LAO PEOPLE'S DEMOCRATIC REPUBLIC

TECHNOLOGY NEEDS ASSESSMENTS REPORT

CLIMATE CHANGE MITIGATION

April 2013

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Technology Needs Assessments Report - Climate Change Mitigation

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Editors:
Department of Disaster Management and Climate Change

Advisors:
Ministry of Natural Resources and Environment

Country Coordination:
Department of National Disaster Management and Climate Change

National consultant:
Mone Nouansyvong

Forestry Sector Contributors:
Department of Forestry, Ministry of Agriculture and Forestry
National Agriculture and Forestry Research Institute, Ministry of Agriculture and Forestry
Department of Forest Resources Management, Ministry of Natural Resources and Environment
Faculty of Forestry, National University of Laos

Agriculture Sector Contributors:
Department of Agriculture, Ministry of Agriculture and Forestry
Department of Livestock and Fishery, Ministry of Agriculture and Forestry
National Agriculture and Forestry Research Institute, Ministry of Agriculture and Forestry
Faculty of Agriculture, National University of Laos

Supporting Team:
Work Group from Ministry of Energy and Mining, Science and Technology, Public Work and Transport, Planning and Investment, Industry and Commerce, Finance; National Economic, Public Work and Urban Planning, Renewable Energy, Water Resources and Environment Research Institute.

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Abbreviations and Acronyms

AIT	Asian Institute of Technology
ASEAN	Association of Southeast Asian Nations
CDM	Clean Development Mechanism
CH_4	Methane
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide equivalent
DMC	Direct seeding mulch-based cropping system
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
N2O	Nitrous oxide
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 mitigation includes two main steps; selection of the priority sectors and prioritization of technologies for mitigation of greenhouse gas (GHG) emissions in the priority sectors. The sector selection and technology prioritization was carried out through a similar process; review of the status and trend of GHG emissions or existing mitigation technologies in different sectors and initially identify the priority sectors or technologies; application of multi-criteria and scoring for prioritization; and stakeholder consultation and sensitivity analysis for validation of the results. The review of the emissions status and trends or existing mitigation technologies mainly focussed on assessment and summary of the emissions, trends and technologies described in the Initial and Second National Communications on Climate Change (INC and SNC)(STEA, 2000 and MoNRE, 2012), Assessment Report on Technology Needs and Priorities for Mitigating Greenhouse Gas Emissions (STEA, 2004), 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 mitigation technologies elsewhere such as IPCC Assessment Report (IPCC, 2007), TNA guidebook[2] and website[3]. The multi-criteriaapplied in the sector and technology prioritization are broadly divided in four main categories, namely contribution to GHG emission reduction, economic, social and environment. 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 thesector selection and technology prioritization workshops. In the prioritization of sectors andtechnologies, those criteria were weighted and scored based on the multi-criteria techniques[4].The stakeholder consultation particularly sector selection and technology prioritization workshops were held in February and May 2012 which participated by public, private, research institutes, academic and international organizations, totally not less than 24 departments or organizations and 35 participants each.

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[1] For example: Forestry Strategy to the year 2020 of the Lao PDR (MAF, 2005) for forestry sector and Agriculture Development to the year 2020 for agriculture sector (MAF, 2011) etc.

[2] For example guidebook on the Technologies for Mitigation of Greenhouse Gas Emissions in the Agriculture Sector (UNEP, 2012)

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

[4] The multi-criteria techniques derived from one recommended in Communities and Local Government, 2009.

Through these processes; two sectors namely forestry, agriculture and four technologies for each sector are chosen as priority sectors and technology needs for greenhouse gas mitigation. Followings are the priority sectors and technologies for GHGs mitigation:

Mitigation technologies for the forestry sector:

- Effective Protection and Protected Area
- Optimal Agro-Forestry
- Optimal Plantation
- Sustainable Community Forest Management

Mitigation technologies for the agriculture sector:

- Organic farming
- Biogas digester
- Feeds improvement
- Agriculture residue to energy

Effective Protected Area Management: as mentioned, the effective protected area management is a technology derived from the combination of multi-disciplinary approach which include the livelihood, incentive and ecosystem-based forest management including REDD plus and effective law enforcement. The chosen of this technology aligns with national policies on the environment protection, biodiversity conservation, ecotourism and climate change. The application of this technology, particularly classification and demarcation of 22 National Biodiversity Conservation Areas (NBCAs), started about 20 years ago. In addition, zoning, patrolling to eliminate forest encroachment and hunting, promoting ecotourism and introduction of REDD mechanism have been implemented for many protected areas. However, the management is ineffective; forest encroachment and conversion still occurs. This is due to insufficient resources for management, ineffective law enforcement, and failing to address livelihood and ownership of forest dependent communities. So the selected effective protected area management is, under TNA, expected to address these mentioned issues and also contribute to maintain and or increase forest cover, biodiversity and being a source of carbon sink.

Appropriate Agro-Forestry System: the appropriate agro-forestry system can serve carbon capture and sequestration, socioeconomic and other environmental benefits. This technology, is actually aligned with the forest strategy to 2020 (MAF, 2005) and the strategy on climate change (WREA, 2010), which aims at promoting appropriate agro-forestry system for enhancing climate change mitigation and adaptation. However, the development of agro-forestry system leads to various impacts at different levels, depending on the site specific condition, combination, technique etc.; so development of appropriate agro-forestry system should be carried out through research and demonstration. The prioritization of this technology in the TNA is expected to support the identification and or innovation of the appropriate or climate change oriented agro-forestry systems that maximize carbon capture and sequestration and generate substantial socioeconomic and environment benefits.

The optimal plantation: a market viable, cost-effective and ecosystem-based plantation is one of the technologies that have a great potential of carbon capture and storage as well as contribution to the conservation of the environment or ecosystem. The selection of this technology reflects the government policies and issues such as replacing dependence on wood from natural forest, afforestation for environment conservation, income and employment creation as well as maximizing benefits from particularly degraded land. At present, 230,000 ha of such plantation has been established (FAO, 2010) and the majority are eucalyptus, teak and rubber. The government targeted to increase the area of plantation up to 500,000 ha by 2020 (MAF, 2005); so there is room for plantation to grow. However, the development of plantation should be promoted at certain land use types that align with law, market-based, cost-effective, suitable species and ecosystem. So the prioritization of the optimal plantation in the TNA is expected to lead to innovation of this technology as well as promotion of appropriate species[5] and techniques for a certain ecosystem as well as sustainable plantation development.

The sustainable community forest management (SCFM)is a key technology which has potential for meeting both biodiversity conservation and sustainable livelihoods, including changing climate mitigation. This technology is aligned with recent government policies, particularly forest strategy, rural development, poverty reduction and building villages as the development unit including decentralized forest and land management. The SCFM has been implemented in Laos since 1993 and majority of the activities are on management of secondary forest, abandon slash-and-burn; rehabilitation of degraded forest and sustainable NTFPs. However, up to date, these activities are still in the initial stage, small scale and facing several challenges in meeting biodiversity conservation and sustainable livelihoods, including changing climate mitigation targets. These challenges include incomplete allocation of land and forest for the village, lack of capacity of local authority including village in planning, mobilization of financial resources for support the implementation and innovation of SCFM including application of best practices. So the prioritization of this technology in the TNA is expected to contribute to the development and

[5] The appropriate species in the context refer to cost-effective, market viable, optimal carbon sequestration and storage, improve ecosystem and multi-purpose for use.

innovation of this technology, which can bring substantial benefits on the livelihood, biodiversity conservation and climate change mitigation.

Organic Farming: organic farming is an environmentally friendly agricultural practice or technology that is essential for reducing GHG emissions from soil and the application of fertilizer. In addition, this technology also helps to reduce emissions from fertilizer and pesticide manufacturing elsewhere. This technology is chosen due to its high score in the criterion of GHG emission reduction as well as its potential of creating income and employment for the farmers, environment conservation, and contribution to avoid emissions from soil and fertilization as mentioned above. Recently, although most of Lao farmers practise organic farming; certified or verified organic farming is at initial stage and small scale in Laos. However, prioritization of this technology in the TNA is expected to contribute to the development of this technology to maximize benefits on the promotion of conservation agriculture, poverty reduction as well as GHG emissions reduction.

The Biogas: is a key technology for reducing GHG emissions from livestock manure management. In addition, this technology helps to reduce commercial energy consumption as well as GHG emissions from energy consumption. Development or implementation of this technology is a means of implementation national policies on the promotion of environmentally sound technology, pollution control, poverty reduction and emissions mitigation. In addition, selecting this technology is also a means to provide alternative energy particularly for farmers. However, the development of the biogas technology depends on livestock manure inputs, including manure management system and proper design and maintenance of biogas systems. These are key problems faced by biogas developers in Laos. So it is a prerequisite to address these issues for the development of biogas technology.

The feeds and feeding improvement: the feeds and feeding improvement is a key technology for reduction of the emissions in the agriculture sector, particularly addressing emissions from livestock enteric fermentation by improving the quality of feeds and optimising feeding. This technology can contribute to the implementation of national policies on rural development and poverty reduction and the achievement of sustainable livestock and climate change mitigation. To date, the feeds and feeding improvement is expanding in the country. However, it is still at small scale and unsystematic; so the prioritization of this technology in the TNA is expected to contribute to the development of this technology and the appropriate application of this technology for maximal benefits in terms of both productivity and emissions mitigation.

Agriculture Residue to Energy: this is an emerging technology with high potential for reducing emissions, particularly from crops residue burning, left to decay and directly input to soil. In addition, this technology also provides an alternative renewable energy. Development of this technology is an implementation of national policies on renewable energy, environmentally sound technology and low carbon or climate change mitigation. However, to date, this technology is still at initial stage, small scale and lacks of good practice in Laos. So development of this technology requires the research and systematic assessment of GHG emissions in its life cycle including its performance. In addition, development of this technology requires the availability of adequate crops residues, proper design of the plant and good maintenance.

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), implemented by the United Nations Environment Programme (UNEP) and the UNEP Risoe Centre (URC). In Asia, technical support is also provided by the Asian Institute of Technology (AIT). The objective of the project is to help countries 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. Many country activities have started in February 2010, and the project will run until Mar 2013. 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 a 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 mitigation 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 mitigation and development priorities

Key existing national policies on climate change mitigation is the Strategy on Climate Change of the Lao PDR(WREA,2010). In addition, there are several relevant strategies that also include climate change mitigation measures such as Environment Strategy to 2020 and Action Plan 2011-2015(STEA, 2004),Renewable Energy Development Strategy of the Lao PDR(MEM,2011), Forestry Strategy to the year 2020 of the Lao PDR(MAF, 2005), agriculture(MAF, 2010), the National Strategy and Action Plan on Environment Sustainable Transport(MPWT,2010) and Strategy on Industrial Process and Commerce of the Lao PDR 2011-2020(MCI,2010).These strategies actually serves development priorities that defined in the national socioeconomic development strategy to 2020(Lao PDR, 2006) and Socioeconomic Development Plan 2011-2015(MPI, 2011)and also climate change mitigation in its sectors.

The Strategy on Climate Change of the Lao PDR (SCC) is the key strategy which focuses on climate change issues including climate change mitigation. This strategy was developed by Ministry of Natural Resources and Environment (MONRE) with collaboration with relevant ministries, organizations and endorsed by the Prime Minister’s Office in 2010. The overall objective of this strategy is to leverage the country’s sustainable development and implementation of the UNFCCC. In which its specific objective is to provide guidance to enable Lao PDR to eliminate negative climate change impacts and mitigate climate changes in a way that promotes sustainable economic development, reduces poverty, protects public health and safety, and enhances the quality of the country’s natural environment and livelihoods of all Lao people. In this regard, the SCC analyzed climate change status, impacts and trends in the country; defines national development directions such as low-carbon or green growth economy and climatic resilient development and identifies specific measures for both mitigation and adaptation in seven key sectors, namely (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. In addition, it also elaborates six measures for achieving the SCC’s targets as following:

- **Climate change mainstreaming** climate change mitigation into the 7th National Socio-Economic Development Plan (NSEDP) 2011-2015(Lao PDR, 2010)and sectoral strategies, programmes and projects;

- **Enhance international partnerships** and seek support from international partners for capacity building and development and transfer of technology to support the implementation of mitigation and adaptation measures and actions;
- **Enhance capacity building** of the government agencies, technical institutions, the private sector and local communities to enable them to participate and carry out effectively the appropriately climate change adaptation and mitigation;
- **Enhance synergy** between development and implementation of mitigation and adaptation and low-cost, energy efficiency, cleaner production, environmental and socioeconomic development to maximize benefits;
- **Develop innovative and appropriate financial instruments to** ensure financial sufficiency and efficiency for the implementation of adaptation and mitigation action plans;
- **Increase awareness, education and community participation** for understanding of climate change impacts and the need for mindset transformation toward mitigation and adaptation, leading to mobilize communities contributing to climate change mitigation and adaptation.

The National Environment Strategy until 2020 and Action Plan 2006-2010 (NES-AP) (STEA, 2004) was formulated in 2004.This strategy instead of providing specific measures for the climate change mitigation, it focused on broader environmental issues that also benefits climate change mitigation, for example addressing (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. Its 7tharea, which aims at promoting the use of clean technology and clean, organic or chemical-free products, along with goods and services that conform to high environmental quality standards, is more proactive on the climate change mitigation.

