnerability while enhancement of adaptive capacity

Development	Economic benefits	Yield/ Income	Support for economic growth particularly GDP and stability including create income and increase.
		SMEs/MSMEs	Enhance SMEs/MSMEs, growth and diversification particularly environmentally and social responsibility enterprise.
	Environmental benefits	Reduce environmental negative impacts	Covers reduction of environmental negative impacts and contribution to environment protection such as protection of land, water, biodiversity resources and ecosystem.
	Social benefits	Employment	Creation of new jobs and employment opportunities including working conditions such as learning and safety.
		Gender equality	Addressing gender gaps and contribution to gender equality particularly opportunities for gender such as income generation, capacity building and employment.
		Socioeconomic equality	Addressing gaps between urban and rural and contribution to rural development and poverty reduction through decentralization, capacity building, local ownership, participation, transparency and good governance.

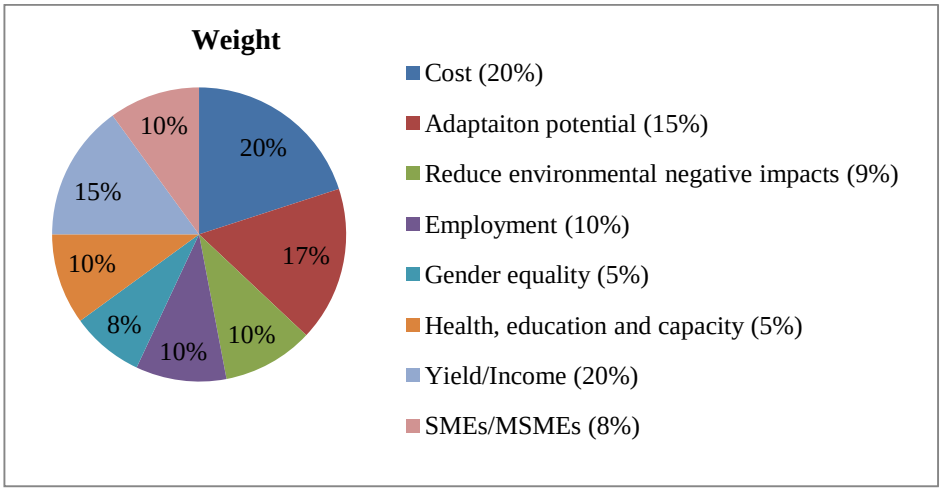

Figure 4: Weighting of the criteria

In the prioritization, the score were given against the criteria by stakeholders. The score varies from 0 to 100; of which, 0 is for the least preferred while 100 is for the most preferred. And basically, technology that gains highest is considered as the highest priority technology for climate change adaptation respectively. The results, from scoring and weighting of each technology are presented in the following table.

Table 11: The results of the scoring of technology prioritization for water sector

Technology Options	Cost/ Investment	Adaptation Potential	Environmental Benefits	Social Benefits			Economic Benefits		Total Costs	Total Score of Benefits	Total Score	Rank
			Environmental Negative Impacts Reduction	Employment Creation	Gender Equity Promotion	Health, Educaiton and Capacity Promotion	GDP/ Income/ Yield	SMEs/ MSMEs				
Flood risk mapping	65	55	80	50	60	70	65	60	13	50	63	7
Early warning	75	100	100	70	60	70	65	75	15	63	78	2
Multi-purpose reservoir and water storage	70	70	0	65	0	50	100	100	14	48	62	8
Optimal water supply system	80	75	70	60	100	100	70	65	16	61	77	3
Disaster impact reduction fund	100	90	80	80	80	75	70	70	20	63	83	1
Climate change oriented irrigation	80	75	65	75	60	65	85	70	16	58	74	5
Effective water sources and basin management	80	75	80	70	60	70	70	80	16	58	74	4
Flood and drought operation center	70	80	70	100	65	70	65	0	14	53	67	6
Groundwater management	0	30	50	0	60	0	0	60	0	21	21	10
Hydrological monitoring	65	0	60	70	50	60	60	85	13	41	54	9

4.5 Results of technology prioritization for water sector

Throughout the prioritization process particularly the assessment of the scores in the criteria and stakeholder judgement; four technologies namely Early Warning System, Disaster Impact Reduction Fund, Climate Change Oriented Irrigation and Water Supply System which obtained highest preferable scores are selected as priority technology need for climate change adaptation in the water sector.

Early Warning System:

Early warning system is one of the area that one of the country priority which defined on the socioeconomic development plan 2011-2015 (MPI, 2011), Strategy on Climate Change of the Lao PDR (WREA, 2010), National Disaster Management Master Plan and plan of the department of hydrology and meteorology of MONRE. However, despite it is the priority, lacking of financial support, knowledge and skills on the system; leading to this system is not yet fully functioned and or effective. With system in place, it is expected that impacts that would result from disasters particularly flood including flash flood could be largely minimized.

Disaster Impact Reduction Fund:

Complementary to the early warning system, disaster management fund or impact reduction fund should be established in order to ensure the preparedness plan implementation, monitoring and recovery of disaster impacts. Despite it is immediate need, facing financial shortage; government only allocates and or mobilized disaster recovery fund periodically or event based basis which caused disaster or flood handling ineffectively, not timely; leading long term and expansion of impacts. So a specific and ready fund is needed for increase effectiveness of the prevention and handling with such disaster in timely manner. The disaster management may include fund raising and management mechanism, responsible organizations and networks in all level, from central to village. With such fund and mechanism in place, it is expected that impacts that would result from disasters particularly flood including flash flood could be largely minimized while adaptive capacity can be enhanced.

Watershed or River Basin Management:

The management of the watershed or river basin is to ensure water supply, both quality and quantity. The management in this context refers to Integrated Water Resources Management. IWRM is perceived as a comprehensive, participatory planning and implementation tool for managing and developing water resources including climate change adaptation. This management associated with applying knowledge from various disciplines as well as the insights from diverse stakeholders to devise and implement

efficient, equitable and sustainable solutions to water and development problems. In addition, it also associates with water allocation and pollution licensing is implemented at the scale of the river basin or catchment, institutional arrangements for water resources management which for example based on hydrological boundaries. There are some initiatives in some key river basin in Laos and it is a high priority of the environment management but due to limited resources and capacity including, the application of these techniques can not cover most river basin and catchment yet. The application IWRM for the watershed is expected to ensure water resources and ecosystem conservation, protection of hydrological process and water supply; which are means for climate change adaptation.

Water Supply System:

Water supply as well as access to clean water is priority of the government. As such water supply system play important roles for ensuring access to clean water in a sustainable manner. The water supply system in this context refers to Nampapa and gravity water supplies which include water reservoir, pumping and pipe is its system and management mechanism. Based on the target of the government, by 2020, 85 percent of Lao people will access to clean water; increase from currently, 77 percent of people have access to clean water and 54 have access to sanitary toilets (MPI 2011). The low access is resulted from number of issues include lack of financial support, lack of regular maintenance of the system, exclusion of climate change in the design and weak water reservoir conservation. So prioritization of this water supply system in TNA is expected to bring about improvement of investment, management mechanism and water supply system as well as increase access to clean water of Lao people including health and sanitation improvement.

Chapter 5. Technology prioritization for agriculture sector

The process and approach of the prioritization of adaptation technologies for water sector was also used for the prioritization of adaptation technologies for agriculture sector. Those processes are review of vulnerability, impact of climate change and identification existing adaptation technologies in the agriculture sector; initial assessment and selection of technology options; and then prioritization of the technology.

The review of the vulnerability, impact of climate change and identification existing adaption technology in the agriculture sector was carried out through literature review of the vulnerability, impact and identification of technologies that recommended policies, plans and reports such as the First and Second National Communication-FNC and SNC (STEA, 2000; MoNRE, 2012), National Adaptation Programme

of Action (WREA, 2010), Strategy on Climate Change of the Lao PDR–SCC (MoNRE, 2010) and Strategy on Agriculture Development to the year 2020 of the Lao PDR (MAF, 2011). In addition, the identification of existing technologies was also revisited in the technology prioritization workshop. Detail of the climate change vulnerability, impact and existing adaptation are as described in section 5.1 and 5.2 respectively.

The initial assessment and selection of the technology options is an important stage before prioritization of technology. It included categorization of existing and recommended technology by scale of application and availability while section of the technology options was taken by expert judgement. This initial assessment and selection was initially carried out with the lead of consultant with consultation and support from the project management team. In addition, the result of assessment and selection were also validated by stakeholders in the technology prioritization workshop. Detail of the initial assessment and selection of the technology options are described in the section 5.3: overview of possible adaptation option in agriculture sector.

The technology prioritization for agriculture was coincidentally taken place with technology prioritization in the technology prioritization for water sector in the workshop technology prioritization held in May 2012. Number of participants and organizations are same number of participants and organizations engaged technology prioritization for water sector (see Annex 4). In the workshop; multi-criteria and scoring are used for assessment of the technology options and prioritization. Detail of the workshop and prioritization were as described in Section 5.4 hereafter.

5.1 Climate change vulnerability and impact on the agriculture sector

Although there is limited assessment of the climate change vulnerability and impacts in agriculture sector; impacts caused by changes of climate and its related disaster is obvious for agriculture sector. As mentioned, the flood and drought already threaten and cause loss of yield, paddy field, livestock and agricultural facilities such as irrigation.

For flooding disaster, in the central and southern parts of Laos was impacted, especially in year 2005, Vientiane was losses amounted to more than 10 million US$ (UNDP 2009). Furthermore, the areas of rain-fed rice fields destroyed by flooding were over 65,937 ha in 1995, 67,500 ha in 1996, 42,900 in 2000, 42,223 ha in 2001, and 57,300 ha in 2005. In 2005 and 2006, paddy rice field irrigation systems damaged by flooding costed over 5 million USD. In addition, In addition, SEA START's study also

climate change impact on agriculture with the use of Conformal Cubic Atmospheric Model (CCAM) and Decision Support System for Agro Technology Transfers (DSSAT version 4.0) crop modeling software revealed that 10 percent of productivity would be lost in Savanakhet province under CO2 concentration of 540 ppm scenarios.

5.2 Existing adaptation technologies of agriculture sector

Number of adaptation technologies in the agriculture sector practiced in the Laos and regions. Those technologies are particularly identified in the strategies, plans and reports such as Strategy for Agriculture Development 2011to 2020 (MAF, 2010),National Adaptation Programme of Action (WREA, 2009), Strategy on Climate Change of the Lao PDR (WREA,2010) and Second National Communication on Climate Change (MoNRE, 2012).In addition, it also described in the Assessment Report of IPCC-AR4 (IPCC, 2007), TNA Guidebook on Agriculture and Climate Techwikietc[4]. However, followings are summary of key technologies that have been practiced and sound applicable to Laos.