The Renewable Energy Development Strategy of the Lao PDR(MEM, 2011) endorsed in 2011, recognizes the long-term demand for renewable energy, such as micro hydro, solar, wind, biomass, biogas, biofuel, energy from solid waste, and geothermal which are all important for climate change mitigations and can contribute to energy independence and security, promotion of environmental sustainability, economic development, poverty reduction, reduction of rural-urban gaps in access and gender inequalities of the country. The strategy set clear targets and strategies that help to achieve the targets that by 2025 such as increase renewable energy to30 percent of total energy or 1,190 ktoe, up from 17 percent (473 ktoe) in 2020 and 5 percent (170 ktoe) in 2015. 100 percent of the population will have access to electricity, 10 percent of imported fuel oil would be replaced by biofuel, and 10 percent of biofuel would be consumed in rural area by ensuring the use throughout the country of B10 (10 percent biofuel, 90 percent diesel) and E10 (10 percent ethanol, 90 percent gasoline). A total of 240 MW of micro-hydro power also expected to be installed, and 50,000 households nationwide would have access to biogas energy. In meeting these targets; it needs to improve institutional arrangement and capacity, supportive measures for promoting development renewable energy, such as tax exemptions and reduction, investment incentives, Clean Development Mechanism; research in renewable energy and awareness raising; technology transfer and establishment of a renewable energy fund (MEM, 2011).

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 mitigation. The envisaged to comprise extensive and scientifically well-managed forests and forest resources, managed with the wide public participation and international cooperation. By 2020, it is expected that forest cover will be 70 percent of total land by 2020; supply of forest products for domestic consumption and export is sustained, important biodiversity, habitats and ecosystem including soil, river basin and climate is preserved; leading to improved livelihoods, revenue and foreign exchange earnings, thereby increasing direct and indirect employment as well as supporting sustainable growth of the agriculture, industrial, ecotourism and hydropower sectors and these goals can be realized though nine programmes of action below:

1) Complete land and forest use planning and allocation;
2) Enhance sustainable production forest management;
3) Ensure sustainable harvesting of Non-timber forest products;
4) Promote tree plantation development in appropriate area with suitable species;
5) Enhance effective harvest/logging quota system;
6) Enhance effectiveness of wood processing industry management and wood use efficiency;
7) Ensure biodiversity and ecosystem conservation;
8) Ensure protection forest and watershed management;
9) Promote sustainable village land use and forest management.

The National Strategy and Action Plan on Environment Sustainable Transport (MPWT,2010) was approved in 2010.Apart from recognizing the growth of the transport sector and importance on environment, safety, health problems, it also included contents about climate change mitigation.

Particularly, Goals 3 of MEPT is to promote travel without the use of engine vehicles (walking, cycling), to increase its share of total transport to 25 percent by 2015 and 30 percent by 2020; Goal 4 is to promote public transport in urban areas (bus, taxi, tuktuk), reaching 15 percent of the total transport by 2015 and 30 percent by 2020; Goal 7: Promote BRT in the capital, Vientiane, and Goal 10 is to promote the application of the UERO III standards on vehicle emissions by 2015 and 2020.In line with these goals, specific actions have also been defined, such as (1) Permissible air quality standards; (2) Research and development on alternative transport that optimizes and maximizes socioeconomic and environmental benefits, for example public transport, alternative fuels, noise control equipment/materials and environmentally-friendly vehicles; (3) Development and improvement of appropriate regulations, standards and guidelines for sustainable transport developments; (4) Development and improvement of institutions and technical capacities for standards establishment and enforcement through inspections; (5) Awareness on sustainable transport; (6) development of a sustainable transport development fund and (7) Technical and financial cooperation and support from development partners and other international organizations for sustainable transport development (MPWT,2010).

The National Socioeconomic Development Strategy to 2020(Lao PDR, 2010) and Seventh Five-Year Socio-Economic Development Plan, 2011-2015(MPI, 2011) defined the development, political priority and direction. Overall, Laos expected to graduated from Least Developed Country status by 2020 and by 2015 it aims to achieve: (1) stable and continuous growth of economy; (2) achieve MDGs and also acquire modern technologies, infrastructure, established a diverse economic foundation for graduation of LDC status; (3) sustainable development by integrating socio-cultural development and environment protection into economic development;(4)political stability, fairness, order in the society, maintain public security and open for regional and international integration. In which the specific targeted include:

- GDP growth at 8 percent per year until 2015. Of which the growth rate per annum of agriculture and forestry, industrial and service sector shall be3.5percent, 15 percent and 6.5 percent respectively. The economic structure would be shared by 23 percent of agriculture and forestry sector,39 percent of industrial sector and 38percent of service sector.. At the meantime, the GDP per capita is estimated to be about US$ 1,700 by 2015;
- Average export value increases by 18 percent while import increase by 5percent per annum;;
- The growth is in environmentally sustainable manners, adheres to set standards, and where possible, job-creating. In addition, the benefit distribution is in equitable manner among the people.

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

The TNA project implementation involves with five main groups: a steering committee, a project management team, a technical working group, partners and other stakeholders. These groups were engaged in the beginning of the project based on the requirements of the MONRE, consultation and decision of the relevant ministries and organizations. The overall goal of involvement of the stakeholder is to ensure project's effectiveness, efficiency, relevance, alignment and timely implementation. The groups' arrangement structure is as shown in Figure1; the roles and responsibilities of each group are described in the section 2.1 while section 2.2 provides information on the engagement processes.

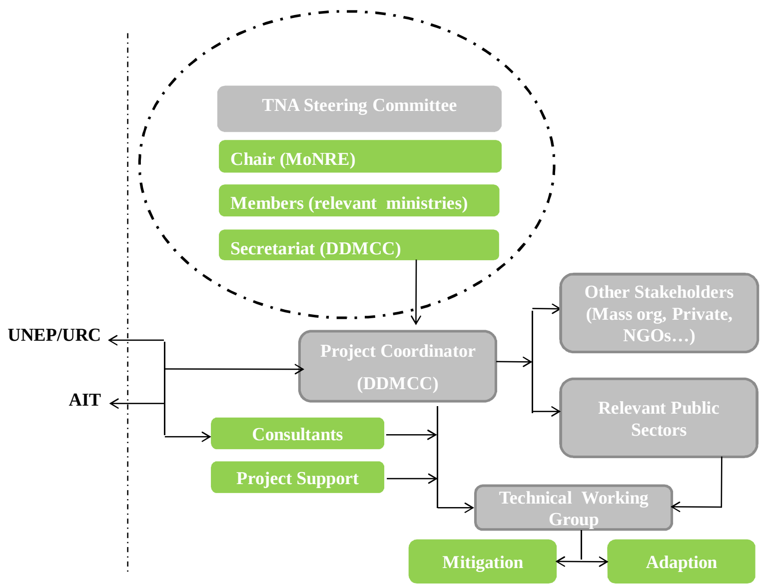

Figure 1 Organization arrangement structure for TNA project implementation.

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 and other stakeholders.

The **steering committee** is a group of senior and decision making staffs members, who were officially nominated. It is chaired by the Vice Minister of MONRE and most of committee members are from public organizations particularly MONRE, relevant ministries those were former members of a committee that supported the development of the strategy on climate change and SNC of Laos. The key roles and responsibilities of this committee are to oversee the implementation of the project, provide policy advice, and approve 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 report to the steering committee and UNEP Risoe Centre. The members of the team include the project director, coordinator, support staff and consultants whowere assigned and recruited by the MONRE. The project director is the director of the NDMCC whose main role is to supervise the team. The coordinator is a senior staff of the NDMCC and UNFCCC 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 Center, the Asian Institute of Technology (AIT) and Technical Working Group and Stakeholders. The support staff are administrative staff of the NDMCC and are responsible for administrative and financial including arrangements of workshops. 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 responsible for providing the TNA teams with the process-related and methodological/technical advisory services and facilitation, including research, analysis and synthesis needed for the project.

Members of the **technical working group** are mainly from same sectors with the steering committee members. 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.

Other stakeholders consist of wide range of organizations, international organizations, private, educational and research institutes and NGOs. This group are involved in the project on requirements of MONRE/TNA project and their 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

Stakeholder engagement is a key element of the TNA project's success. However, it may not possible to engage all the stakeholders due to time and resources constraints.. So, to the extent possible and sounds effective and efficient; and through assessment; this TNA project involved the stakeholders in most important steps or activities through the project cycle such as project inception, sector selection and technology prioritization workshop; review and validation of the report.

The stakeholder assessment is for identifying and screening key public, private, international organizations, projects and individual who are relevant and influenced on the project as well as GHG emissions and removal to engage in the project implementation. The assessment was carried out based on1) the project's goals and planned activities, 2)roles, responsibility and influence of organizations that are relevant to the GHG emissions and removal, 3) the organizations that were member of the steering committee for development of the strategy on climate change of the Lao PDR-SCC (WREA,2010)and 4)the organizations that are involved in the implementation of activities associate with GHG emissions and removal particularly GEF/UNDP funded SNC project, Climate Protection through Avoided Deforestation (CliPAD) project, REDD plus piloted projects, Nationally Appropriate Mitigation Actions (NAMA) in the Transport Sector, Renewable Energy, Sustainable Forest Management and organic farming. In addition, it also based on the political, socioeconomic significance and influence of the different organizations. Through this process, key stakeholders are engaged in the project implementation. Those stakeholders were listed in the Annex 1.

The stakeholder engagement arrangement or plan is another important element in order to engage the stakeholder effectively and efficiently for instance what kind of activities, where, when and how they should be engaged. In this project, however, instead of creating a specific stakeholder engagement plan separately, it focussed on the arrangement of stakeholders to participate in the implementation of the project planned activities as in the logical framework. So the stakeholders were engaged throughout the project cycle. For example, during inception phase, the stakeholders were involved in the project inception workshop in February 2011,providinginformation in relation to their sectors, comments and suggestion on the project activity planning, coordination mechanism for project implementation and reporting of TNA project; in the project activity implementation phase, the stakeholders were members of the technical working groups coordinating with project management team (Department of National Disaster Management and Climate Change), participating in sector and technology prioritization workshops in February and May 2012 respectively; and they also provided feedback and validation of the TNA report during the reporting phase. Pictures below are taken at sector selection and technology prioritization workshops.

Picture 1: Inception and sector selection workshop in February 2012

Picture 2: Technology prioritization workshop in May 2012

Chapter3. Sector selection

The sector selection for climate change mitigations was conducted through a participatory process, as recommended in the TNA guidebook (UNDP and UNFCCC, 2010), which includes initial sector identification, review of emissions status and trend of the identified sectors, and sector prioritization. The initial sector identification, review of the emissions and trend was conducted by a national consultant through consultation and support from department of National Disaster Management and Climate Change and working group. The sector selection involved wider stakeholders and was carried out through a consultation workshop.

The key sectors and sub-sectors were initially defined based on the sector and subsector defined and or recommended in the Strategy on Climate Change-SCC (MONRE, 2010), the Initial National Communication-INC (STEA, 2000), Second National Communication-SNC (MONRE, 2012) as well as the2006 IPCC Guideline for the National Greenhouse Gas Inventory (IPCC, 2007). Those defined and recommended sectors are energy, industry, agriculture, forestry and waste while the subsectors are as shown in Annex 3.

The review of the emissions status and trend in different sectors was carried out, based on the results of greenhouse gas inventory and mitigation in the INC and SNC. The results of the review were described in Section 3.1.The sector selection was conducted through the sector selection workshop which used criteria, sensitivity analysis and consultation for the judgement of priority sectors. The details of the sector selection workshop and results were explained in Section 3.2.

3.1 An overview of greenhouse gas emissions status and trends of the different sectors

Lao PDR completed its Initial National Communication on Climate Change (INC) in 2000 and Second National Communication on Climate Change (SNC) in 2012. The INC and SNC captured greenhouse emissions particularly in 1990 and 2000respectively. In addition, the long term emissions trends in different sectors were also projected in the SNC. However, the emissions trends are very much dependent on the socioeconomic development priority and trends; so the review of the greenhouse gas emissions status and trend in this section covers a summary of overall emissions status and trends reported in the INC and SNC, including provision of socioeconomic and sectoral development trends and priorities coincidental with greenhouse gas emissions.

Base on the INC, Lao PDR was a net sink country in the year 1990.In that year, the country's total emissions was 24.18GgCO_2e while its GHG removal was121.64GgCO_2e, leading to net sink of about 97.47 GgCO_2e.Among four sectors; energy, agriculture, land use change and forestry (LUCF) and waste; LUCF was the largest source of emission which accounted for 72percent of total emissions meanwhile it was only the single source of carbon sink with sequestration capacity of about 121.64GgCO_2e as mentioned. Agriculture and energy sector were the second and third largest source of emissions which shared 24 percent and 4percentof the total emissions respectively while waste sector emitted the least (WREA,2000).

The SNC covered the GHG emission by sources and removal in five sectors: energy, industrial process, agriculture, land use change and forestry (LUCF) and waste in the year 2000. It revealed that the emissions were far greater than removal in the year where total emissions reached 54,903.22 GgCO_{2e} while the removal was only 2,046.73 GgCO_2.As a result, Laos became a country with about 52.86 GgCO_2e of net emissions in the year 2000. Compared to the year 1990, the emissions are on the rise for all sectors and there was a big change in emissions in LUCF. Figure 2 below showed that emissions and sink status and changing trend between 1990 and 2000.