Crop diversification:

Crop diversification in this context includes introduction of new cultivated species, improved genetics and varieties of crops including conservation of seeds and crop diversity for diversification. The new species or variety may be imported while the improved genetics and varieties are through biotechnological and genetic process including domestication and breeding of wild or traditional crop species and Non-timber forest product. As for the import of new variety, of cause it should be monitored, control based on particularly the regulations on the import of fauna and flora. Similarly the improvement of the variety of crop should also follow the regulations on biotechnology. In addition, importantly the crop diversification is to ensure enhancement of both quantity and quality of productivity, value added and resilience to diseases, pest and environmental stresses including flood and drought.

In Laos, in overall, this practice is in the initial stage of the development. Although there are some initiatives on demonstration of flood or floating and drought tolerant rice variety but the yield resulted from the technologies is uncertain and or mixed. However, such crop diversification is a priority defined particularly in the agriculture development strategy (MAF, 2010), Notational Socioeconomic Development Plan (2011-2015, (MPI, 2011) and policies on food security, commercialization and

[4] http://climatetechwiki.org/category/service/agriculture

industrialization of the agriculture sector as well as climate change adaptation which called for further development and development through research and capacity development.

Ecological Pest Management or Control:

Ecological Pest Management (EPM) is a natural method for increasing the strengths of natural systems to reinforce the natural processes of pest regulation and improve agricultural production. Chemical pesticides are used only where and when these natural methods fail to keep pests below damaging levels" (Frison et al, 1998; 10).The key components of an EPM approach are crop, soil, pest management and herbicide application. Crop Management includes selecting appropriate crops for local climate and soil conditions while soil Management is maintaining soil nutrition and pH levels to provide the best possible chemical, physical, and biological soil habitat for crops. Pest Management, using beneficial organisms that behave as parasitoids and predators and herbicide is a product from pest repelling herbs by extracting the chemical, odder, liquid etc as from herbs and use for spraying crops.

EPM contributes to climate change adaptation by providing a healthy and balanced ecosystem in which the vulnerability of plants to pests and diseases is decreased (LEISA, 2007). By promoting a diversified farming system, the practice of EPM builds farmers' resilience to potential risks posed by climate change, such as damage to crop yields caused by newly emerging pests and diseases. In addition, with the EPM approach, farmers can avoid the costs of pesticides as well as the fuel, equipment and labour used to apply them(Pimentel et al, 2005).

Agro-forestry:

Agro-forestry is an integrated production which combines trees, crops and or animals on the same area of land. In general it is categorized into three broad types: agrosilviculture (trees with crops), agrisilvipasture (trees with crops and livestock) and silvopastoral (trees with pasture and livestock) systems. Integrated cropping, mixed farming, stratus cropping, terrace and hedgerow and contour planting are often mixed or applied in the agro-forestry system. In Laos, most of the practices are in the forms of plantation and orchards, alley cropping, economical and biological improve fellow, contour hedgerow, home garden, Taungya system (Hansen K.P, Sodarak, H. 1996).In addition, there are some practices on tree fence, pasture and livestock. However, to date, although it lacks specific research and confirmation about the agro-forestry and climate change adaptation; but based on the research and alike with agro-forestry practice elsewhere it can be assumed that with appropriate design and substantial management; agro-forestry can improve the resilience of agricultural production to current climate variability as well as long-term climate change through the use of trees for intensification, diversification and buffering of

farming systems from extreme climate including flood and drought, maintaining improve soil fertility, retention of water; leading to ensure production through the years or during wetter and drier years.

Community-managed seeds bank and storage:

Community-managed seeds bank and storage associates with the selection of seeds, building storage system, storage of seeds, and managed by organized responsible body with the use of saving and supplying mechanism. Seed security is key resource to ensure the quality and quantity of the production. It is of important particularly for poor farmers in developing countries (Wambugu et al, 2009). Availability of quality seeds helps ensure long term production and conservation of diversity. It is also immediate needs for household and community particularly during the extreme climate such as flood, drought; when seeds are needed for recovery of the production. In Laos, traditionally each farmer selects and keeps seeds for next production. Moreover, with recognition the needs of the seeds particularly in the changing climate and food insecurity, there are more activity and organized systems on seeds keeping. Those include seeds project, rice bank and production of quality seeds for increase income and productivity. However, there are some challenges associates with effectiveness and sustainability especially maintaining and or improvement of the regular savings schemes, participation of wider communities including changing the prevailing 'relief' mentality (Datta, 2009). In addition, there are also financial and technical challenges about storage including cleaning, drying and moisture and pest infestations control.

5.3 An overview of possible adaptation technology options in agriculture sector

Although numbers of technologies are available for adaptation; according to the Strategy for Agriculture Development 2011to 2020 (MAF, 2010),National Adaptation Programme of Actions (WREA, 2009), Strategy on Climate Change of the Lao PDR (WREA,2010) and Second National Communication on Climate Change (MoNRE, 2012)including consultation and justification of the stakeholders in the technology prioritization workshop; the key recommended adaptation technology options are summarized in the table 12 below.

Table 12: Adaptation technology options and categorization in the agriculture sector

Sub-sector	Technology	Scale of application	Availability
Crops	Crop diversification	Small to medium	Short term

management	Pest management or control	Small	Medium term
	Seeds bank and storage	Small to medium	Short term
	Integrated cropping system	Small to medium	Short term
	Floating rice cultivation	Small to medium	Short term
	Drought tolerant rice	Small to medium	Short term
	Organic farming	Small to medium	Short term
	Non-timber forest product management	Small to medium	Short term
	Greenhouse cropping	Small to medium	Short term
	Crops genetic improvement	Small to medium	Short term
Livestock	Livestock disease control	Small to medium	Short to medium term
	Livestock health promotion	Medium	Short term
	Genetic improvement	Small	Medium to long term
	Clean production	Medium	Short term
	Feeds and feeding improvement	Medium	Short term
Agriculture management	Improve agricultural subsidy mechanism		

5.4 Process and criteria for technology prioritization in the agriculture sector

The technologies prioritization in the agriculture sector was coincidentally conducted with technology prioritization in the water sector and using the same processes. As mentioned earlier in the Chapter 5, overall process include review of vulnerability and impact on climate change and identification of existing adaptation technologies in the agriculture sector, selection or screening of technology options, validation of the technology option and the prioritization. However, as the review of vulnerability and impact on climate change and existing adaptation technologies in the agriculture sector areas already described in the section 5.1 and 5.2 respectively. The technology options are also explained in the section 5.3; so the following description focused on the validation of top ten technology options and prioritization of four priority technologies for climate change adaptation in the technology prioritization workshop.

The technology prioritization workshop was organized in May 2012, which was participated by 37 participants from various organizations (Annex 4).The workshop aims to validate the technology options

and prioritize four priority adaptation technologies out of the technology option. To realize these; pre-workshop, the stakeholders were informed about the adaptation technologies and options as in the section 5.2 and 5.3 as well as technologies recommend in the FNC (STEA, 2000), NAPA (WREA, 2009), SNC (MoNRE, 2012), Strategy on Agriculture Development (MAF, 2011) including in the IPCC AR4 (IPCC, 2007) and climate techwiki. During the workshop; the stakeholders discussed on the steps and methodologies for technology prioritization particularly validation of the technology options, assessment and prioritization of four technologies with the use of the multi-criteria, scoring including sensitivity analysis and agreement of the results.

Through the stakeholder consultation and validation; ten technology options as presented in the Table 13 were selected for further assessment and prioritization.

Table 13: Results of the scoring of the adaptation technologies in the agriculture sector

No	Ten Technology Options
1	Biogas
2	Appropriate Water Management for Paddy Field
3	Promote Use of Adapted and High Production Cattle
4	Agricultural Soil Carbon Management
5	Organic Farming
6	Integrated Farming
7	Fodders Improvement and Appropriate Feeding/Feeds optimization
8	Crop Land Management
9	Land Suitability and Ecosystem Based-Agriculture
10	Crops Residual to Energy

The criteria applied in the prioritization of the technologies are same criteria used for technology prioritization for forestry sector, as shown in the table 10, which covers three main areas: cost or investment, potential for adaption, contribution to sustainable development (economic, environmental and social). In addition, prior to the technology prioritization, these criteria were weighted as presented in the figure 4 before.

Similarly, for technology prioritization in the agriculture sector; the technologies were scored against the criteria by stakeholders. The score ranks from 0 to 100; of which 0 is the least preferred while 100 is most preferred. Under this approach, the technology that obtains that highest score is considered as highest

priority technology and reversely. Through the process, score of each technology can be summarized the table 14 below.

Table 14: results of the scoring of technology prioritization for agriculture sector

Technology Options	Cost/ Investment	Adaptation Potential	Environmental Benefits	Social Benefits			Economic Benefits		Total Costs	Total Score of Benefits	Total Score	Rank
			Environmental Negative Impacts Reduction	Employment Creation	Gender Equity Promotion	Health, Educaiton and Capacity Promotion	GDP/ Income/ Yield	SMEs/ MSMEs				
Climate change oriented irrigation	95	90	70	65	60	60	80	60	19	58	77	7
Flood prevention and drainage system	79	75	70	65	60	0	60	50	16	45	61	9
Promote integrated farming	75	80	90	90	70	60	90	90	15	66	81	5
Livestock disease prevention and control	93	90	75	78	100	80	90	80	19	68	87	1
Crop diversification	95	90	75	70	65	65	85	90	19	63	82	4
Rural climate resilient infrastructure development	90	100	75	75	60	70	90	90	18	66	84	3
Agricultural development subsidy mechanism	100	95	78	60	80	70	80	100	20	65	85	2
Integrated land use planning and sustainable resettlement	75	77	85	70	65	65	65	60	15	56	71	8
Conservation agriculture and preservation of agriculture land	70	75	100	100	70	65	70	80	14	63	77	6
Research on climate change impact on agriculture	0	0	0	0	0	100	0	0	0	10	10	10

5.5 Results of adaptation technology prioritization in the agriculture sector

Throughout the prioritization process particularly the scoring against criteriaand consultation of the stakeholders; four technologies which received highest scores are selected as priority technology needs for climate change adaptation in the agriculture sector. Those technologies are:

1) Livestock disease prevention and control;
2) Agricultural Development Subsidy Mechanism;
3) Climate Resilient Rural Infrastructure and
4) Crop Diversification.

Livestock disease prevention and control:

Livestock diseases are one of the challenges faced by Lao farmer and also government. Every year impacts caused by diseases lead to loses of productivity, income, uncertain food security and negative impacts on human health. The changes of climate are anticipated to exacerbate the situation due to increasing temperatures can support the expansion of vector populations into cooler areas while in the cooler and temperate region can be risky of diseases. Changes in rainfall pattern can also influence an expansion of vectors during wetter years and can lead to large outbreaks. Improving livestock disease control including improvement of livestock health is, therefore, of important for enhancement of adaptive capacity to changing climate and ensuring productivity including minimization of economic losses, environmental and human health impacts.

Livestock disease prevention and control include management of livestock import and transportation, monitoring and control of diseases outbreaks, developing and improving antibiotics, vaccines and diagnostic tools, evaluation of ethnotherapeutic options, and vector control techniques.. In addition, it also includes improvement of livestock health through feeds improvement, vaccination, farming system management and safety consumption.