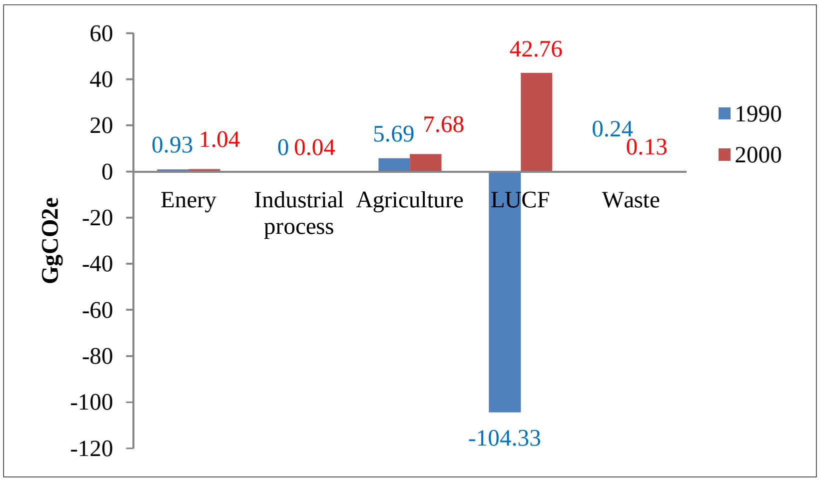

Figure 2: GHG emissions and removal by sector in 1990 and 2000 (GgCO_2e).
Source: Modified from INC (STEA, 2000) and SNC (MONRE, 2012)

In the future, as projected in the SNC (MoNRE, 2012), the emissions of most sectors were anticipated to grow along with the country's economic growth and development priority. Described below are the overall development trends and priorities, and energy, industry, agriculture, forestry and solid waste management development plan and their projected emissions.

Overall development trends and priorities:

As mentioned earlier, Laos expected a GDP growth rate of about 8percent per year until 2015. Expected annual growth of agriculture and forestry, industrial and service sector are 3.5percent, 15percentand 6.5percentrespectively. In addition, Laos also on the track to fulfill the MDGs, including lift its people above the poverty line by 2015,graduatingfrom least development country (LDC) status by 2020 and in the meantime ensuring environment sustainability, political stability, fairness, order in the society and public security (MPI, 2011).

To realize these goals, the overall directions for future development, as defined in the socioeconomic development plan 2011 to 2015,focused on livelihood improvement, promotion of industrialization and modernization, including implementing mega projects effectively to create a strong industrial foundation, enhancing linkage between agricultural and forestry production and manufacturing and commercialization, including utilizing newer technologies for improving their productivities and effectiveness. Utilize energy potential and create Laos as a battery of ASEAN[6],improve transportation as a landlocked country to link with countries in the regions, improve communication and services infrastructure at the central and down to village level. In the meantime, protect and sustain the environment and plan for mitigating climate change and social developments.

Energy sector:

The energy sector is an important sector for development and is expected to experience fast growth. As defined in the energy strategy to 2020 (MEM, 2010), the sector has the following development targets:

- 6,954.9 MW of electricity will be built. 1,800 MW will be lignite power plant and the rest will be from hydropower. 5,716 MW of installed capacity is planned for electricity export, of which 1,700 MW exported by lignite power plant;
- 70%of population have access to electricity in 2010 and 90%in 2020;
- Promote use of renewable energy such as solar, hydropower, wind, biogas and biomass[7].

Likewise, the energy demand is forecasted to increase 3.6 percent per year or from 1.8 Mtoe to 3.9 Mtoe from 2005 to 2025. In regard to different sectors, energy consumption is expected to increase from 6.1 percent in 2005 to 16.9 percent in 2025 in the industrial sector; 6.8 percent in 2005 to 34 percent in 2025 in the transport sector. By product, the biomass is expected to be main fuel form, followed by fuel oil.

[6]ASEAN stands for Association of Southeast Asian Nations.

[7]Promote use of waste wood and fast growing tree plantation for biomass electricity.

However, the fuel oil demand is increasing much faster. Figured 3 is the projected demand of biomass, fuel oil, electricity, and coal which will increase from 1,322 ktoe, 36ktoe, 87 ktoe, and 30 ktoe in 2005 to 1,473 ktoe, 729 ktoe, 225 ktoe, 115 ktoein 2015 and then 1,624 ktoe, 1,523 ktoe, 516 ktoeand 308 ktoein 2025 respectively (MEM, 2011).

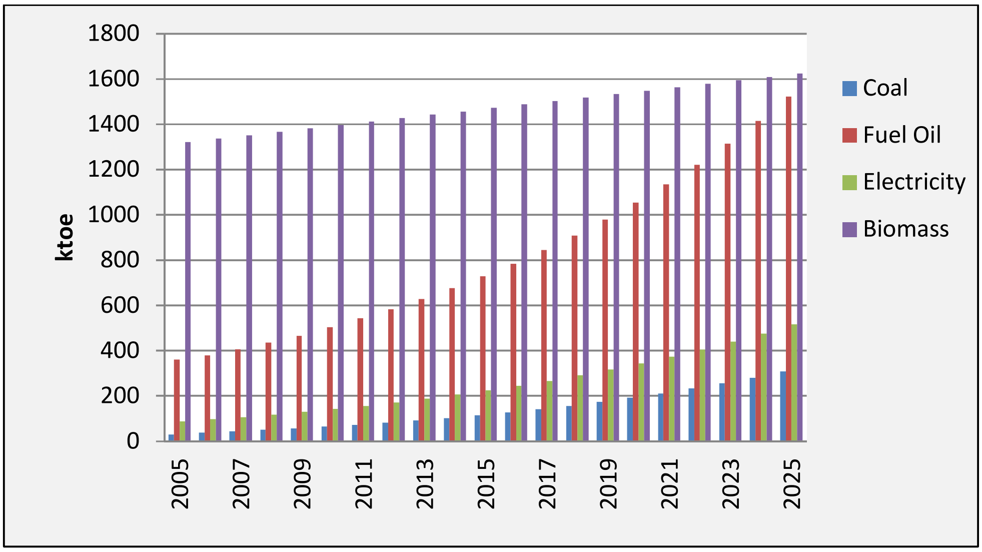

Figure 3 Energy consumption in 2005 and projected until 2025 (ktoe)

Source: MEM, 2011

Furthermore, for fuel oil, Lao State of Fuel predicted that the demand by type will also increase as shown in the table below.

Table 1 Estimate fuel oil demand from 2010 to 2020 in ktoe

Fuel type/Year	**2010**	**2015**	**2020**
Gasoline P	0.89	4.06	9.75
Gasoline R	145.22	245.34	406.85
Jet kerosene	10.29	12.84	14.17
Kerosene	459.88	738.81	1,175.53
Residential fuel oil	5.89	8.96	15.86
Lubricant	2.96	11.70	23.70

Source: Lao State of Fuel, 2011

With the increase of energy consumption; emissions will coincidentally increase, particularly from fuel oil and coal consumption. Meanwhile electricity and biomass, especially energy from renewable sources, are expected to contribute to emissions reduction rather than increasing emissions as several policies and projects have been planned for carbon offset mechanism and technologies. However, as projected by the measures for mitigation of climate change for SNC, the emissions from fuel oil consumption will increase from1,000 GgCO_2e in 2010 to more than 1,800 GgCO_2e in 2015 and nearly 3,000 GgCO_2e in 2020 if the fuel consumption[8] increased as expected in Table 1.

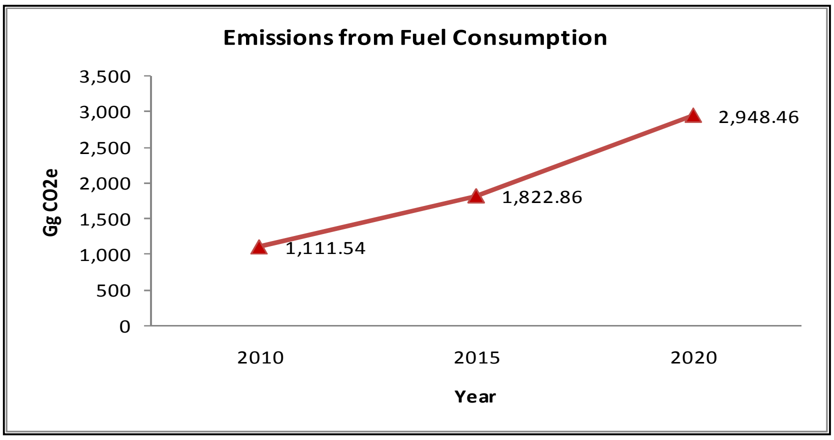

Figure 4 Projected GHG emission from fuel oil from 2010 to 2020.

Source: Measure for Climate Change Mitigation. MONRE, 2012

Emissions from coal combustion will also increase from 186.34 GgCO_2ein 2010 to 342.97 GgCO_2e in 2015; 594.8 GgCO_2e in 2020 and then to 989.77 GgCO_2e in 2025 if 65ktoe of coal is consumed in 2010,115 ktoe in 2015;192 ktoe in 2020 and 308 ktoe in 2025 as estimate by MEM (2011) in Figure 5.

[8]The calculation also assumed that actual fuel oil consumption was 90 percent as fuel oil stock regulation defined that 10 percent of fuel oil is required to be stocked.

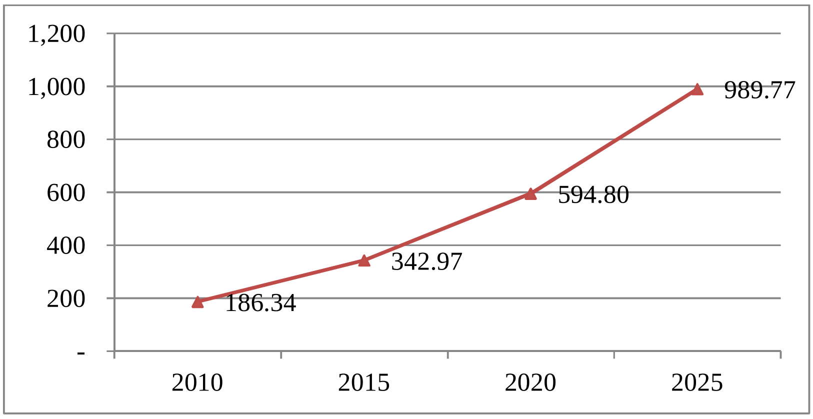

Figure 5 Projected GHG Emissions from Coal Consumption from 2010 to 2020 ($GgCO_2e$).

Source: Measure for Climate Change Mitigation. MONRE, 2012

Industry sector:

Cement production was the main source of emissions in the industrial sector. It is anticipated that the production will continue to increase. Base on the scenario where GDP is the driver, the country's cement production is projected to increase 15 percent annually on average. By 2010, the cement production will be831,200 tons and it will increase to 4,422,056 tons by 2020,7,969,610 tons by 2030,12,871,771.74 tons by 2040 and then to19,852,990 tons by 2050.Based on such cement production projection, the emissions will increase about 7.48 per year on average and increase from 648.07 $GgCO_2$ein 2010 to 3,972.85 in 2030 and then 9,896.72 $GgCO_2$ein 2050 (Figure 6).

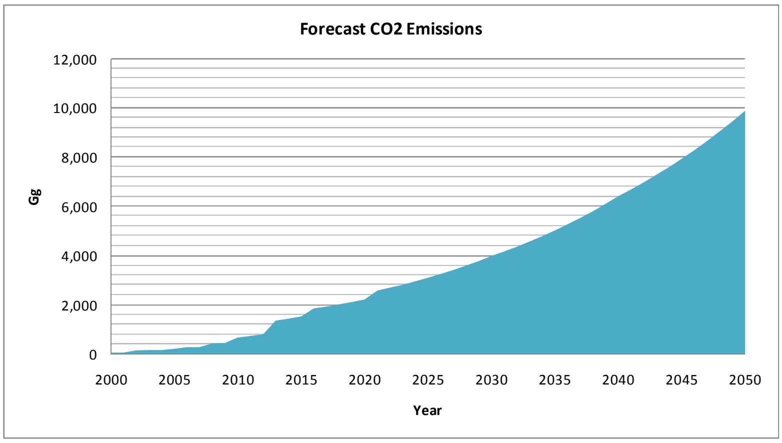

Figure 6Emissions from cement production 2000 to 2010 and the forecast to 2050

Source: Measure for Climate Change Mitigation. MONRE, 2012

Agriculture sector:

As defined in the National Socioeconomic Development Plan (SEDP) 2011-2015, the development of agriculture sector focused on three main areas: rice and crops production, livestock and irrigation. Rice production was targeted to reach 4 million tones and rice paddy area of 1.04 million hectares. The growth of domestic animal breeds is targeted at 4-5percent per year, specifically 2-3percentforcows and buffaloes, 4percentforpigs and 6percentforpoultry. The irrigation for agricultural development using machines and electricity is planned to cover 60-70percent of the cultivating area in flat lands or 50percent of rice and livestock lands and industrial plantation areas (MPI, 2011).

Based on this growth trends or priority projected in SNC, the production from rice cultivation and livestock will increase as in Figures7 and 8. In the meantime, the emissions which were projected using econometric model and population and GDP as drivers will increase from less than 150 million tons in 2001 to more than 300 million tons in 2030(Figure 9). Likewise coincidence with increase livestock's numbers, emissions from livestock are projected to more than double from more than 120 million tons in 2001 to more than 250 million tons in 2030 (Figure 10).

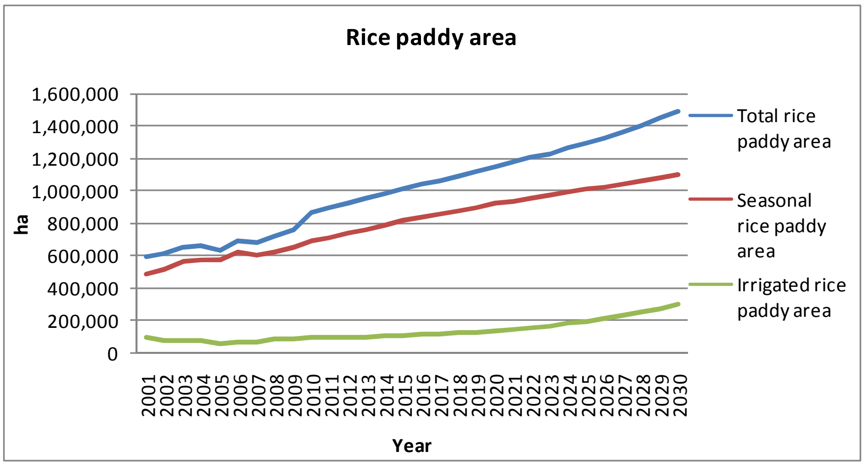

Figure 7Area of rice paddy from 2001 to 2010 and the forecast to 2030

Source: Measure for Climate Change Mitigation. MONRE, 2012

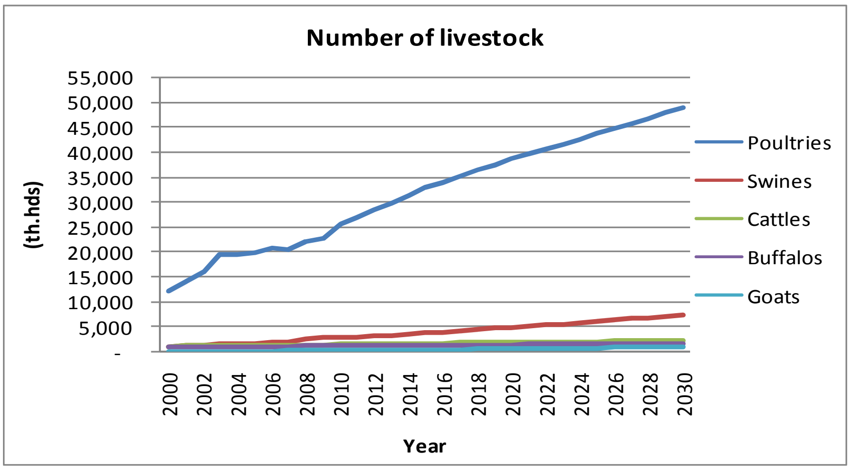

Figure 8Number of livestock from 2001 to 2010 and the forecasted to 2030

Source: Measure for Climate Change Mitigation. MONRE, 2012

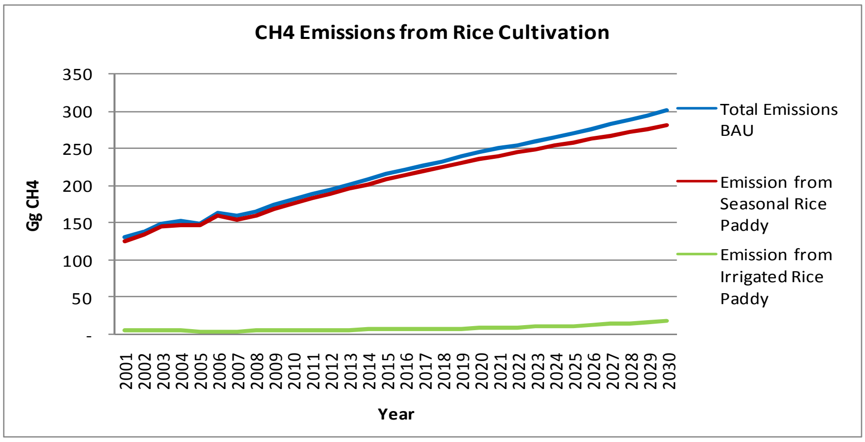

Figure 9Methane emissions from rice cultivation from 2001 to 2010 and the forecast to 2030

Source: Measure for Climate Change Mitigation. MONRE, 2012

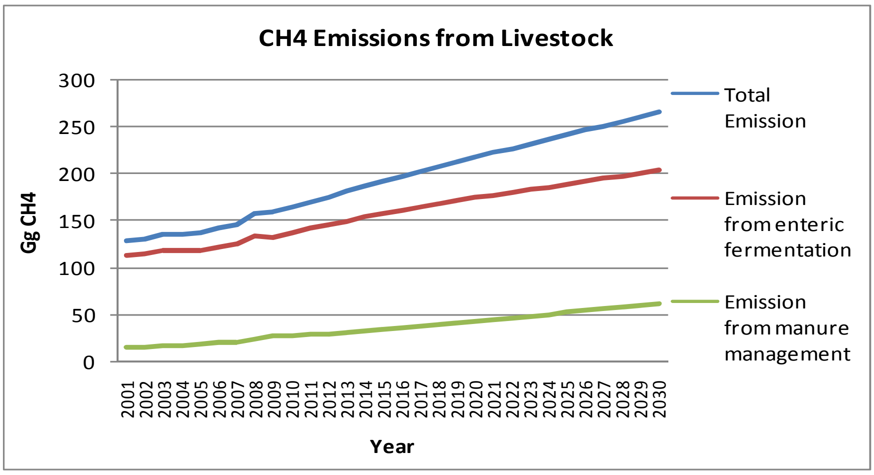

Figure 10Methane emissions from livestock from 2001 to 2010 and the forecast to 2030

Source: Measure for Climate Change Mitigation. MONRE, 2012

Forestry sector:

The key development target of the forest sector is to increase forested area to 70 percent[9] of the total land area from presently 40.3 percent[10], by naturally regenerating up to 6 million ha and planting trees up to 500,000 ha in unstocked forest area. In addition, the forest sector will also promote ecosystem services through using carbon credits (REDD[11], CDM[12]), sustainable forest and NTFPs harvesting, ecotourism etc as incentives for forest conservation. The sector also plans to restore degraded forest and forest land, and enhance law enforcement particularly on forest conversion and unsustainable logging.

If these measures are taken effectively, the country successfully increases its natural forest coverage of 70 percent(about 16.58 million ha)with additional 500,000 ha of plantation, logging and conversion of forest are under control until 2020; with this scenario, Laos's forest would be able to sequestrate about 69,183.34 Gg of CO_2(Table 2).

[9] MAF,2005: Forest Strategy to the year 2020 of the Lao PDR.

[10] MAF,2012: the forest cover inventory of the base year 2010.

[11]Reducing Emissions from Deforestation and Forest Degradation

[12] Clean Development Mechanism

Table 2 GHGs removal potential in Lao by 2020

Greenhouse gas source and sink categories	CO_2 removals ($GgCO_2e$)
Total Removal from land-use change and forestry	**- 69,183.34**
A. Changes in forest and other woody biomass stocks	- 10,500.09
B. Forest and grassland conversion	
C. Abandonment of managed lands	- 58,683.25
D. CO_2 emissions and removals from soil	-
E. Other (please specify)	-

Source: Measure for Climate Change Mitigation. MONRE, 2012

Solid Waste Management:

Solid waste generation seems slowly changing in Laos. Ten years back, waste generation was at 0.75 kg/capita/day (UNEP, 2001). In 2011, the survey of the four main towns, namely Vientiane capital, Louangpravang, Sayabuly and Vientiane Province, by the Lao Pilot Project for Narrowing Development Gap towards ASEAN Integration (LPPE) found that the average waste generation was at 0.66 kg/capita/day. However, the SNC projected that waste generation rate per capita will increase from 0.66 kg/capita/day in 2010 to 1.30 kg/capita/day and then 2.22 kg/capita/day, leading to total solid waste generation of about 2.63 million tons by year 2020 and5.27 million tons by 2030 (Table 3).

Table 3 Estimate solid waste generation 2011 to 2030

Year	Population (1000 persons)	Waste production rate in urban (kg/capita/day)	Waste production rate rural (kg/capita/day)	Waste production in urban (t/day)	Waste production in rural (t/day)	Total waste production (1000t/yr)
2011	6,263	0.66	0.40	1,157.35	1,785.63	1,074.19
2015	6,881	0.93	0.56	2,101.89	2,560.49	1,701.77
2020	7,376	1.30	0.78	3,639.06	3,562.45	2,628.55
2025	7,791	1.74	1.04	5,820.49	4,629.32	3,814.18
2030	8,229	2.22	1.33	8,758.59	5,693.08	5,274.86

Source: Measure for Climate Change Mitigation. MONRE, 2012

Taking the scenario or assumption that 50 percent of waste disposal was land filled in 2010 and 20 percent of this waste is treated under managed system; the proportion of the waste disposed at landfill and controlled by managed system increase 20 percent every five years until 2030; ,CH_4 emissions will be3.34Gg in 2010 and will increase to 14.53Gg in 2020 and then 45.45 Gg in 2030 (Table 4).

Table 4 Projected CH4 emissions from solid waste disposal to the year 2030

Year	**Total waste production (th./yr)**	**Estimate waste disposed at landfill(percent)**	**Total waste disposed at the landfill (th.t)**	**Managed landfill (th.t)**	**Unmanaged landfill (th.t)**	**CH_4 Emissions from managed landfill (Gg)**	**CH_4 Emissions from unmanaged landfill (Gg)**	**Total CH_4 emissions (Gg)**
2010	1,074.19	0.5	537.09	107.42	429.67	1.39	1.95	3.34
2015	1,701.77	0.6	1,021.06	306.32	714.74	3.96	3.24	7.20
2020	2,628.55	0.7	1,839.99	735.99	1,103.99	9.52	5.01	14.53
2025	3,814.18	0.8	3,051.34	1,525.67	1,525.67	19.73	6.92	26.65
2030	5,274.86	0.9	4,747.38	2,848.43	1,898.95	36.84	8.62	45.45

Source: Measure for Climate Change Mitigation. MONRE, 2012

3.2 Process, criteria and results of sector selection

As mentioned in the beginning of the Chapter 3; the sector selection process included initial sector selection, review of the status and trend of emissions indifferent sectors and then sector prioritization. The initial sector selection, review of the status and trend of emissions were as described in the Chapter 3 and section 3.1 before; hence here the content focused on the sector prioritization.

The sector selection was conducted in the sector selection workshop and application of multi-criteria, scoring and expert judgement as a key tool for supporting the selection. The sector selection workshop was held on 17thFebruary 2012, which was participated by key stakeholders representing 18 organizations from public, private and international organizations (Annex 3).Before the workshop, the stakeholders were informed about the emissions status and trends of different sectors as described in the section 3.1and presentation of sectors defined in the IPCC AR4(IPCC, 2007). During the workshop, the stakeholders discussed the steps and methodologies for sector prioritization particularly application of multi-criteria, scoring and agreement on the results.The multi-criteria applied in the prioritization of the sectors, in general, originated from the criteria recommended in the TNA guidebook (UNDP and UNFCCC, 2010). However, they were elaborated, edited and reached consensus amongst the stakeholders during sector selection workshop prior to the application. These criteria were divided into four main categories: contribution to GDP, GHGs reduction and sequestration, environmental and social improvement. Below is the detailed criteria and their descriptions.

Table 5: The criteria for technology prioritization

Category	**Criteria**		**Description**
GHGs reduction	GHGs reduction and sequestration enhancement potential		Potential for GHGs reduction and or enhancement of the sequestration indifferent sectors. This potential could be assessable, comparable or indicated by observing emissions history and trend as well as development trends or targets of different sectors. In addition, another observation or assumption is, the highest emissions are the greater potential for emissions reductions it could be.
Cost/ Investment	Cost and or Investment		Cost or investment in the implementation, operation and maintenance of the technology.
Developm ent	Economic benefits	Yield/ Income	Support for economic growth particularly increase and stabilization of revenue and or GDP including create income
		SMEs/ MSMEs	Enhance growth and diversification of SMEs/MSMEs particularly environmentally and social responsibility enterprises.
	Environmental benefits	Reduce air pollution	Improving air quality, reducing air pollutants such as SOx, NOx, suspended particulate matter, non-methane volatile organic compounds, dust, fly ash and odour and other toxics.
		Reduce environmental negative impacts	Reduction of environmental negative impacts and contribution to environment protection such as protection of land, water, forest, wildlife including biodiversity and ecosystem.
	Social benefits	Employment	Creation of new jobs, employment and opportunities including working conditions such as learning and safety.
		Gender equality	Addressing gender gaps and contribution to gender equality particularly opportunities for income generation, capacity building and employment for women
		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.

In the prioritization, the technologies were scored against the criteria. The scoring is an assessment of the sector performances and score ranks from 1 to 5; of which 1 is the least preferred while 5is the most preferred. As result of the scoring and assessment including consultation, the agriculture and forestry were the top two priorities under the TNA project (Table 6).