Agricultural development subsidy mechanism:

It is the fact that the key obstacle of the development in Laos associates with adequate and effective subsidy and financial support. To date, the agriculture subsidy and insurance is not yet well-established or in sustainable manner in Laos. The production under changes of climate and its related disaster can add more risks for farmers and stakeholders. So, agricultural development subsidy mechanism including insurance against crop loss and market fails is pre-requisite for agriculture development of Laos. Without

this mechanism in place, Laos may not be able to realize its policies and targets on agriculture production, development of agricultural based industry process, improvement of people livelihood and poverty reduction timely. The subsidy mechanism for Laos context should include overall agricultural subsidy, development fund and or easy credits, insurance for production failure not only because of climate change, flood or drought but also due to failure of market and production technology that particularly beyond farmer's capacity to handle. In addition, the specific policy, good agriculture and production management system should be place to ensure effective financial and credits management.

Climate resilient rural infrastructure:

The agriculture development is beyond dependence on fertile land, water, weather and cultivation technologies. The infrastructure such as irrigation, road, warehouse, transportation, and markets system is also critical factor for the development particularly quality, durable and tolerance to changing climate and disaster. This infrastructure is insufficient and or poor conditions particularly in the rural area. Although the rural infrastructure is the priority of the government due to limited financial resource, the development is slowly going. So if investment is not taken place sufficiently and effectively, agriculture development and adapting to climate change can be at risk or ineffective; lead to loss of production as well as economics and quality of life of farmers.

Crop Diversification:

The crop diversification is fundamental for agriculture development and conservation of biodiversity. Although it is in the initial stage of development; as it is a priority defined in the national policies as well as under this project more investment in this area in the future is expected in order to ensuring sustainable productivity including climate change resilience and conservation of biodiversity.

Chapter 6. Summary and Conclusions

The technology needs assessment for climate change adaptation was basically conducted though participatory process. The assessment involved with two main steps; sector selection and prioritization of adaptation technology in the selected sectors. The key approach used in the selection and prioritization process included literature review, application of the multi-criteria, scoring, expert judgement and sensitivity analysis.

The sector selection which aims to scope or screen for priority or vulnerable sector was carried out through review of the climate change vulnerability, impact status and trends in different sectors, initial identification of sectors and prioritization of the sector in the sector selection consultation workshop in February 2012 and applied multi-criteria, scoring and expert judgement for assessment and decision respectively.

The technology prioritization workshop which basically aims to select four priority technologies was organized in May2012. The workshop followed the steps and methodologies for technology prioritization, as suggested in the TNA handbook (UNDP and UNFCCC, 2010) particularly technologies identification, editing technology and categorization, and prioritization of technologies with the use of the criteria and scoring, sensitivity analysis and decision on the priority technologies through stakeholders consultation.

Through the process and approach particularly score in the criteria and expert judgments; two sectors and eight technologies are chosen as priority sectors and technologies needs for climate change adaptation respectively. Those sectors are water and agriculture sector and eight technologies, four technologies each for water and agriculture sector were summarized as follows:

Adaptation technologies for water sector:

Four adaptation technologies for water sector consist of Early Warning System, Disaster Impact Reduction Fund, Climate Change Oriented Irrigation and Water Supply System.

Early Warning System:

is pre-requisite for flood prevention. It involved with setting up system weather forecast, modeling of discharge, water gauges, information dissemination tools provide the information to society or community including enhancement of readiness or preparedness and recovery plan for minimizing

impacts that would be caused by extreme event including flood. This technology is practiced in Laos years ago by different stakeholders but it is not systematically functioned due to shortage of financial support, knowledge and skills on the system including equipments and tools. However it is priority of the country as defined on the socioeconomic development plan 2011-2015 (MPI, 2011), Strategy on Climate Change of the Lao PDR (WREA, 2010), National Disaster Management Master Plan and so son. With system in place, it is expected that the impacts which may result from disasters particularly flood including flash flood could be minimized; leading prevention property and life of the people from losses.

Disaster Impact Reduction Fund:

To complement to the early warning system, disaster management fund or impact reduction fund should be established. Previously fund for recover after disasters were insufficient due to mobilization of fund was on the ad hoc basis and lacked of mechanism; leading expansion of impacts and or chronic. So a specific and ready fund is needed for increase effectiveness of the prevention and handling with such disaster in timely manner. The disaster fund management should include fund raising and management mechanism, responsible organizations and networks in all level, from central to village. With such fund and mechanism in place, it is expected that impacts that would result from disasters particularly flood including flash flood could be largely minimized while adaptive capacity can be enhanced.

River Basin or Watershed Management:

The river basin or watershed is of significance for environment and socioeconomic development including climate change adaptation. To sustain water resource and ensure environment and socioeconomic development, practical tools should be in place. Recently, Integrated Water Resources Management (IWRM) which embedded participatory techniques and multi-disciplinary is developed and perceived as a key tool for realize such sustainability including climate change adaptation. Similarly, strategy on water resources management of Laos also defined to apply IWRM for all river basin and watershed management. To now, there are some initiatives on the application of IWRM particularly for Nam Ngum and Nam Theun-Kading river basin. In addition, by 2015, at least 5 river basins such as Sebangfai, Sebanghieng, Sekong, Sedone and Nam Ouwill be completed its IWRM and management committee. So prioritization of this technology means support implementation of water resources policy including food and nutrition security, pervert reduction, environmental, renewable energy development, climate change mitigation and adaptation.

Water Supply System:

The water supply system means set of water reservoir and supply system such as Nampapa and gravity water supplies including water use group and management mechanism. Currently, only 77 percent of people have access to clean water and 54 have access to sanitary toilets (MPI 2011), so to realize targets defined in the MDG, Laos needs more investment in this area and design the system in the climate change context. So prioritization of this water supply system in TNA is expected to enhance investment, management mechanism and water supply system as well as increase access to clean water of Lao people including health and sanitation improvement.

Adaptation technologies for agriculture sector:

Throughout the prioritization process particularly the scoring against criteriaand consultation of the stakeholders; four technologies which received highest scores are selected as priority technology needs for climate change adaptation in the agriculture sector. Those technologies are:

5) Livestock disease prevention and control;
6) Agricultural Development Subsidy Mechanism;
7) Climate Resilient Rural Infrastructure and
8) Crop Diversification.

Livestock disease prevention and control:

Livestock is one of foundation of socioeconomic and livelihood of farmers. Recently diseases outbreak becomes one of the challenges for Lao farmer and also government. Every year impacts caused by diseases lead to loses of productivity, income, uncertain food security and negative impacts on human health. The changes of climate are anticipated to exacerbate the situation due to increasing temperatures can support the expansion of vector populations into cooler areas while in the cooler and temperate region can be risky of diseases. Therefore, livestock disease prevention and control which covers management of livestock import and transportation, monitoring and control of diseases outbreaks, developing and improving antibiotics, vaccines and diagnostic tools, evaluation of ethnotherapeutic options, and vector control techniques including improvement of livestock health are of important for enhancement of adaptive capacity to changing climate and ensuring productivity including minimization of economic losses, environmental and human health impacts.

Agricultural development subsidy mechanism:

It is the fact that the key obstacle of the development in Laos associates with adequate and effective subsidy and financial support. To date, the agriculture subsidy and insurance is not yet well-established or in sustainable manner in Laos. The production under changes of climate and its related disaster can add

more risks for farmers and stakeholders. So, agricultural development subsidy mechanism including insurance against crop loss and market fails is pre-requisite for agriculture development of Laos. The subsidy mechanism in this context include agricultural subsidy, development fund and or easy credits, insurance for production failure not only because of climate change, flood or drought but also due to failure of market and production technology that particularly beyond farmer's capacity to handle. Without this mechanism in place, Laos may not be able to realize its policies and targets on agriculture production, development of agricultural based industry process, improvement of people livelihood and poverty reduction timely.

Climate resilient rural infrastructure:

The agriculture development is beyond dependence on fertile land, water, weather and cultivation technologies. The infrastructure such as irrigation, road, warehouse, transportation, and markets system is also critical factor for the development particularly quality, durable and tolerance to changing climate and disaster. This infrastructure is insufficient and or poor conditions particularly in the rural area. Although the rural infrastructure is the priority of the government due to limited financial resource, the development is slowly going. So if investment is not taken place sufficiently and effectively, agriculture development and adapting to climate change can be at risk or ineffective; lead to loss of production as well as economics and quality of life of farmers.

Crop Diversification:

The crop diversification is fundamental for agriculture development and conservation of biodiversity. Despite it is in the initial stage of development and numbers of efforts are needed to research, develop and deploy such technology in order to effectively contribution to sustainable productivity including climate change resilience and conservation of biodiversity.

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Annexes

Annex 1: List of key stakeholders involved in the TNA process

General		
Name	**Organization/Institution**	**Type of organization/institution**
Mr. XayavethVixay	Department of National Disaster Management and Climate Change (DNDMCC), MoNRE	Government
Mr. SyamphoneSengchandala	DNDMCC, MoNRE	Government
Mr. Mr. ImmalaInthaboualy	DNDMCC, MoNRE	Government
Mr. BountheeSaythongvanh	DNDMCC, MoNRE	Government
Mr. BuathongTheothavong	DNDMCC, MoNRE	Government
Mr. KhampadithKhammounhueng	Department of Environment Promotion,	Government
Ms. ChandaSouliya	MoNRE	
Ms. Simountha	Department of Water Resources, MoNRE	Government
Mr. SackdaPhixayavong	Department of Water Resources, MoNRE	Government
Mr. KeoKorakoth	Department of Forest Resources Management, MoNRE	Government
Mr. ThongsaySihalath	Department of Land Management, MoNRE	Government
Ms. Chansouk Si Oudome	Department of Meteorology and Hydrology, MoNRE	Government
Ms. DalounyVilaythong	Natural Resources and Environment Research Institute, MoNRE	Research Institutes
Ms. NguenmanyKhamphoumy	Natural Resources and Environment Research Institute, MoNRE	Research Institutes
Mr. LaeManivong	Department of agriculture, MAF	Government
Ms.PhonguenPhosalath	Department of agriculture, MAF	Government
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Mr. PhousithPhoumavong	Department of Agriculture and Forestry	Government

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Mr. SomesoukSomechai	National Agriculture and Forestry Research Institute (NAFRI), MAF	Research Institute
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Mr. KhamsenOunkham	Department of Forestry, MAF	Government
Ms. SouthchaiPhilavong	Department of Forestry, MAF	Government
Mr. SithongThongmanivong	Faculty of Forestry, NUoL	Academic
Mr. SivangXayavong	Department of Energy Management, MEM	Government
Mr. ViengsoukSanapaya	Department ofEnergy Management, MEM	Government
Dr. Simone Nampanya	Center for Malaria Control, MPH	Government
Ms. BounthanomePhimmasone	Center for Water Sanitation and Hygiene, MPH	Government
Mr. XaythavoneSihanath	Department of Transport, MPWT	Government
Mr.PhouthasomeInthavong	Department of Urban Planning and Housing, MPWT	Government
Mr, HoumphanPhaduangdaetha	Public Work and Transport Research Institute, MPWT	Research Institute
Mr. LamkhaXayasanh	Public Work and Transport Research Institute, MPWT	Research Institute
Mr. PhouthasomeInthavong	Public Work and Transport Research Institute, MPWT	Research Institute
Ms. LathsamySouthammavong	Faculty of Environment Science, NUoL	Academic
Mr. SengchanPhaxayaseng	Department of Technology and Innovation, MST	Government
Mr. BounchanDouangvilay	Department of Technology and Innovation, MST	Government
Mr. HoumphengTheuadbounmy	Renewable Energy Research and Development Center, MST	Research Institute
Mr. Viengsavanh	National Economic Research Institute	Research Institute