Table 6 Result of the sector selections

Sectors/ Criteria	Contribution to GDP	Potential for GHGs Reduction / Sequestration	Benefiting Environment /Ecosystem	Contribute Poverty Reduction	Employment	Initiative (existing=5; none existing =1)	Total Score	Priority
Forestry	5	3	5	4	4	4	25	2
Transport	3	4	2	5	3	4	21	4
Industry	4	3	2	3	4	4	20	5
Residential/buildings	3	4	3	3	3	4	20	5
Agriculture	5	4	4	5	5	3	26	1
Waste	1	3	2	1	2	3	12	6
Energy production and supply	5	3	3	4	4	4	23	3

The agriculture and forestry sector were chosen according to the scores in the criteria in the table 6 above. Likewise, the selection of these two sectors are due to their crucial roles and alignment with the socioeconomic development, environment preservation and emissions reduction. Based on previous performance; the agriculture and forestry sectors generated 30 percent of Laos' GDP for the period of 2006 to 2010 and it expected that these sectors' share will remain stable during 2011-2015 (MPI, 2011). The majority of Lao are living in the rural area and employment also falls in these two sectors (UNDP, 2010). In addition, top government's policies are associated with agriculture and forestry such as policies on poverty eradication, food security, protection of environment and increase forest coverage to 70 percent of the total land area (MPI, 2011; MAF, 2005).

On the other hand, forestry and agriculture sectors were the first and second largest while they also have great potential for reduction of emissions in the country (STEA, 2000; MoNRE, 2012). Recently there are some emissions mitigation initiatives in place such as REED plus; selecting these two sectors can support the up scaling and expansion of the good practices.

Chapter 4. Technology prioritization for the forestry sector

Similar to the sector selection process, the prioritization of mitigation technologies for forestry sector were carried out through the reviewing emissions sources and sink, existing mitigation technologies in the forestry sector in the country and region before prioritization of the technology. The review of the GHG emissions and existing mitigation technologies in forestry sector in the country and region was carried out by identifying and summarizing of the technologies that were defined and recommended in particularly the Initial and Second National Communication-INC and SNC(STEA, 2000; MoNRE, 2012), Strategy on Climate Change of the Lao PDR –SCC (MoNRE, 2010) and Forest Strategy to the year 2020 of the Lao PDR (MAF, 2005).The results of the review were summarized in section 4.1 and 4,2.The technology prioritization was conducted in the technology prioritization workshop which held in May2012, which participated by 37 participants from 24departments of relevant ministries and organizations (Annex 4).The workshop followed the technology prioritization process and criteria as recommended in the guidebook (UNDP and UNFCCC, 2010) and the results were described in Section 4.3.

4.1 GHG emissions in the forestry sector

The GHG emissions in forestry or land use change and forestry seems fluctuated. In 1990, this sector was net sink with large GHGs removal. Reversely it was net sources of emissions in 2000.Whereas, based on the future projection made in Table 2 in previous chapter indicated that Laos's forest would be able generate net sink and sequestrate 69,183.34 Gg of CO_2e by 2020 if forest is preserved effectively.

According to the initial and second GHGs inventory, the forestry sector or LUCF was the largest sources of GHG emissions and removals in Laos. The first GHG inventory conducted for the year 1990 revealed that land use change and forest (LUCF) released 17,310.17GgCO_2e, which was the largest source of emissions, accounted for 72 percent of the country's total GHG emissions. At same the time, this sector sequestrated 121,641GgCO_2e, which means that this sector was net sink with removal of about 97,470 GgCO_2e in 1990. The key sources of emissions were forest conversion, loss of biomass stock including burning onsite, offsite and decay while forest plantation and restoration of abandoned and poorly managed forest land were key sources of sink.

Like 1990, the second GHGs inventory conducted for the year 2000 found that LUCF remained the largest emissions and removal with total emissions and removal of 44,805.22 GgCO_2e and 2,244 GgCO_2e respectively or net emissions of 42,758.48Gg CO_2e.The emissions from forest conversion accounted for

82.55 percent and 17.45 percent emitted from loss of forest land and biomass stock. However, a comparison between 1990 and 2000 indicates that the emission seemed to increase much faster. The sequestration capacity dropped while emissions increased more than fifty percent over a decade. While Laos's forest would be able to sequestrate 69,183.34 GgCO2e of CO_2in 2020 if Lao realise its targets of increasing natural forest coverage to 70 percent and500,000 ha of plantation, control logging and conversion of forest strictly.

4.2 Existing Mitigation Technologies in the Forestry Sector

There are a number of mitigation measures and/or technologies practiced in Laos for addressing forest destruction and losses as well as reducing GHG emissions in the forestry sector. Those mitigation measures and technologies associates with particularly controlling and preventing forest conversion, forest degradation, improving forest conservation and wood use efficiency, replacing fuel wood with renewable energy, as well as enhancing afforestration and reforestation.

The controlling and preventing forest conversion aims to control and prevent forest losses due to slash-and-burn agriculture and development projects (road, dam, mining, urban and agriculture expansion etc. which are the main cause of forest conversion (WREA, 2010; MAF, 2005). Mitigation technologies for addressing slash-and-burn agriculture include controlling cropping rotation, shifting or replacing the slash-and-burn agriculture with integrated farming and or agro-forestry practices, improving livelihood[13]or providing incentives for forest conservation. While the key measures or technologies for addressing forest losses due to development projects is enforcement of laws particularly environmental impact assessment regulations[14] and decrees.

Mitigation measures and technologies on the prevention of forest degradation are selected based on the main causes of forest degradation. The measures and technologies include promoting sustainable forest harvest/management to reduce emissions from timber logging, substituting wood fuel with other fuels alternative such as biogas, hydropower electricity, energy-saving cooking stoves community-based fuel-wood plantations to reduce emissions from fuel wood, and promoting livelihood choices as mentioned above and sustainable livestock as a means for addressing the forest fires, which are mainly caused by uncontrolled slash-and-burn agriculture and burning grassland for animal grazing and hunting.

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[13] Improve livelihood in this context include livestock, cash crop, alternative jobs and enterprises.

[14] The EIA regulation was promulgated in 2004 and it was upgraded to Environment and Social Impact Assessment Decree in 2010.

The conservation of forest includes establishment and management of conservation forest or protected area, protection forest, community forest while afforestation focused on plantation.

Summary below are some technologies associate with key areas of forest destruction, degradation, forest conservation and afforestation.

The controlled cropping rotation, under policy on elimination of shifting cultivation, is a technology to control conversion of forest by shortening the rotation of shifting cultivation or slash-and-burn practice from long term or unrepeated rotation to three-year rotation. This means the slash-and-burn would be rotated in three plots. This technology has been implemented for decades but it is critical and results were mixed; the yield was decreasing due to depletion of soil nutrient which cannot be recoverable in the short period, as a result cultivation moves to some forest areas. While in some areas the shifting cultivation was shifted to integrated farming or a form of agro-forestry; the expansion of shifting cultivation was limited. It is a matter of fact that the control of rotation is workable for only certain areas and group of farmer. The integrated farming and agro-forestry, although it is likely to be sustainable, lacks evidence and or study on successful practices particularly regarding to climate change mitigation.

The livelihood improvement, similar to incentive based conservation, is soft tool helping local people improve living standard while expecting contribution of local on forest conservation as the result. It includes education and awareness raising in order for the local people to reduce dependence and destruction of forest while contribution to the conservation of forest, land allocation and land use planning, sustainable forest and Non-Timber Forest Products (NTFP) management, sustainable farming and livestock keeping, alternative job, enterprises and some infrastructures.

Prevention forest from degradation employs several technologies such as forest classification and land allocation, sustainable forest harvest management and promotion of efficient use of wood. The forest classification has been carried out for years and the classification divided forest into three main types: protection forest, conservation forest and production forest. Logging is only allowed for the production forest and required to follow sustainable practice such as application of selection cutting, quota[15] system and logging period[16]. The harvesting of wood for fuel and household constructions is allowed for

[15] Usually government issues logging quota once a year and based on a timber survey and marking.

[16] Usually the logging period is not allowed during raining season or wildlife breeding season which usually starts from July to October.

degraded forest or community use forest which is not among the three main categories. In addition, for the efficient use of particularly fuel wood, energy saving cooking stoves are introduced and widely used by local residents, including urban dwellers. Furthermore, hydro-electricity and biogas are other key sources of clean energy replacing fuel wood utilization. In addition, community-based forest management, fire prevention and enrich planting are also applied to prevent forest from degradation.

The sustainable forest management, in this context means natural forest that applied sustainable forest yield harvest/management which followed or employed certified forest management or logging systems. This system plans the timber logging based on the biomass increment in the forest, selective cutting including seeds tree conservation system. Sustainable forest management, in fact, has been implemented widely since of the forest law was enacted in 1995. This technology, as defined in the forest law 1995, allows timber logging only in the managed production forest and government designated development areas. Logging must follow the selection cutting system, exclude endanger species or species on the red list and logging is forbidden in the raining season as well as wild animal breeding season. In addition, logging must follow the environmental protection law and go through particularly environment impact assessment.

Community-based forest management, over the last decade, Laos has implemented sustainable community forest management (SCFM), particularly since the first National Forestry Conference in 1989 and approval of the National Forestry Action Plan (NFAP) in 1991. However, the SCFM was mainly implemented and or supported by international organizations (development projects) and the local governmental organizations, especially District of Agriculture and Forest Office (DAFO), Provincial Agriculture and Forest Office (PAFO). Well-known examples include the Lao-Swedish Forestry Program (LSFP) (1996-2001), which was implemented in the south, community based natural resource management of FOMACOP-NAFRI-IUCN (2002-2004), and the rural development in mountainous areas program of GIZ (2004-2007) in the north part of Laos. The SCFM in Laos involved participatory land use planning and land allocation (LUP/LA), Rapid Rural appraisal (RRA) and then community based natural resource management (CBNRM) and SCFM principles. The SCFM is regarded as a good tool for conservation, promoting sustainable livelihood as well as strengthening local community in term of leadership and organization. In addition, it can benefit both climate change mitigation and adaptation, although, emissions sequestrations and its roles in minimizing vulnerability were not quantified. However, experiences from the previous projects indicated there are a number of challenges for implementation of SCFM, particularly time shortage and financial support. To date, Provincial Agriculture and Forest Office (PAFO, District of Agriculture and Forest Office (DAFO) and villages apply SCFM for forest management, however, data on the number of areas and sizes are not recorded and it is hard to quantify the emissions reduction from the practice. With the opportunity on carbon credits, ecosystem services and Lao government's policy on three builds (province is strategic unit, district is planning unit and village as the development focus is implementing unit) and poverty eradication, there is potential to revitalize and upscale or expand the SCFM in order to maximize benefits to local people and contribute to climate change mitigation.

Forest plantation, has been conducted in Laos for a long time. Teak trees have been planted since 1975 and boomed again during 1990s. This is also similar for eucalyptus. Rubber, black wood, and palm etc. are now booming. However, some species such as rubber and eucalyptus had been halted by the government in 2011. The plantation is mainly for commercial and afforestation purposes and the benefits vary from one to another among different species and systems. From the perspective of climate change mitigation, plantation is a key source of carbon sink and has great potential for Laos. Based on the GHG inventory for the year 2000, when the plantation in Laos was 62,000ha; 514.20 Gg of carbon was stored in plantations. Plantation has potential to expand in Laos as there exist large degraded and or barren areas and the government keeps promoting environmentally friendly species plantation for conservation and commercialization.

Forest management techniques, Reducing Emissions from Deforestation and Forest Degradation (REDD), the REDD under the international framework is a fairly new concept and recently implemented in Lao PDR. The Readiness Preparation Proposal (R-PP) was developed and submitted in August 2010 and in the mean times the Lao REDD Task Force was established. Based on the R-PP (2010), Laos has a great potential for carbon sequestration via REDD practice; US$ 28 to 33[17] can be earned or 5,600 to 6,600[18] ktCO2 can be sequestrated from the REDD mechanism if appropriate reforestation and afforestration are implemented effectively (Savathvong, 2010). To date, a number of REDD projects are implementing in the ground, particularly protected areas such as Namphui, Nam Et Phouloey, Nam Xam, Nam Kading, Xepian and Xexap national biodiversity conservation areas (NBCA). Many international development organizations were involved, such as WB, ADB, GIZ, Finnish, JICA, SNV, RECOFTC, WWF, WCS and etc. The benefits of REDD are not proved in the country. However, various socioeconomic,

[17] About US$ 10 to 15 million can be earned from stopping illegal and unsustainable logging; US$ 1.25 million can be earned from elimination of slash and burn; US$ 15 million from controlling forest land concession; US$ 0.3 million from restoration of unstocked forest and US$ 1 million from efficiency fuel wood utilization.

[18] Taking the example of carbon's price of US$ 5 per tCO2.

environmental including climate change mitigation benefits can be expected. The challenge for REDD include market uncertainty, technical aspect, competition and or pressure on the forest land and resources.

4.3 An overview of possible mitigation technology options in the forestry sector

There are several mitigation technology options in the forest sector. This section, however, instead of re-assessment of the technology options, summarized and edited the technology options defined in relevant policies, plans and reports particularly the Assessment Report on Technology Needs and Priorities for Mitigating Greenhouse Gas Emission (STEA, 2004),Forest Strategy to the year 2020 of the Lao PDR (MAF, 2005),Strategy on Climate Change of the Lao PDR (WREA,2010) and Second National Communication on Climate Change (MoNRE, 2012) which developed through comprehensive participatory process. The summary of the technology option was initially conducted by consultant and project implementation team. In addition, they were also reviewed, edited and re-affirmed by the stakeholders particularly at the workshop on technology prioritization in May 2012. Those mitigation technology options are summarised and presented as in the table 7 below.