	(NERI), MPI	
Ms. KhamnangKhounphakdy	National Economic Research Institute (NERI), MPI	Research Institute
Mr. KeophaseurthChanthaphime	Department of International Personal, MoFA	Government
Mr. PhiengsavanhThammasith	Department of International Finance, MoFA	Government
Mr.PhetmixayKasermsouk	Department of Industry Process, MIC	Government
Mr. RubenitoLampayan	IRRI	International Organization
Ms. PanyVanmanivong	IRRI	International Organization
Ms. TitaroseVijitpan	MRC	International Organization
Ms. ParichatBorkham	MRC	International Organization
Ms. KhamphoneLueangvanh	MRC	International Organization
Mr. Uwe Singer	IUCN	International Organization
	UNDP	International Organization
Mr. Chansome	WB	International Organization

Annex 2: the priority adaptation projects in the NAPA

No.	Sector	Priority Projects
1	**Agriculture**	**Priority One:** 1) Strengthen the capacity and knowledge of the National Disaster Management Committee (NDMC) 2) Promote secondary occupations and livelihood of farmers affected by disasters influenced by climate change **Priority Two:** 3) Improve land use planning in hazard-prone and -affected areas 4) Promote short-duration paddy and other cash crops in natural hazard-prone areas. 5) Strengthen technical capacities of local agricultural officers in natural hazard-prone areas 6) Improve and develop crop varieties and animal species that are better adapted to natural hazard-prone areas 7) Improve and construct crop and animal disease laboratories at central and local levels and build related capacity of technical staff 8) Train farmers on the processing and storing of human and animal food stuffs 9) Establish and strengthen farmers groups in natural hazard prone areas 10) Promote soil improvement using locally available organic fertilizer and existing agricultural waste 11) Develop appropriate bank erosion protection systems for agricultural land in flood prone areas 12) Promote integrated pest management (IPM) and use of herbal medicines in pest management and livestock treatment 13) Develop the capacity of technical staff in organic fertilizer research.
2	**Forestry**	**Priority One:** 1) Continue the slash-and-burn eradication programme and permanent job creation programme 2) Strengthen capacities of village forestry volunteers in forest planting, caring and management techniques, as well as the use of village forests **Priority Two:** 3) Carry out surveys and identify and develop forest areas suitable for supporting seed production 4) Promote and establish tree nurseries to provide saplings to areas at high risk from flooding or drought 5) Raise public awareness on wildlife conservation and forest fire prevention 6) Set up and further strengthen technical capacities of forest fire management teams at provincial, district and village levels

		7) Develop public awareness campaigns to disseminate information on forest and wildlife regulations and laws, and strengthen implementation of these regulations 8) Develop agro-forestry systems for watershed protection and erosion reduction in steep areas 9) Develop small reservoirs in upland areas in order to provide water for wildlife/aquatic animals and plants during the dry season 10) Develop a public awareness campaign on pest and disease outbreaks in wildlife caused by natural disasters, as well as on associated preventive measures 11) Develop an extension campaign on integrated forest plantation management for crop pest and disease control 12) Conduct research and select seeds of plant species suitable for flood- and drought-prone areas 13) Construct bush fire barriers/forest fire protection buffer zones in forest conservation areas 14) Build research capacity on wildlife pests/diseases and outbreaks of animal diseases

	Water and water resources	**Priority One:** 1) Raise awareness on water and water resource management 2) Map flood-prone areas 3) Establish an early warning system for flood-prone areas, and improve and expand meteorology and hydrology networks and weather monitoring systems 4) Strengthen institutional and human resource capacities related to water and water resource management 5) Survey underground water sources in drought-prone areas 6) Study, design and build multi-use reservoirs in drought-prone areas **Priority Two:** 7) Conserve and develop major watersheds 8) Build and improve flood protection barriers to protect existing irrigation systems 9) Improve and protect navigation channels and navigation signs 10) Repair/rehabilitate infrastructure and utilities damaged by floods in agricultural areas
	Public health	**Priority One:** 1) Improve systems for the sustainable use of drinking water and sanitation, with community participation, in flood- and drought-prone areas 2) Improve knowledge and skills of engineers who design and build water and sanitation systems **Priority Two:** 3) Raise public awareness on sanitation in flood-prone areas 4) Improve and standardize the quality of drinking water 5) Expand epidemic disease diagnostic laboratories at regional and provincial levels, to provide disease epidemic information in a timely fashion to flood- and drought-affected areas 6) Improve prevention and treatment of water-borne diseases 7) Develop a timely and accurate reporting system for epidemic diseases 8) Improve the capacity of the epidemic disease surveillance system

Annex 3: List of key stakeholders involved in the inception and sector selection workshop

	Name	Organization/Institution	Type of organization/ institution
1	Mr. KhampadithKhammounhueng	Department of Environment Promotion, MoNRE	Government
2	Mr. SyamphoneSengchandala	Department of Disaster Management and Climate Change	Government
3	Mr. Immala Inthaboualy	Department of Disaster Management and Climate Change, MoNRE	Government
4	Mr. BountheeSaythongvanh	Department of Disaster Management and Climate Change, MoNRE	Government
5	Mr. VanthonePhonnasan	Department of Disaster Management and Climate Change, MoNRE	Government
6	Ms. ChindalakVilanon	Department of Disaster Management and Climate Change, MoNRE	Government
7	Ms. ThounheuangBuiyavong	Department of Disaster Management and Climate Change, MoNRE	Government
8	Ms. Simountha	Department of Water Resources, MoNRE	Government
9	Ms. DalounyVilaythong	Natural Resources and Environment Research Institute, MoNRE	Research Institutes
10	Mr. LaeManivong	Department of agriculture, MAF	Government
11	Mr.KhamphoneMounlamai	National Agriculture and Forestry Research Institute (NAFRI), MAF	Research Institute
12	Mr.BounmanhKeomolakoth	National Agriculture and Forestry Research Institute (NAFRI), MAF	Research Institute
13	Mr. KhamsenOunkham	Department of Forestry, MAF	Government
14	Mr.KaisonePhengsopha	Faculty of Forestry NoUL	Academic
15	Mr. SivangXayavong	Department of Energy Management , MEM	Government
16	Mr. XaythavoneSihanath	Department of Transport, MPWT	Government
17	Mr.PhouthasomeInthavong	Department of Urban Planning and Housing, MPWT	Government
18	Mr, HoumphanPhaduangdeth	Public Work and Transport Research Institute, MPWT	Research Institute
19	Mr. BounchanDouangvilay	Department of Technology and Innovation, MST	Government
20	Mr. PhiengsavanhThammasith	Department of International Cooperation, MPI	Government

21	Mr. Viengsavanh	National Economic Research Institute (NERI), MPI	Research Institute
22	Mr. KeophaseurthChanthaphime	Department of International Personal, MoFA	Government
23	Ms. KeophouthoneInthavong	Department of International Finance, MoF	Government
24	Mr.PhetmixayKasermsouk	Department of Industry Process, MIC	Government
25	Mr. RubenitoLampayan	IRRI	International Organization
26	Ms. PanyVanmanivong	IRRI	International organization
27	Ms. TitaroseVijitpan	MRC	International Organization
28	Ms. ParichatBorkham	MRC	International Organization
29	Mr. Uwe Singer	IUCN	International Organization
30	Ms. SomesanithMounphoxay	Second National Communication (SNC) Project (MoNRE/UNDP)	Project
31	Mr. SomesavanhSivilay	Second National Communication (SNC) Project (MoNRE/UNDP)	Project
32	Mr. Chansome	WB	International Organization
33	Ms. DouangchaiSichanthavong	LBD	Private
34	Mr. OudoneTamixay	Faculty of Environment Science, NUOL	Academic
35	Ms. VathsudaNilathxai	Faculty of Environment Science, NUOL	Academic
36	Mr. MoneNouansyvong	Consultant, TNA project	Project

Adaptation Work Group

	Name	**Organization/Institution**	**Type of organization/ institution**
1	Mr. SyamphoneSengchandala	Department of Disaster Management and Climate Change , MONRE	Government
2	Mr. Immala Inthaboualy	Department of Disaster Management and Climate Change , MONRE	Government
3	Mr. BountheeSaythongvanh	Department of Disaster Management and Climate Change , MONRE	Government

4	Ms. ThounheuangBuiyavong	Department of Disaster Management and Climate Change , MONRE	Government
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6	Mr. KhamsenOunkham	Department of Forestry, MAF	Government
7	Mr. SivangXayavong	Department of Energy Management , MEM	Government
8	Mr. XaythavoneSihanath	Department of Transport, MPWT	Government
9	Mr.PhouthasomeInthavong	Department of Urban Planning and Housing, MPWT	Government
10	Mr, HoumphanPhaduangdeth	Public Work and Transport Research Institute, MPWT	Research Institute
11	Mr. BounchanDouangvilay	Department of Technology and Innovation, MST	Government
12	Mr.PhetmixayKasermsouk	Department of Industry Process, MIC	Government
13	Mr. Uwe Singer	IUCN	International Organization
14	Mr. Chansome	WB	International Organization
15	Mr. MoneNouansyvong	Consultant, TNA project	Project
16	Mr. SomesavanhSivilay	Second National Communication (SNC) Project (MoNRE/UNDP)	Project
17	Mr. OudoneTamixay	Faculty of Environmental Science, NUoL	Academic
18	Ms. VathsudaNilathxai	Faculty of Environmental Science, NUoL	Academic

Adaptation Work Group

	Name	**Organization/Institution**	**Type of organization/ institution**
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4	Ms. Simountha	Department of Water Resources, MoNRE	Government
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8	Mr.KaisonePhengsopha	Faculty of Forestry NoUL	Academic
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11	Mr. KeophaseurthChanthaphime	Department of International Personal, MoFA	Government
12	Ms. KeophouthoneInthavong	Department of International Finance, MoF	Government
13	Mr. RubenitoLampayan	IRRI	International Organization
14	Ms. PanyVanmanivong		
15	Ms. TitaroseVijitpan	MRC	
16	Ms. ParichatBorkham		International Organization
17	Ms. SomesanithMounphoxay	Second National Communication (SNC) Project (MoNRE/UNDP)	Project
18	Ms. DouangchaiSichanthavong	LBD	Private

Annex 4: List of key stakeholders involved in the technology prioritization workshop

No	Name	Organization/Institution	Type of organization/ institution
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3	Mr. BountheeSaythongvanh	Department of Disaster Management and Climate Change, MoNRE	Government
4	Mr. VanthonePhonnasan	Department of Disaster Management and Climate Change, MoNRE	Government
5	Ms. MonxamSothipmany	Department of Disaster Management and Climate Change, MoNRE	Government
6	Ms. ChindalakVilanon	Department of Disaster Management and Climate Change, MoNRE	Government
7	Ms. ThounheuangBuiyavong	Department of Disaster Management and Climate Change, MoNRE	Government
8	Mr. KeoKorakoth	Department of Forest Resources Management, MoNRE	Government
9	Ms. ChandaSouliya	Department of Environment Promotion, MoNRE	Government
10	Mr. SackdaPhixayavong	Department of Water Resources, MoNRE	Government

11	Mr. ThongsaySihalath	Department of Land Management, MoNRE	Government
12	Ms. Chansouk Si Oudome	Department of Meteorology and Hydrology, MoNRE	Government
13	Mr. PhimphacksomphanPhalakhone	Department of Livestock and Fishery, MAF	Government
14	Ms. PhouNguenPhosalath	Department of Agriculture, MAF	Government
15	Mr. SyammoneSisongkham	Department of Irrigation, MAF	Government
16	Mr. PhousithPhoumavong	Department of Agriculture and Forestry Extension Services, MAF	Government
17	Mr. SouksomeSomechai	National Agriculture and Forestry Research Institute (NAFRI), MAF	Research Institute
18		Faculty of Agriculture, NUoL	Academic
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20	Mr.KaisonePhengsopha	Faculty of Forestry NoUL	Academic
21	Mr. ViengsoukSanapanya	Department of Energy Management, MEM	Government
22	Mr. SengchanPhasaiyaseng	Department of Technology and Innovation, MST	Government
23	Mr. HoumphengTheuatbounmy	Renewable Research Institute, MST	Research Institute
24	Mr. PhouthasomeInthavong	Department of Urban and Housing, MPWT	Government
25	Mr. LamkhaXayasan	Public Work and Transport Research Institute, MPWT	Research Institute
26	Ms. VilaykhamLathsaad	National Disaster Management Office, MSWF	Government
27	Dr. Simone Nampanya	Center for Malaria Control, MPH	Academic
28	Mr. LatsamyInthavongsa	Department of Water Sanitation and Hygiene, MPH	Government
29	Ms. BounthanomePhimmasone	Center for Water Sanitation and Hygiene, MPH	Government
30	Ms. LathsamySouthammavong	Faculty of Environment Science, NUoL	Academic
31	Mr. HoumphengTheuadbounmy	Renewable Energy Research and Development Center, MST	Research Institute
32	Ms. KhamnangKhounphakdy	National Economic Research Institute, MPI	Research Institute
33	Mr. PhiengsavanhThammasith	Department of International Finance, MoFA	Government
34	KhamphoneLueangvanh	MRC	International Organization
35	Mr. MoneNouansyvong	Consultant, TNA project	
36	Ms. LathsoudaVilathxai	Faculty of Environment Science, NUOL	Academic
37	Ms. LathdavoneBuaphaseut	Faculty of Environment Science, NUOL	Academic
38	Mr. OudonTavamixai	Faculty of Environment Science, NUOL	Academic

Agriculture Sector

Name	Organization/Institution	Type of organization/institution

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2	Ms. MonxamSothipmany		Government
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4	Ms. ChandaSouliya	Department of Environment Promotion, MoNRE	Government
5	Mr. PhimphacksomphanPhalakhone	Department of Livestock and Fishery, MAF	Government
6	Ms. PhouNguenPhosalath	Department of Agriculture, MAF	Government
7	Mr. PhousithPhoumavong	Department of Agriculture and Forestry Extension Services, MAF	Government
8	Mr. SouksomeSomechai	National Agriculture and Forestry Research Institute (NAFRI), MAF	Research Institute
9		Faculty of Agriculture, NUoL	Academic
10	Ms. LathsamySouthammavong	Faculty of Environment Science, NUoL	Academic
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12	Ms. LathdavoneBuaphaseut	Faculty of Environment, NUoL	Academic

Forestry Sector

	Name	**Organization/Institution**	**Type of organization/institution**
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4	Mr. KeoKorakoth	Department of Forest Resources Management, MoNRE	Government
5	Mr. ThongsaySihalath	Department of Land Management, MoNRE	Government
6	Mr. SithongThongmanivong	Faculty of Forestry, NUoL	Academic
7	Mr. ViengsoukSanapanya	Department of Energy Management, MEM	Government
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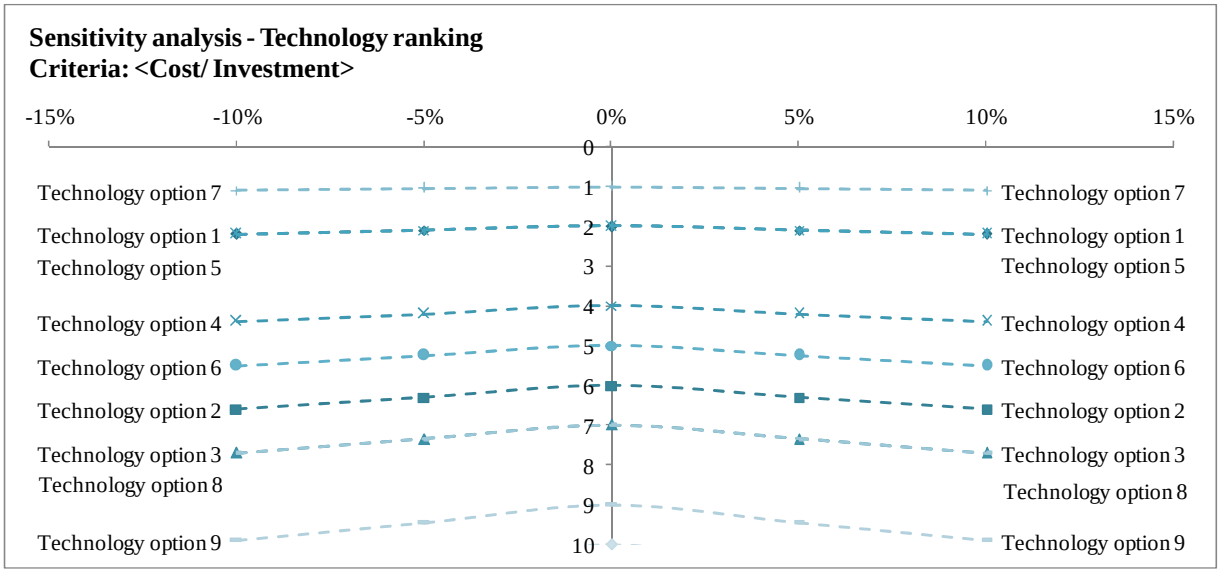
4	Mr. SyammoneSisongkham	Department of Irrigation, MAF	Government
5	Mr.KaisonePhengsopha	Faculty of Forestry NoUL	Academic
6	Mr. PhouthasomeInthavong	Department of Urban and Housing, MPWT	Government
7	Mr. LamkhaXayasan	Public Work and Transport Research Institute, MPWT	Research Institute
8	Ms. VilaykhamLathsaad	National Disaster Management Office, MSWF	Government
9	Dr. Simone Nampanya	Center for Malaria Control, MPH	Government
10	Mr. LatsamyInthavongsa	Department of Water Sanitation and Hygiene, MPH	Government
11	Ms. BounthanomePhimmasone	Center for Water Sanitation and Hygiene, MPH	Government
12	Ms. KhamnangKhounphakdy	National Economic Research Institute, MPI	Research Institute
13	Mr. PhiengsavanhThammasith	Department of International Finance, MoFA	Government
14	KhamphoneLueangvanh	MRC	International Organization
15	Ms. LathsoudaVilathxai	Faculty of Environment, NUoL	Academic

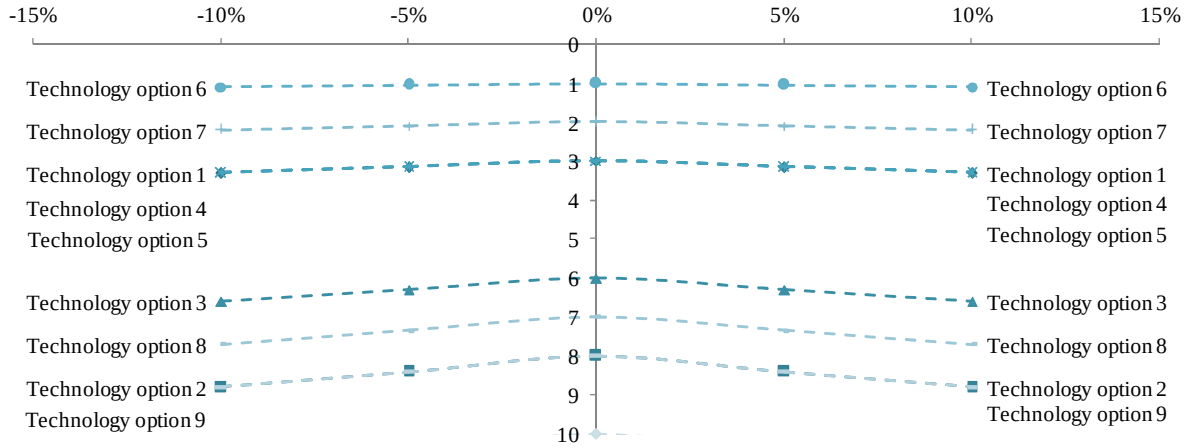
Annex 5: Sensitivity analysis of the criteria and score of technologies

Agriculture Sector:

Technology 1	Climate change oriented irrigation
Technology 2	Flood prevention and drainage system
Technology 3	Promote integrated farming
Technology 4	Livestock disease prevention and control
Technology 5	Crop diversification
Technology 6	Rural climate resilient infrastructure development
Technology 7	Agricultural development subsidy mechanism
Technology 8	Integrated land use planning and sustainable resettlement
Technology 9	Conservation agriculture and preservation of agriculture land
Technology 10	Research on climate change impact on agriculture