Table 7 The mitigation technology options in forestry sector

No	Category/Sub-sector	Key mitigation technology options
1	Eeliminating "slash-and-burn" agriculture	1. Livelihood-based forest conservation 2. Rotation cropping 3. Sustainable Non-Timber Forest Products (NTFP) management 4. Sustainable community forestry 5. Agro-forestry 6. Sustainable agriculture
2	Reducing fuel wood consumption	1. Biogas 2. Small hydropower electricity 3. Energy-saving cooking stoves 4. Solar energy 5. Use of harvest residues 6. Community-based fuel-wood plantations
3	Reducing forest fires	1. Green hedgerow 2. Agro-forestry 3. Strengthen forest fire monitoring and prevention unit 4. Increasing awareness of villagers
4	Promote sustainable production forest management	1. Sustainable forest harvest/Forest certified system 2. Sustainable NTFP (Non-Timber Forest Products)harvest 3. Enhance forest maintenance (pruning and thinning, enrich planting and assisted natural forest regeneration-direct seeds sowing)
5	Promote sustainable protection forest management	1. Optimal protection forest management 2. Ecosystem-based protection forest management 3. Enhance forest maintenance (enrich planting and assisted natural forest regeneration-direct seeds sowing)
6	Promote sustainable	1. Ecosystem service-based protected area management

	conservation forest/Protected area management	2. Livelihood/incentive-based protected area conservation 3. Enhance forest maintenance (enrich planting and assisted natural forest regeneration-direct seeds sowing)
7	Minimize forest impact caused from development projects	Effective enforcement of EIA decree/regulation
8	Pursuing carbon market opportunities/forest investment	1. Reduced Emissions from Deforestation and Forest Degradation (REDD) 2. Clean Development Mechanism (CDM)
9	Promote/Enhance reforestation	1. Enrich planting 2. Direct sow
10	Promote/enhance restoration and maximize benefits from degraded forest	1. Optimal plantation 2. Assisted abandonment (re-growth) 3. Agro-forestry 4. Integrated cropping
11	Promote wood efficiency	1. Efficient processing 2. Efficient design 3. Use waste wood for energy
12	Strengthen forest sector administration	1. Precise forest information and planning 2. Effective law enforcement 3. Forest awareness and education 4. Established forest volunteer, forest fire monitoring unit and forest expert network

4.4 Process, criteria of technology prioritization in the forestry sector

As mentioned earlier in the Chapter 4, the process of technology prioritization included the reviewing emissions sources and sink, examining existing mitigation technologies in forestry sector and then prioritization of the technology. The review of emissions sources and sink and existing mitigation technologies were as explained in the section 4.1 and 4.2 respectively; hence here focused on the certain activities and approach for technology prioritization particularly technology prioritization workshop including steps and methodologies employed for prioritization of technologies during the workshop.

The technology prioritization workshop was organized in May 2012, participated by 37 participants representing 24 departments or organizations of government, academic, research institutes, private, international organizations and projects. The list of the participants is in the Annex4. Before the workshop, the stakeholders were informed about the emission sources and sink as in section 4.1 and mitigation technologies and options as in the section 4.2 as well as technologies recommend in the INC (STEA, 2000), TNA (STEA, 2004), SNC (MoNRE, 2012) and in the IPCC AR4(IPCC, 2007. During the workshop, the stakeholders were introduced to and discussed on the application of the steps and methodologies that suggested in the TNA guidebook(UNDP and UNFCCC, 2010),particularly identification, edition and categorization of technologies; screening top ten technology options from the edited technologies and then prioritizing four technologies out of ten technologies as priority technology needs.

The identification, edition and categorization were conducted by stakeholders, based on the technology options in the Table 7 and elsewhere which perceived by the stakeholders and then used expert judgement for the scale of application of the technology and its availability. Similarly ten technology options were selected through expert judgment and while four priority technologies were prioritized with the use of multi-criteria and scoring techniques including sensitivity analysis. The criteria applied in the prioritization of the technologies were divided into three main categories: technology performance, GHGs reduction and contribution to development particularly economic, environmental and social aspects. These criteria were, in general, elaborated, edited and agreed by the stakeholders with reference to the criteria recommended in the TNA guidebook (UNDP and UNFCCC, 2010). In the prioritization of the technologies, the criteria were weighted based on their significance perceived by stakeholders and then technologies were scored against the criteria. The score were ranked from 0 to 100 by expert judgement; 0 is the least preferred while 100 is most preferred. Followings are the identified, edited and categorized technologies (Table 8); ten technology options resulted from expert judgment (Table 9); applied criteria and weighing (Table 10 and Figure 10); the results of MCDA process with individual scores for technologies and overall weighted scores (Table 11) while four priority technologies are presented in section 4.5 and the sensitivity analysis is put in the Annex 5.

Table 8 Edited technologies and categorization

No	Category/Sub-sector	Key mitigation technology options	Scale of application	Availability
1	Eeliminating “slash-and-burn” agriculture	1. Livelihood-based forest conservation	Medium to large scale	Short to medium term
		2. Rotation cropping	Medium scale	Short term
		3. Sustainable Non-Timber Forest Products (NTFP) management	Medium scale	Short to medium term
		4. Sustainable community forestry	Medium scale	Short to medium term
		5. Agro-forestry	Medium to large scale	Short to medium term
		6. Sustainable agriculture	Medium scale	Short term
		7. Relocation (of the shifting cultivator)	Small to medium scale	Short term
		8. Sustainable agriculture	Small to medium scale	Short to medium term
2	Reducing fuel wood consumption	1. Biogas	Small to medium scale	Short term
		2. Hydropower electricity	Small to large scale	Short term
		3. Energy-saving cooking stoves	Small scale	Short term
		4. Solar energy	Small scale	Short to medium term

		5. Use of harvest residues	Small to medium scale	Short to medium term
		6. Community-based fuel-wood plantations	Small to medium scale	Short to medium term
3	Reducing forest fires	**1.** Green hedgerow	Small to medium scale	Short to medium term
		2. Agro-forestry	Medium to large scale	Short to medium term
4	Promote sustainable production forest management	1. Sustainable forest harvest/Forest certified system	Medium to large scale	Short to medium term
		2. Sustainable NTFP (Non-Timber Forest Products)harvest	Small to medium scale	Short to medium term
		3. Enhance forest maintenance (pruning and thinning, enrich planting and assisted natural forest regeneration-direct seeds sowing)	Small to medium scale	Medium to long term
5	Promote sustainable protection forest management	1. Optimal protection forest management	Medium scale	Medium term
		2. Ecosystem-based protection forest management	Medium scale	Medium term
		3. Enhance forest maintenance (enrich planting and assisted natural forest regeneration-direct seeds sowing)	Small to medium scale	Medium term
6	Promote sustainable conservation forest/Protected area management	1. Ecosystem service-based protected area management	Medium scale	Medium term
		2. Livelihood/incentive-based protected area conservation	Medium scale	Medium term
		3. Enhance forest maintenance (enrich planting and assisted natural forest regeneration-direct seeds sowing)	Small to medium scale	Medium term
7	Minimize forest impact caused from development projects	Effective enforcement of EIA decree/regulation	Medium scale	Short term
8	Pursuing carbon market opportunities/forest investment	1. Reduced Emissions from Deforestation and Forest Degradation (REDD)	Medium to large scale	Short to medium term
		2. Clean Development Mechanism (CDM)	Medium scale	Short to medium term
9	Promote/enhance restoration and maximize benefits from degraded forest	1. Optimal plantation	Medium to large scale	Short to medium term
		2. Assisted abandonment (re-growth)	Medium scale	Medium term
		3. Agro-forestry	Medium scale	Medium term
		4. Integrated cropping	Medium scale	Medium term
10	Promote wood efficiency	1. Efficient processing	Small to medium scale	Medium term
		2. Efficient design	Small to medium scale	Medium term
		3. Use waste wood for energy	Small to medium scale	Medium term
11	Strengthen forest sector administration	1. Precise forest information and planning	Small to medium scale	Short to medium term
		2. Effective law enforcement	Medium to large scale	Short to medium term
		3. Forest awareness and	Medium to large scale	Short term

		education		
		4. Established forest volunteer, forest fire monitoring unit and forest expert network	Small to medium scale	Short to medium term

Table 9 Shortlisted Technology Options

No	Ten Shortlisted Technology Options
1	Optimal plantation
2	Effective law enforcement
3	Incentive-based conservation
4	Forest fire control
5	Micro-hydro electricity
6	Energy saving cooking stove
7	Effective preservation of protection and protected area
8	Upland agriculture research
9	Capacity building
10	Reforestation of degraded forest

Table 10 The criteria for technology prioritization

Category	Criteria		Description
GHGs reduction	GHGs reduction and sequestration enhancement		Potential for GHGs reduction and or enhancement of the sequestration indifferent sectors. This potential could be assessable/comparable or indicated by observing emissions history and trend as well as development trends or targets of different sectors. In addition, another observation is, the highest emissions are the greater potential for emissions reductions it could be.
Cost/ Investment	Cost or Investment		Cost or investment in the development, application or operation and maintenance of the technology.
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 air pollution	Improving air quality, reducing air pollutants such as SOx, NOx, suspended particulate matter, non-methane volatile organic compounds, dust, fly ash and odour and other toxics.

		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.

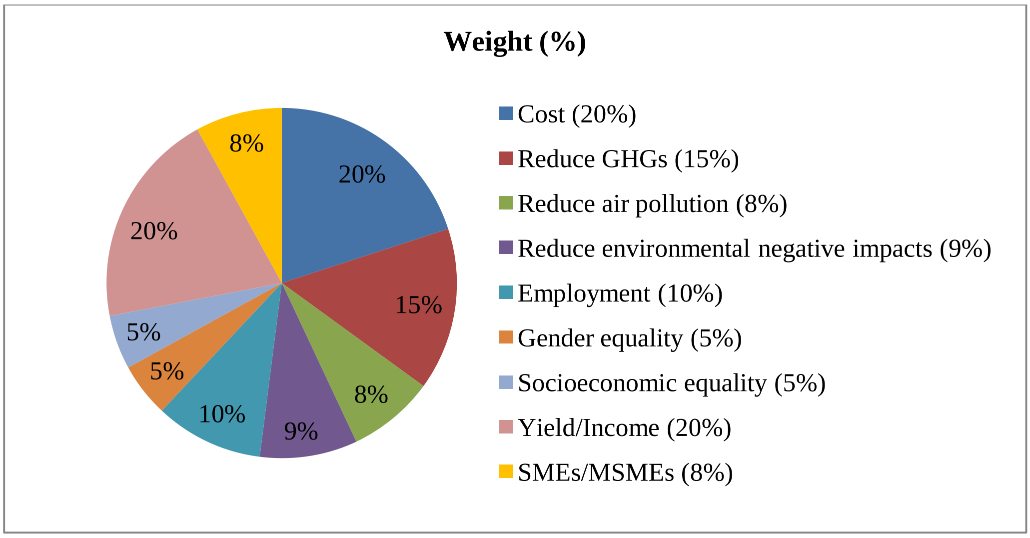

Figure 11 Weighting of the criteria

Table 11 The results of the scoring of technology prioritization for forestry sector

Technology Options	Cost	Environmental Benefits			Social Benefits			Economic Benefits		Total costs	Total score of benefits	Total score	Rank
	Cost/ Investment	GHGs Reduction	Reduce air pollution	Reduce environmental negative impacts	Employment	Gender equity	Balance urban and rural development	GDP/ Income/ Yield	SMEs/ MSMEs				
Optimal forest plantation	65	100	30	60	100	60	0	100	80	13	62	75	3
Effective law enforcement	70	80	60	90	25	80	80	30	30	14	44	58	8
Optimal agro-forestry	65	70	70	75	70	100	80	90	80	13	63	76	2
Effective forest fire control	70	60	100	80	50	0	10	0	10	14	31	45	9
Sustainable production forest management	55	80	70	90	80	50	50	90	85	11	64	75	5
Sustainable community forest management	55	80	60	80	80	90	100	80	80	11	64	75	4
Effective conservation forest management	65	80	60	90	80	70	70	90	100	13	66	79	1
Forestry and agro-forestry research	100	0	0	0	0	80	80	40	0	20	16	36	10
Capacuty building on GHGs mitigation	85	60	60	70	50	80	80	70	70	17	53	70	6
Restoration of degraded forest	0	90	80	100	70	65	65	70	60	0	61	61	7

4.5 Results of technology prioritization for forestry sector

Throughout the prioritization process particularly the scoring and assessment,four technologies, namely Effective Protected Area Management, Optimal Agro-Forestry, Optimal Forest Plantation, and Sustainable Community Forest Management which obtained highest scores or most preferable, are selected as priority technology needs for climate change mitigation in the forestry sector.

Effective Protected Area Management:

As mentioned previously, effective protected area management is a technology derived from the combination of multi-disciplinary approach which promotes full function and maximizes benefits from ecosystem services with appropriate techniques together with effective law enforcement to realize forest sustainability of a certain area. This technology is associated with appropriate protected area planning, livelihood improvement, incentive and ecosystem-based forest management and REDD plus mechanism. It is chosen based on the respective score in the criteria, its perceived potential for ensuring sustainability of the conservation forest, and its alignment with national policies. On the other hand, selecting this technology actually aims to address encroachment, conversion and degradation and or loss of conservation forest as well as ineffective management, especially to address ineffective law enforcement, lack of good planning, and to improve livelihood and ownership of forest dependent communities, including increase awareness for the protection of conservation forest with adequate investment. This technology is in the pipeline of the forest strategy to the year 2020 of the country (MAF, 2005), which aims to apply multi-disciplinary or effective approach for sustaining forest resources and management and has been in place for years. Recently there are several initiatives on the promotion of sustainable conservation management through ecotourism[19], REDD plus, law enforcement (for example, promotion of Forest Law Enforcement and Governance by cooperation between the Department of Forestry Inspection (DoFI) and the International Union for Conservation of Nature (IUCN) Lao in 2009-2011[20] and the EU[21]), and forest investment programmes[22]. However, these actions are in initial stage and lack of synergy or as a package for a certain area. In addition, there is lack of concrete effective or sustainable conservation models. So effective conservation management, in this TNA, is expected to explore and apply multi-disciplinary or approach appropriately and effectively to sustain natural forest resources,

[19]http://www.ecotourismlaos.com/

[20]http://www.iucn.org/about/work/programmes/forest/fp_our_work/fp_our_work_thematic/fp_our_work_flg/fp_forest_law_our_work/fp_forest_law_our_work_ongoing/fleg_lao/?3697/DoFI-and-IUCN-collaborate-to-promote-Forest-Law-Enforcement-and-Governance

[21]http://www.forestcarbonasia.org/in-the-media/eu-promotes-forest-governance-in-laos/

[22]http://www.theredddesk.org/countries/laos/info/activity/forest_investment_program_lao_pdr_national

contribute to maintain and or increase forest cover to meet targeted of the government which aims to increase forest area up to cover 70 percent of total land area by 2020 (MAF, 2005).

Optimal Agro-Forestry System:

The optimal or appropriate agro-forestry system is a technology, in this context, refers to agro-forestry system that provides most socioeconomic and environmental benefits including carbon sequestration. This technology involves tree, crops, NTFP and livestock grazing system and associates with ecosystem-based agro-forestry, market and livelihood-based approach. This technology is chosen according to the respective score in the criteria. In addition, there are some related initiatives and the technology is in line with the national policies, such as the forest strategy to 2020 (MAF, 2005) and the strategy on climate change (WREA, 2010) which intended to promote appropriate agro-forestry systems that could enhance both climate change mitigation and adaptation. This technology, in fact, has been implemented in Laos for a long period of time. It included plantation and orchards, alley cropping, economical and biological improve fellow, contour hedgerow, home garden, and Taungya systems (Hansen K.P, Sodarak, H. 1996). However, it is recognised that the development of agro-forestry system can lead to various impacts at different levels as it depends on the site specific condition, combination, technique etc. So development of appropriate agro-forestry systems through research and demonstration is needed. In this regard, the prioritization of this technology in the TNA is expected to support to exploration of the appropriate or climate change oriented agro-forestry systems that can maximize carbon capture and sequestration as well as socioeconomic and environment benefits.

Optimal Plantation:

Optimal plantation is, in this context, tree plantations that generate maximum socioeconomic and environment benefits, including carbon capture and sequestration in a certain circumstances and land suitability. Similarly this technology is chosen according to the respective scores in the criteria as well as its potential roles on socioeconomic and environment including carbon sequestration and alignment with national policies.

At the present, 230,000 ha of the plantation shave been established (FAO, 2010).The majority are eucalyptus, teak and rubber, including emerging of agar wood and jatropha. The plantations, although it lacks of exact data, contribute to quite large employment, income generation and reduced dependence on the natural wood. However, in 2012, some plantations, particularly eucalyptus and rubber, which seem to lead to unexpected impacts or over expansion, are halted by the government until 2015.So optimal plantations, which are particularly market-oriented, cost-effective and add value to or help restoration of the degraded forest and land, are required as an option for plantation development. However, the research and development of optimal plantation is limited; the prioritization of the optimal plantation in the TNA is expected to assist government to search for appropriate species[23] and location including approach for future sustainable plantation development.

Sustainable Community Forest Management:

The sustainable community forest management (SCFM) is a technology that expects to realize forest sustainability through improvement in local livelihood, local forest ownership and forest ecosystem-based management techniques. The SCFM is a promising technology and is chosen according to the respective score in the criteria. More importantly, it is chosen because of its potential socioeconomic and environmental benefits, including carbon sequestration, and alignment with national policies.

The roles of the SCFM can be various, depending on the management purpose and site specific conditions. However, in Laos, most SCFM or Community Forestry Programmes intended to promote sustainable use of secondary forest, non-timber forest products (NTFPs) and rehabilitation of degraded forest as a way for forest conservation and livelihood improvement (MAF, 2005).Therefore SCFM plays key roles in the restoration of forest as well as improving livelihood of local communities. Similarly, from the climate change mitigation point of view, it can be significant for GHGs emission reduction and sequestration; the SNC (2012) indicated that management of re-growth and rehabilitation of forest represents a key source of GHG removal. With local people participation and livelihood recognized as critical factor for forest conservation, currently REDD plus includes livelihood and local participants as a core element of its programme. Likewise, strategy on Climate Change (MoNRE, 2010) and Forestry Strategy to the year 2020 of the Lao PDR (MAF, 2005) identified SCFM as a core component of the strategy. In addition, SCFM is also integrated in the Strategy on National Growth and Poverty Eradication (Lao Government, 2003) and the Prime Ministry's order on the building of villages as development units (PM, 2012). However, the SCFM is still implemented at a small scale and not fully developed although it has been implemented in Laos since 1993 and has some foot prints. This is because of the fact that the majority of SCFM activities were carried out with support from international organizations (development projects) and the local governmental organizations, especially Provincial Agriculture and Forest Office (PAFO) and District of Agriculture and Forest Office (DAFO). Insufficient financial and human resources including unclear boundary of community forest and lack of appropriate plans impeded the development of SCFM. However, the prioritization of this technology in the TNA is expected to take this technology

[23]The appropriate species in the context refer to species are most cost-effective, market viable, large carbon sequestration and storage while maintain and or improves ecosystem and multi-purposes for use.

forward and support its implementation through research and application of approaches appropriate to the location and communities.

Chapter 5. Technology prioritization for agriculture sector

The technology prioritization for agriculture was conducted at the same time and through similar process as the technology prioritization for forestry sector. The process included review emissions sources and sink, existing mitigation technologies in the agriculture sector and prioritization of the technology. The review of emissions and existing mitigation technologies in the agriculture sector was as described in the Section 5.1and 5.2respectively. The technology prioritization for agriculture sector was conducted coincidentally with technology prioritization for forest sector which took place in the technology prioritization workshop which held in May2012. 37 participants from 24 departments or organizations attended the workshop and list of participants are as in the Annex 4. At the workshop, technologies were prioritised through the process as recommended in the Technology Need Assessment Handbook (UNDP and UNFCCC, 2011) and MCA, specifically technology identification, categorization, prioritization with the use multi-criteria, scoring and assessment of the results by conducting sensitivity analysis as well as stakeholders consultation. The detail of the process and results of the technology prioritization was given in the Section 5.3 and 5.4 respectively.

5.1 GHG emissions of agriculture Sector

As mentioned, Laos had completed the first GHG inventory for the year 1990 and the second inventory in 2000. However, the inventory revealed that the emissions from the agriculture sector were the second largest after LUCF for both years. The emission from this sector was 5,696.67 $GgCO_2e$ in 1990 and grew up to 7,675.79 $GgCO_2e$ in the year 2000. While the share in the total emission decreased from 24 percent in1990 to14.52percentin 2000. However, the key sources of the emissions for 1990 and 2000 remained unchanged and these sources were rice cultivation and manure management, which generated about 95 percent and 65 percent of total emissions from the sector respectively. The rest emissions[24]were from agriculture soil, manure management and burning of agricultural residue and savanna (STEA, 2000 and MoNRE, 2012).

[24]The emissions from agriculture soil, burning of agricultural residue and savanna were not covered in GHGs inventory 1990.

5.2 Existing technologies of agriculture Sector

Multiple mitigation technologies in the agriculture sector were applied in the Laos and regions. Those technologies are identified in the strategies, plans and reports such as Assessment Report on Technology Needs and Priorities for Mitigating Greenhouse Gas Emission (STEA, 2004),Strategy for Agriculture Development 2011to 2020 (MAF, 2010),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), Technologies for Greenhouse Gas Mitigation in the Agriculture Sector (UNEP, 2012), ClimteTechWikietc.[25]. However, not all the technologies are applied and or applicable in Laos; so described below are a summary of only the main areas where measures and technologies have been practiced and are proved to be applicable to Laos.

Rice cultivation:

The key technology for reducing the emissions from rice cultivation is water scheme management. Water scheme management has been traditionally practiced by Lao farmers through the country. It is particularly in the form of mid-season drainage. This practice was usually conducted once the rice plant's growth is stable and sometime just before harvesting. However, this technology is less applicable in the areas where rice is grown on wetland and in dry areas. Furthermore, some technologies are implemented along with this technology. Those are drought tolerant rice variety improvement, including promoting appropriate fertilizing and controlling excessive application of chemical fertilisers in the paddy field. However, these technologies are under demonstration and not yet widely applied.

Livestock:

The key technology for reducing the emissions from livestock enteric fermentation includes feeds and feeding improvement, promotion use of healthy and high productivity cattle, swine for the breeding and producing higher rate of calves and piglet.

For feeding improvement, some livestock projects have been implemented in Laos, particularly application of new variety and better quality of grasses and feeds for feeding cattle and pig. Nowadays, 8,478 ha of new variety of the grass such as Brachiararuziziensis, Panicum maximum, Pannisetum purpureum, stylo grass etc were established, it is expected to more than double (DLF, 2012).

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

Selection of healthy and high productivity cattle, swine for the breeding and producing higher calving and piglet rate is desirable, not only in terms of the higher number of calves and piglet, but also in terms of lower feed intake per unit of product as well as emissions. This practice has been promoted for decades through the country. To date, however, it is still in small scale but it is expected to continue to increase as it is low cost and applicable for rural areas. In addition, government set a clear policy on promoting farmer organization including livestock raising groups for livelihood improvement and commercialization.

Manure management:

The key technology for reducing emissions from livestock manure is biogas digester. This technology, the manure is fermented in the digester and converted to methane which can be used as fuel for cooking, heating and etc. There are different sizes and types of biogas digester, rank from 4 m^3 to 16 m^3, which allow its flexibility for different size of farms, economic and location. The biogas is an area which the government of Laos targeted on as it biogas not only reduces the emissions, but it also reduces odder, risk of water pollution or contamination of manure and health impact while waste from the digester is good fertilizer. In addition, this technology is considerably low cost. In 2011, about 2,715 biogas digesters with total capacity of 12,950 m^3 exist in 48 districts and 838 villages (DLF, 2012). The number of biogas is expected to increase as the government set a clear policy for promoting technology as such and technical support or advisory support for example the cost of technical support is free of charge or offered by the government. However, more attention is needed for maintenance.

Crops land management:

Several technologies have been initiated to improve the crops system. These include agronomy, agro-forestry, non-tillage/residue management and soil amendment for increase crops land productivity.

Agronomy:

Agronomic practices which include improving crop varieties, extending crop rotations especially with legume crops, avoiding or reducing use of bare fallow, adding appropriate amount of fertilizers, temporary vegetative cover between successive agricultural crops, or between rows of tree are crucial for climate change mitigation and conservation of soils. However, in Laos there lacks of study and information on the carbon capture and sequestration effects, including cost and constraints in the application of these technologies.

None or low tillage:

No-tillage system is being piloted in some provinces in Laos by some organizations and projects. Most of them are in the form of no-tillage, low-tillage or direct seeding mulch-based cropping system (DMC) and mainly applicable for such crops as rice, maize, soybean and grassland. This system, although there were findings that profitability and production costs, labour and yields of the this agricultural systems are not different from other or tillage but total aboveground and belowground biomasses produced and brought back to the soil with higher dry matter which is important for carbon storage in soil.

Agro-forestry:

As mentioned, carbon storage in soil and above ground can be achieved through appropriate designs of agro-forestry system. Since the agro-forestry system is various; appropriate agro-forestry system depends on geographical, composition and system, market and capacity matter. However, in Laos although the ago-forestry has been practiced for years but it still lacks of research on the appropriate system and information about the total benefits including climate change mitigation from different types and schemes of such agro-forestry system.

Increased productivity of croplands (including fertilization):

Carbon storage in the croplands especially grazing lands can be improved through a variety of measures that promote productivity. For instance, alleviating nutrient deficiencies by fertilizer or organic amendments increases plant litter returns and, hence, soil carbon storage (Schnabel et al., 2001; Conant et al., 2001). This practice adopted by some conservation agriculture programmes in Laos particularly the Lao National Agro-Ecologocal Project (PRONAE). However, research elsewhere indicated that adding nitrogen often stimulates N_2O emissions (Conant et al., 2005) and offsetting some of the benefits. Irrigating grasslands, similarly, can promote soil carbon gains as recommended by Conant et al. (2001) but it seems impractical in Laos either. So, as recommended by Schlesinger (1999) it is important to consider the net effect of this practice and emissions from energy use and other activities on the irrigated land.

5.3 An overview of possible mitigation technology options in agriculture sector

Although a variety of technologies are available for GHGs mitigation; the key recommended mitigation technology options for agriculture sector which can be summarized from reports, strategies and stakeholder consultation such as the Assessment Report on Technology Needs and Priorities for Mitigating Greenhouse Gas Emission (STEA, 2004),Strategy for Agriculture Development 2011to 2020 (MAF, 2010),Strategy on Climate Change of the Lao PDR (WREA,2010),Second National

Communication on Climate Change (MoNRE, 2012)and consultation workshop on the technology prioritization are only feeds optimization, high producing cattle, gas recovery or biogas, paddy field water management or mid- season drainage, organic farming, crop land and pasture management.