Sensitivity analysis - Technology ranking
Criteria: <Adaptation Potential>



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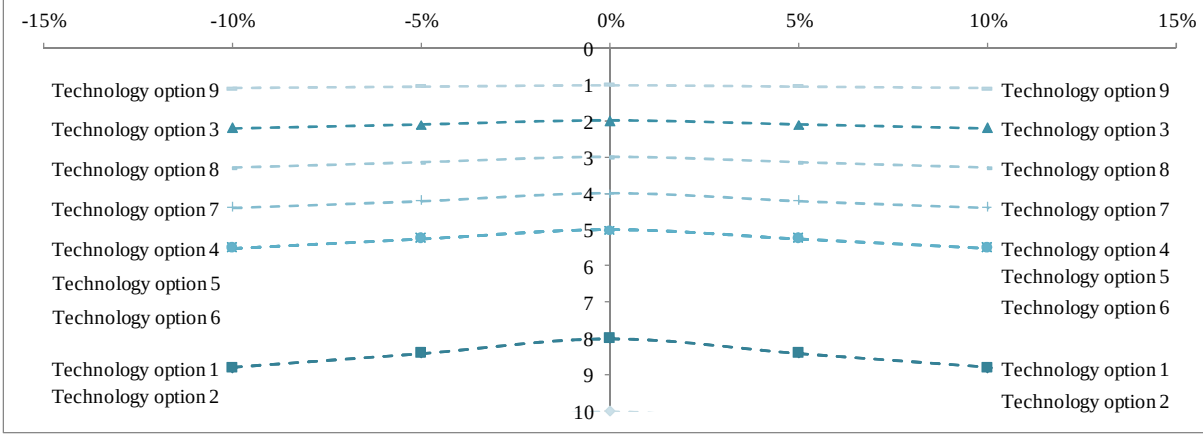

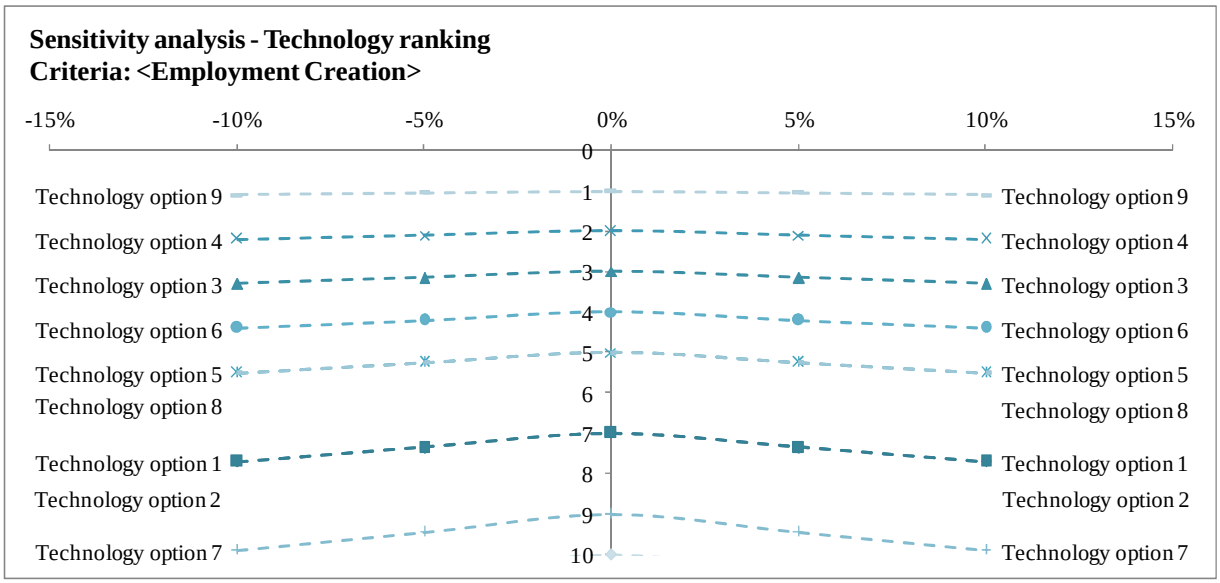
Sensitivity analysis - Technology ranking
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10%
15%
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2
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5
6
7
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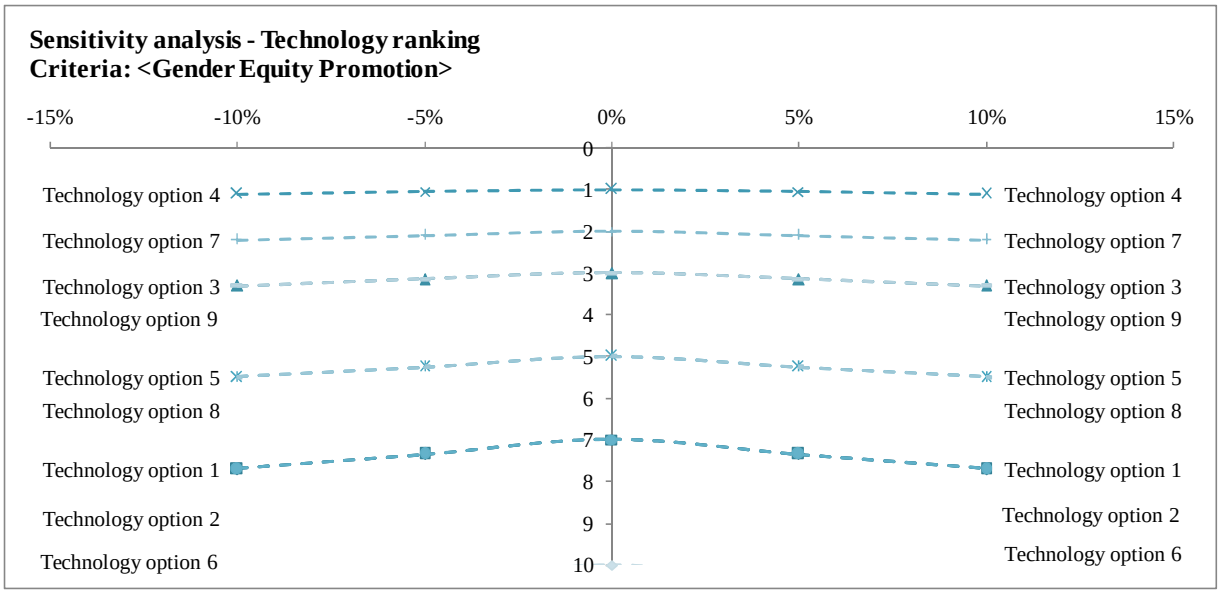
Technology option 2
Technology option 7


Sensitivity analysis - Technology ranking
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-5%
0%
5%
10%
15%
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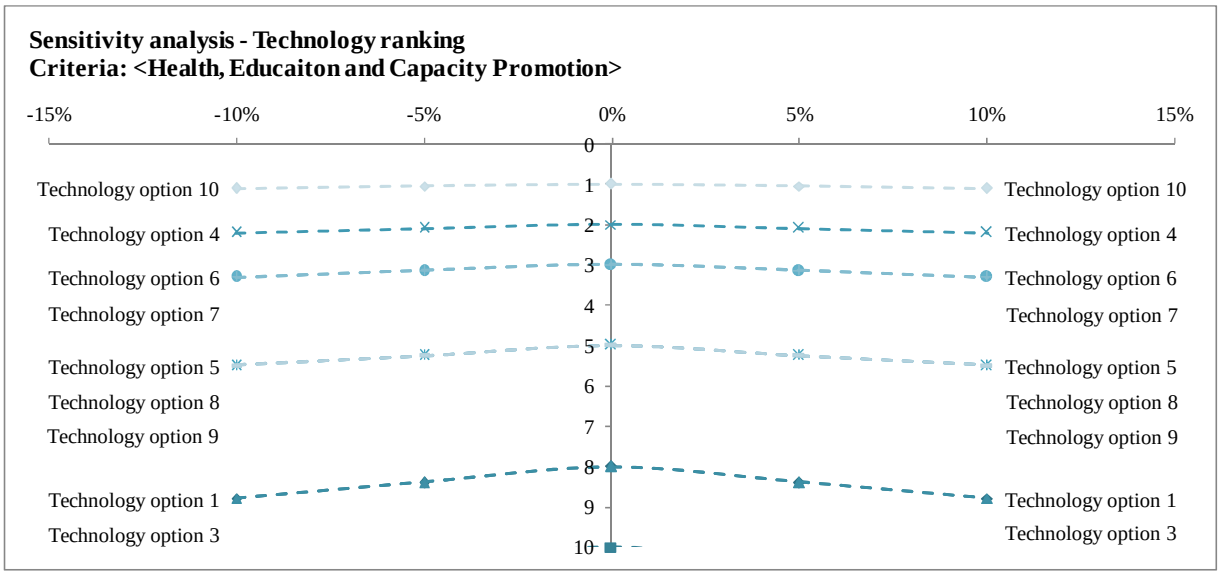
4
5
6
7
8
9
10
Technology option 4
Technology option 7
Technology option 3
Technology option 9
Technology option 5
Technology option 8
Technology option 1
Technology option 2
Technology option 6


Sensitivity analysis - Technology ranking
Criteria: <Health, Educaiton and Capacity Promotion>
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-10%
-5%
0%
5%
10%
15%
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1
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Technology option 10
Technology option 4
Technology option 6
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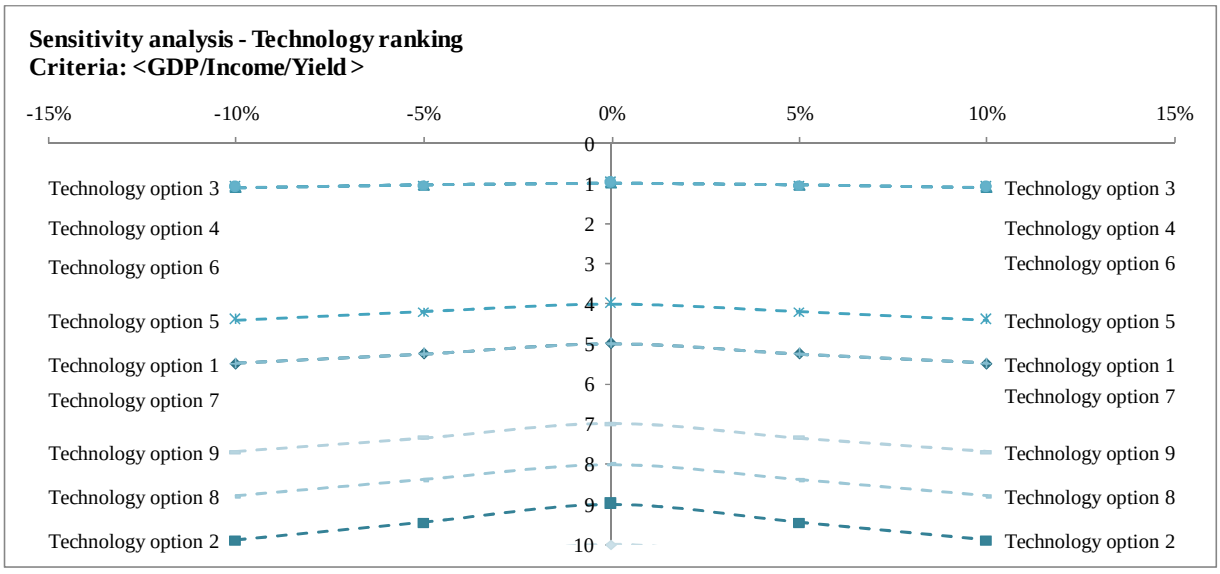
Technology option 5
Technology option 8
Technology option 9
Technology option 1
Technology option 3


Sensitivity analysis - Technology ranking
Criteria: <GDP/Income/Yield >
-15%
-10%
-5%
0%
5%
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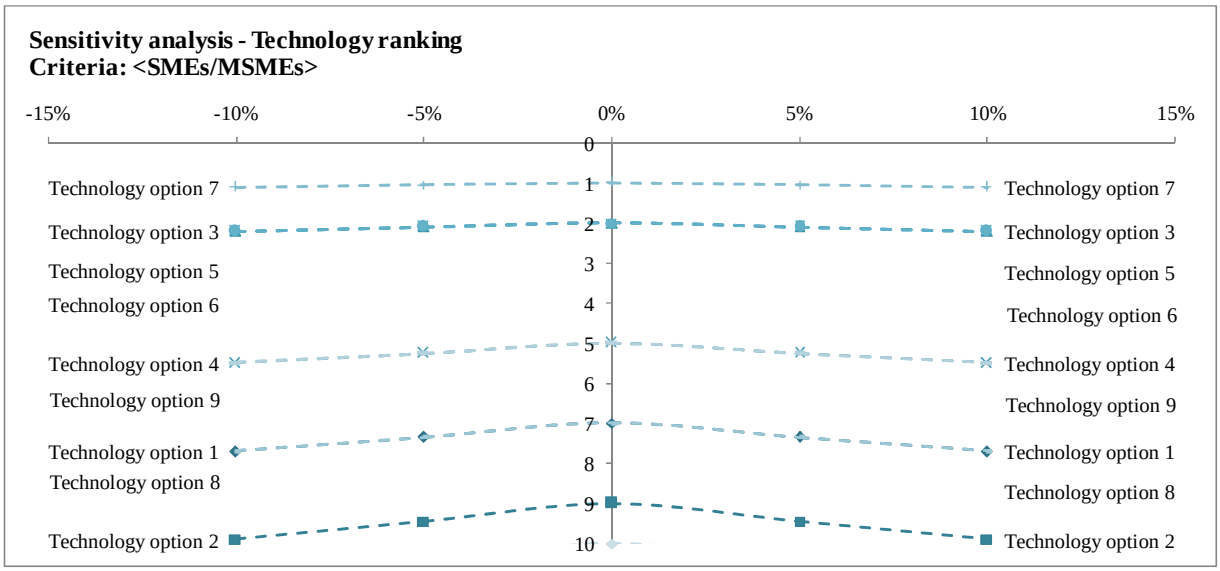
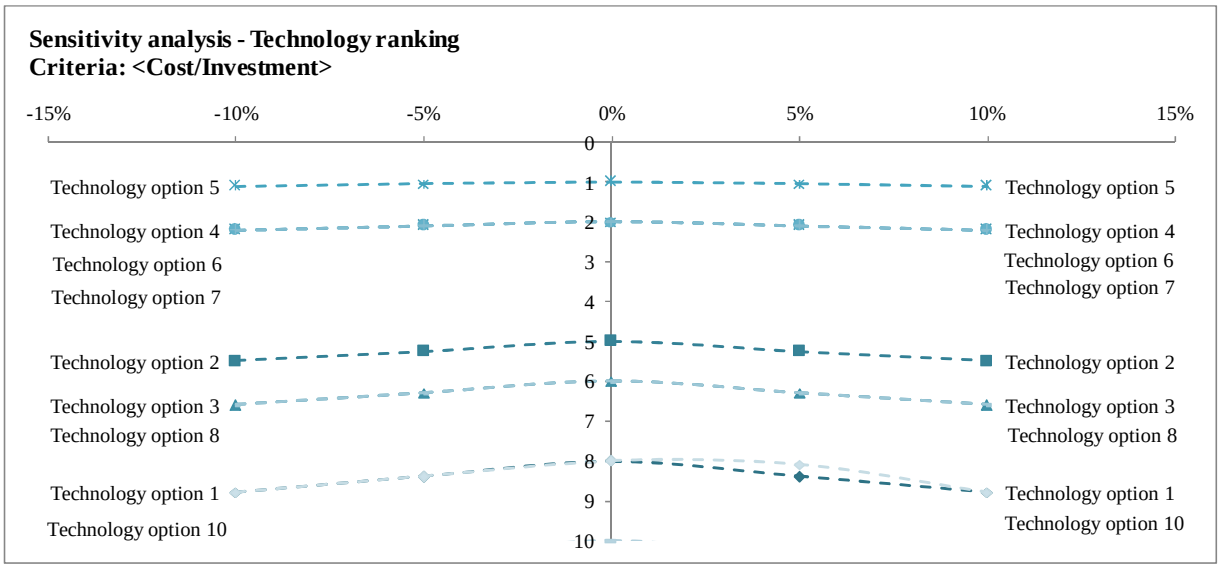
Technology option 3
Technology option 4
Technology option 6
Technology option 5
Technology option 1
Technology option 7
Technology option 9
Technology option 8
Technology option 2



Water Sector:

Technology 1	Flood risk mapping
Technology 2	Early warning
Technology 3	Multi-purpose reservoir and water storage
Technology 4	Optimal water supply system
Technology 5	Disaster impact reduction fund
Technology 6	Climate change oriented irrigation
Technology 7	Effective water sources and basin management
Technology 8	Flood and drought operation center
Technology 9	Groundwater management
Technology 10	Hydrological monitoring


Sensitivity analysis - Technology ranking
Criteria: <Cost/Investment>
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-10%
-5%
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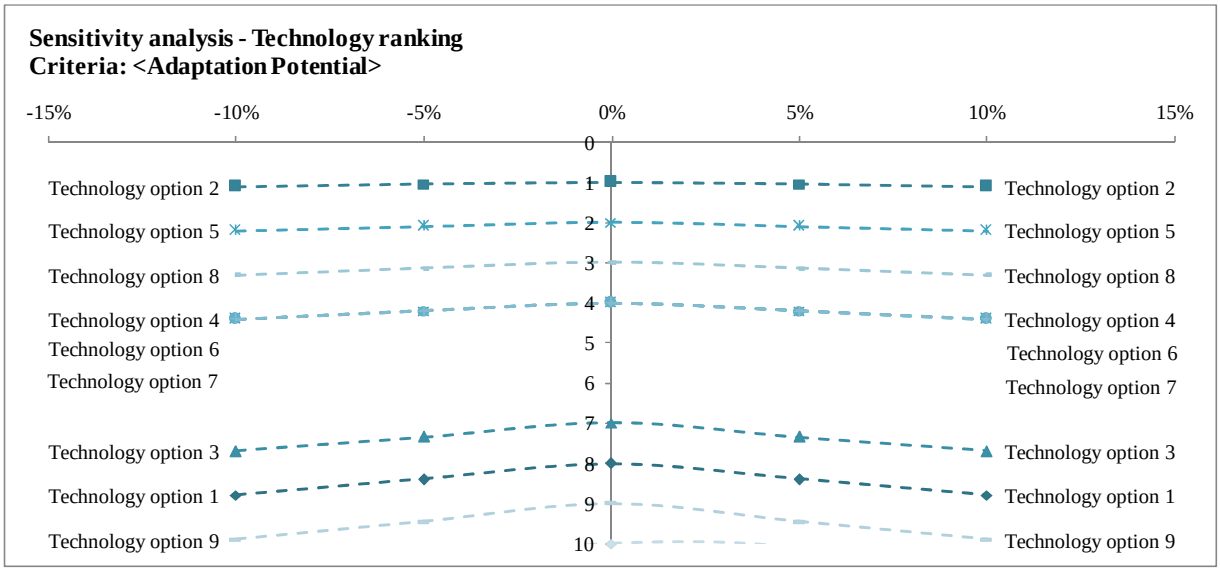
Technology option 5
Technology option 4
Technology option 6
Technology option 7
Technology option 2
Technology option 3
Technology option 8
Technology option 1
Technology option 10


Sensitivity analysis - Technology ranking
Criteria: <Adaptation Potential>
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-10%
-5%
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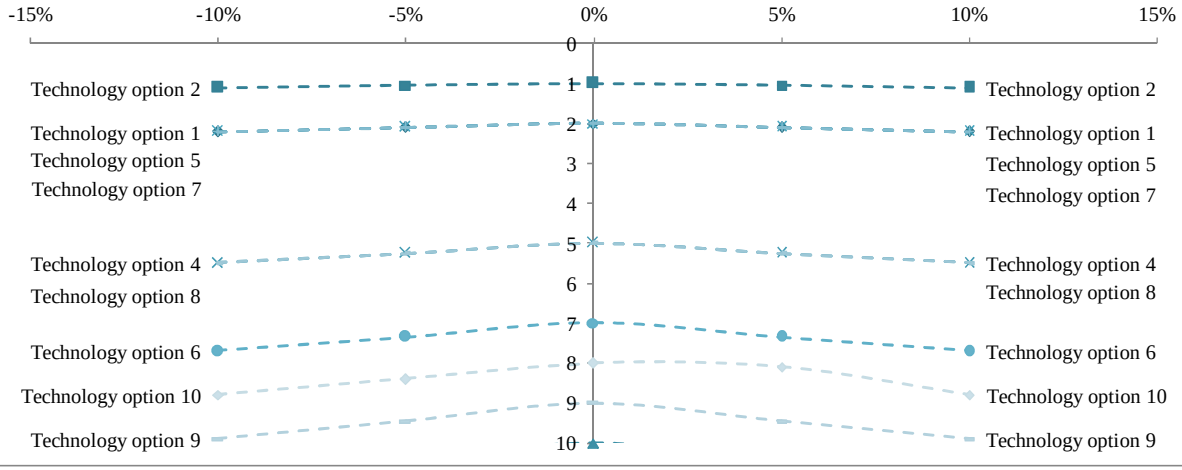
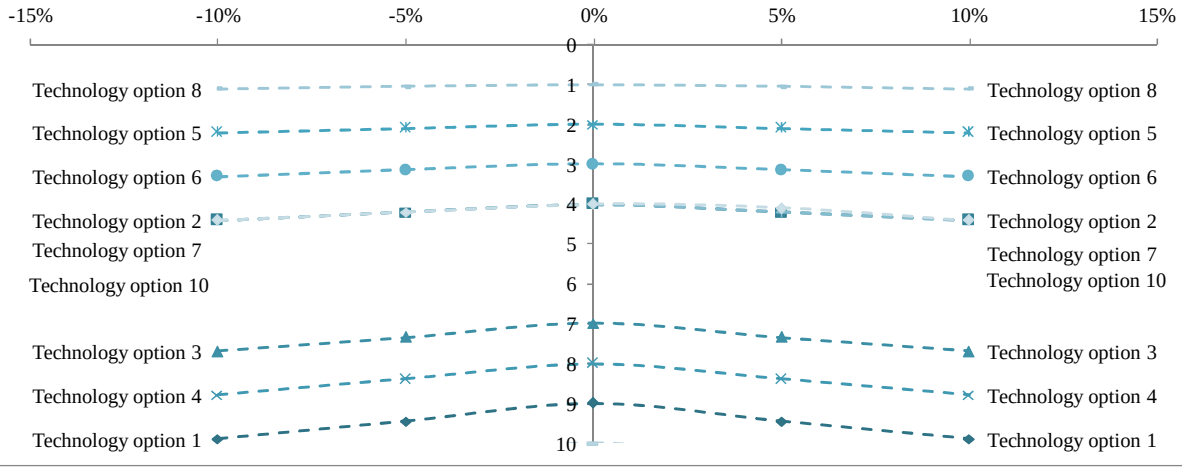
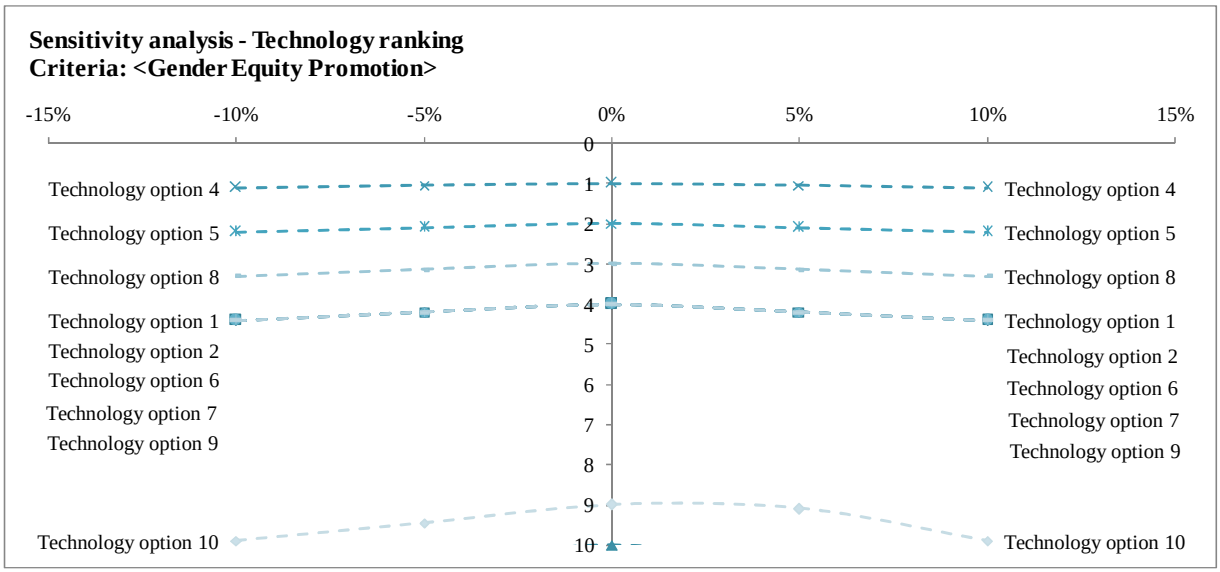
Technology option 2
Technology option 5
Technology option 8
Technology option 4
Technology option 6
Technology option 7
Technology option 3
Technology option 1
Technology option 9

Sensitivity analysis - Technology ranking
Criteria: <Environmental Negative Impacts Reduction>



Sensitivity analysis - Technology ranking
Criteria: <Employment Creation>




Sensitivity analysis - Technology ranking
Criteria: <Gender Equity Promotion>
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Technology option 4
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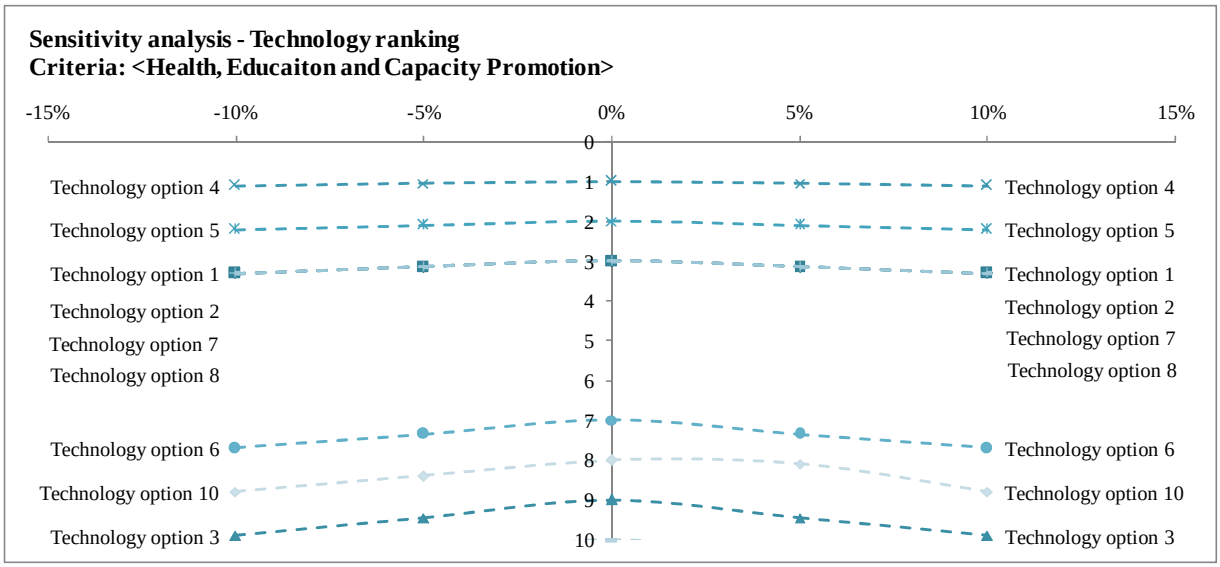
Technology option 8
Technology option 1
Technology option 2
Technology option 6
Technology option 7
Technology option 9
Technology option 10


Sensitivity analysis - Technology ranking
Criteria: <Health, Educaiton and Capacity Promotion>
-15%
-10%
-5%
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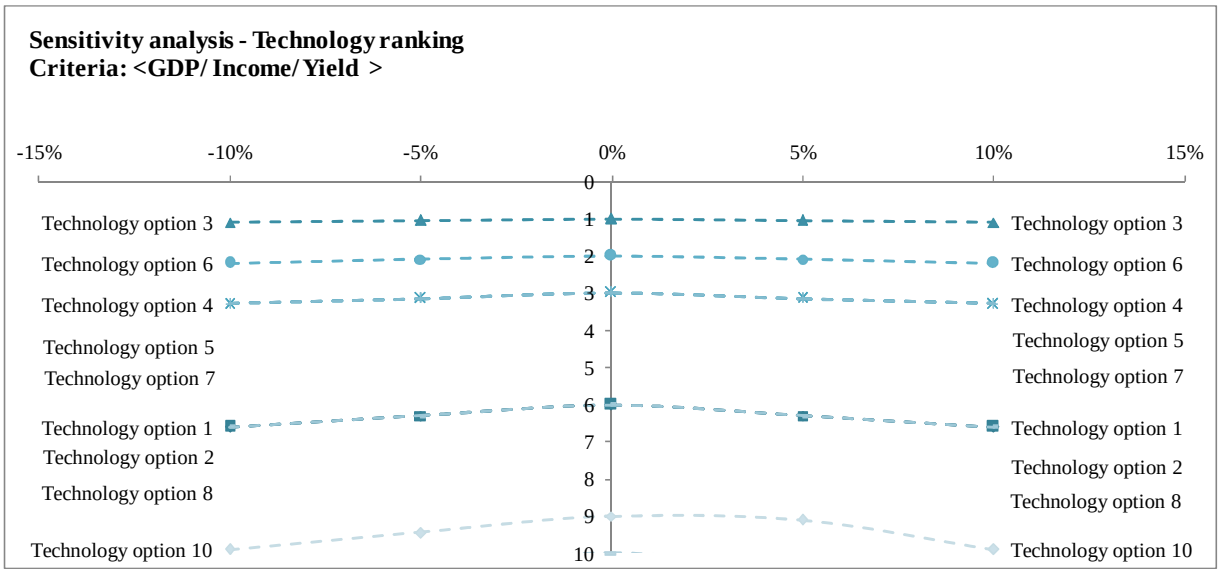
Technology option 4
Technology option 5
Technology option 1
Technology option 2
Technology option 7
Technology option 8
Technology option 6
Technology option 10
Technology option 3


Sensitivity analysis - Technology ranking
Criteria: <GDP/ Income/ Yield >
-15%
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-5%
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Technology option 3
Technology option 6
Technology option 4
Technology option 5
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Technology option 1
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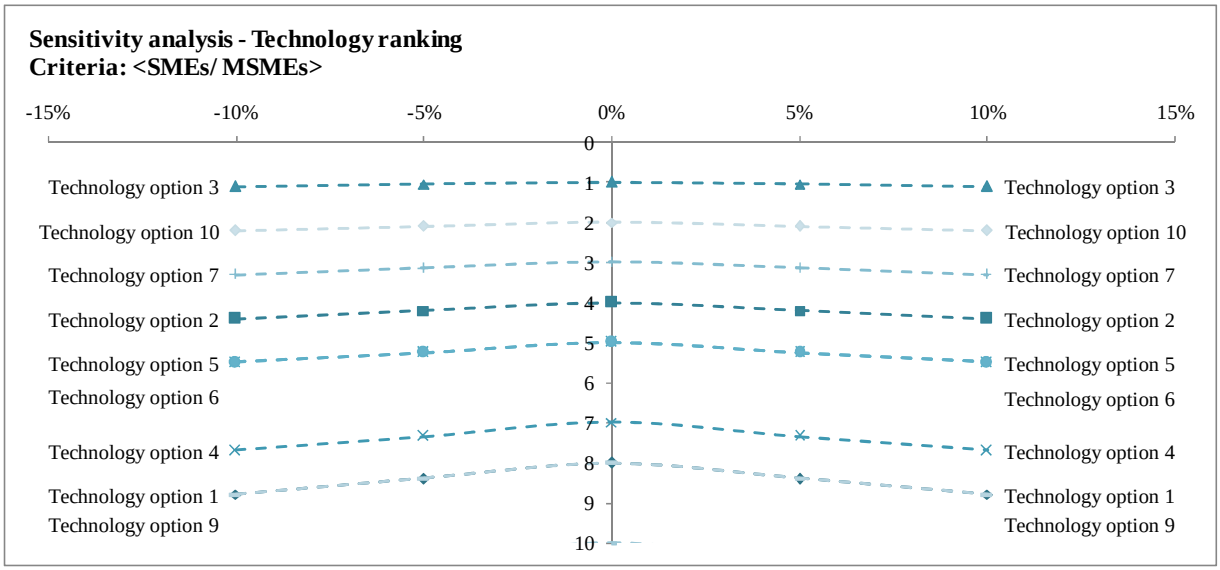
Technology option 8
Technology option 10


Sensitivity analysis - Technology ranking
Criteria: <SMEs/ MSMEs>
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-10%
-5%
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Technology option 3
Technology option 10
Technology option 7
Technology option 2
Technology option 5
Technology option 6
Technology option 4
Technology option 1
Technology option 9

Annex 6: Technology Factsheets for selected technologies

Annex 7: Picture of the workshops