Feeds optimization:

Feed optimization is a key option as, apart from having potential for GHGs mitigation, it is also important for promotion of productivity. Feed optimization includes feeds quality improvement and efficient utilization with proper feeding, cattle can eat less per unit and be ready for the slaughter in a shorter period. Although it lacks of detail study in Laos but the research elsewhere revealed that there is potential for GHGs mitigation though feed optimization; Arthur *et al*(2001) found that with efficient feed, low residual feed intake (RFI) cattle and high RFI cattle are about same level of productivity. The studies by Okine *et al (*2001) and Herd *et al (*2002) also indicated 15% - 30% of methane emissions reduction and 15% - 20% reduction in manure production (Nkrumah *et al.* 2006; Hegarty*et al.* 2007). In addition, it also reduces age at slaughter as the faster an animal grows the lower the total feed requirements are, leading to lower methane emission per live weight gain. With feedlot cattle system in 2-5 months reduced 34–54 percent of time to slaughter (McCrabb*et al.* 1998).

MoNRE (2012) anticipated that if feeds optimization is applicable and is applied among 30 percent to 50percentof total livestock in Laos from 2015 to 2030 and if 15percent to 30percent of emission reductions can be achieved as suggested in the above study; 2,361.10 GgCO_2e can be reduced during 2015 and 2030 or on average 164.44 GgCO_2e reductive per year.

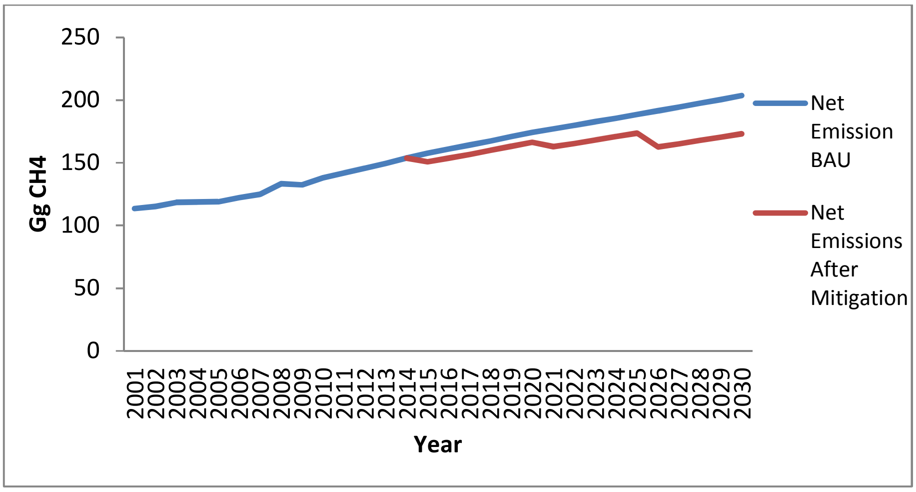

Figure 12 Project emissions reduction potential efficiency feeding improvement, Source: MoNRE, 2012: Measure for climate change mitigation. MONRE, 2012

In addition, feed improvement which can help to ensure feeds, health for livestock and productivity is crucial for development of livestock sub-sector, livelihood and also economic of the country. Government strategies particularly agriculture development strategy and livestock sub-sector development strategy recognized and identified the feeds improvement as a foundation for the development.

Biogas digester:

As mentioned earlier, methane recovery is one of the promising options. MoNRE (2012) predicted that if this technology is applied for emissions reduction from 2015 to 2030 for50percent to 70percent of total livestock which raised in farm system such as liquid, paddock and so on, where manure is used for methane recovery, and 30 percent to 50 percent of emissions can be reducible as estimate, the emissions reduction by 2030 will be 194.93 $GgCO_2e$ CH_4 or 12.18 $GgCO_2e$ CH_4 per annum on average.

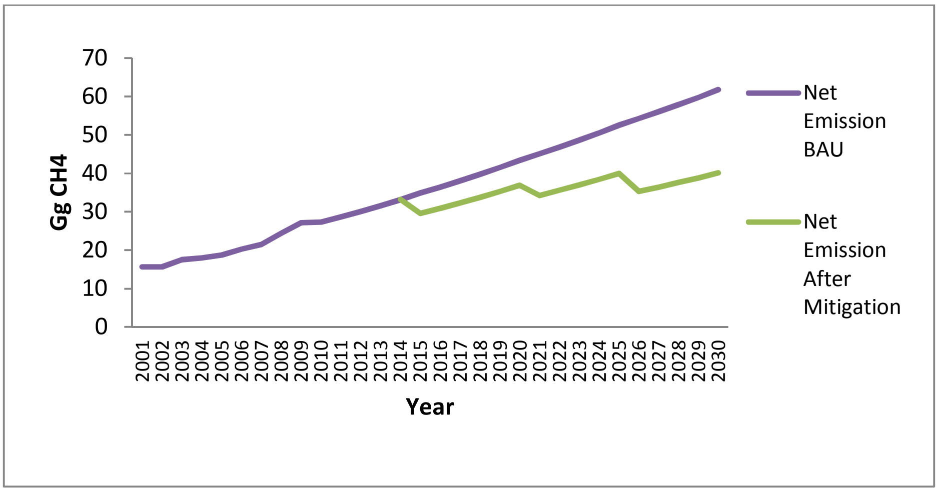

Figure 13 Projected emissions reduction potential from manure management. Source: MoNRE, 2012: Measure for climate change mitigation. MONRE, 2012

In addition, the livestock wastes has a potential for biogas production which approximately 4 million metric tons of animal dung[26]is produced per year and this can generate around $2.8x10^8$ m^3 of biogas per year, or equivalent to 5x108 kWh electricity (about 216 MTOE) (LIRE, 2011).

[26]COUNTRY PAPER: Utilization of Biomass for Renewable Energy, in Lao People Democratic Republic for Workshop on Utilization of Biomass for Renewable Energy, 11-15 December 2006, Kathmandu, Nepal.

Organic farming

Based on the research, evident elsewhere and observation of actual practice in Laos, organic farming is considered as a climate change mitigations for agriculture sector. Organic farming could considerably reduce the GHG emissions of the agriculture sector and make agriculture almost GHG neutral (Niggli et al., 2009). GHG emissions of agriculture would be reduced by roughly 20 per cent. Another 40 per cent of the GHG emissions from agriculture could be mitigated by sequestering carbon into soils at the rates of 100kg of C ha-1 yr-1 for pasture land and 200kg of carbon/ha per year for arable crops. By combining organic farming with reduced tillage, the sequestration rate can be increased to 500kg of carbon/ha per year in arable crops as compared to ploughed conventional cropping systems, but as the soil C dynamics reach a new equilibrium, these rates will decline in the future. This would reduce GHG emissions by another 20 per cent (Uprety.D.C et al, 2012).

As for the benefits of the organic farming, as described in the TNA Mitigation Agriculture (2012) and observation in Laos, it can be summarized as following:

- Organic agriculture can improve soil fertility and N supply by using leguminous crops, crop residues and cover crops, to eliminate fossil fuel used to manufacture N fertilizer elsewhere. The addition of the crop residues and cover crops leads to the stabilization of soil organic matter at higher levels and increases the sequestration of CO_2 into soils;
- Organic agriculture increases soil's water retention capacity, which would enable a crop to survive longer in a drought cycle. This could help the crops adapt to unpredictable climatic conditions. Soil C retention is most likely to withstand climatic challenges and soil erosion, an important source of CO_2 losses, is effectively reduced by organic agriculture;
- Organic agriculture can contribute to agro-forestry production systems, which offer additional means to sequester C;
- Organic systems are highly adaptive to climate change due to the application of traditional skills and farmers' knowledge, soil fertility-building techniques and a high degree of diversity;
- Organic agriculture as a water protector reduces water pollution due to the absence of pesticides and chemical fertilizers;
- Organic agriculture is compatible with conservation tillage, thereby enabling even greater C sequestration potential by incorporating this mitigation technology.

5.4 Process and criteria for technology prioritization in the agriculture sector

The technologies prioritization in the agriculture sector was conducted in apparel with technology prioritization in the forestry sector and applied the same processes. As mentioned earlier in the Chapter 5, the process include review of emissions sources and sink; existing mitigation technologies in the agriculture sector and the prioritization of the technologies. The results of the review of the emissions sources and sink and existing mitigation technology in the agriculture sector were already explained in the section 5.1 and 5.2 respectively. So this section focused on the technology prioritization particularly in the technology prioritization workshop. The technology prioritization workshop in May 2012brought together37 participants from various organizations (Annex 4).Before the workshop, the stakeholders were informed about the mitigation technologies and options as in the section 5.1 and 5.2 as well as technologies recommend in the FNC (STEA, 2000), the Assessment Report on Technology Needs and Priorities for Mitigating Greenhouse Gas Emission (STEA, 2004), SNC (MoNRE, 2012) and in the IPCC AR4 (IPCC, 2007). During the workshop, the prioritization of the technology followed the steps and methodologies for technology prioritization, as recommended in the TNA Handbook (UNDP and UNFCCC, 2011),particularly identifying technologies, editing technologies and categorizing them, selection of top ten technology options from the edited technology list and then prioritize four technologies out of the ten technology options with the use of the criteria, scoring including sensitivity analysis and consensus of the results amongst the stakeholders.

The identification of technologies based on the technology option mentioned in the section 5.3 potential mitigation technology that generated in the technology prioritization workshop in May 2012 while technology edition and categorization were conducted by assessment of the technology application scale and availability though group discussion and expert judgement. As a result, the edited and categorized mitigation technologies can be summarized and presented as in the Table 12 below.

Table 12 Mitigation technology options and categorization in the agriculture sector

Sub-sector	Technology	Scale of application	Availability
Rice cultivation	Water management scheme (mid-season drainage)	Small to medium	Short term
	Appropriate application of fertilizer, manure/Precise farming	Small	Medium term
Livestock enteric fermentation	Feeds improvement: *Feeds optimisation* *Extension of ammoniated straw and silage*	Small to medium	Short to medium term

Livestock manure management	Biogas	Medium	Short term
Crops management	Integrated cropping system	Small to medium	Short term
	Agro-forestry	Medium to large	Short term
	Organic farming	Small	Short term
Others	Precise farming	Small	Medium to long term
	Agronomy: Agricultural biotechnology to produce crop varieties with enhanced carbon sequestration Cover crop	Medium	Long term
	Nutrient management: Management of nitrogenous fertilizers Mitigation of CO_2 by mycorrhiza	Small	Long term
	Tillage/Residue management: Conservation tillage Biochar	Small	Short to medium term
	Direct seeding technology	Small	Short to medium term
	Chemical fertilizer amendment	Small	Medium term

The selection of top then technology was conducted by expert judgement of ten technologies in the table 12 above, that are perceived to have greatest mitigation potential and most preferable. So the top ten selected technologies are as in the following Table 13.

Table 13 Shortlisted technologies in the agriculture sector

No	Ten Shortlisted 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

As mentioned, priority technologies were prioritized using the multi-criteria decision analysis method and four technologies are selected out of top ten technologies mentioned above. The criteria applied in the prioritization of the mitigation technologies of agriculture sector are same criteria and weight that applied for technology prioritization for forestry sector, as shown in the table 10 and Figure 10.In the prioritization of last four technologies, an assessment of the technology performances, the top ten technologies were scored against the criteria. The score ranks from 0 to 100; in which 0 is the least preferred while 100 is most preferred. Through this process, each of technology was scored for their contribution on social, environmental and economic criteria. The overall weighted scores were calculated using the scores and weights and the last four technologies that received the highest overall weighted scores are organic farming, biogas, cropland management and feeds improvement as shown in the Table 14 below.

Table 14 Results of the scoring of technology prioritization for agriculture sector

Options	Cost	Environmental Benefits			Social Benefits			Economic Benefits		Total costs	Total score of benefits	Total score	Rank
	Cost/ Investment	GHGs Reduction	Reduce air pollution	Reduce environmental negative impacts	Employment	Gender equity	Balance urban and rural development	GDP/ Income/ Yield	SMEs/ MSMEs				
Biogas	30	100	100	100	75	60	75	80	80	6	69	75	2
Appropriate Water Management for Paddy Field	70	50	0	0	0	55	0	35	0	14	17	31	10
Promote Use of Adapted and High Production Cattle	70	0	60	70	35	60	60	55	65	14	37	51	8
Agricultural Soil Carbon Management	100	70	70	80	65	60	60	0	55	20	40	60	7
Organic Farming	80	70	70	75	100	100	100	80	75	16	65	81	1
Integrated Farming	80	60	65	60	50	70	60	50	50	16	45	61	6
Fodders Improvement and Appropriate Feeding	75	80	70	65	75	65	70	80	70	15	59	74	3
Crop Land Management	70	85	75	70	60	65	65	70	70	14	57	71	5
Land Suitability and Ecosystem Based-Agriculture	0	50	60	60	30	40	55	55	60	0	41	41	9
Crops Residual to Energy	55	75	80	70	80	0	65	100	100	11	63	74	4

This assessment, however, as recognized that there would be uncertainty and variation of the scoring, sensitivity analysis was employed in order to re-affirm and address the variation. The sensitivity analysis was conducted based on the observation distribution of the score and change in rank. Annex 5 provided the results of the sensitivity analysis.

5.5 Results of technology prioritization and discussion

Throughout the prioritization process particularly the scoring and assessment,four technologies, namely Organic Farming, Biogas, Feeds and Feeding Improvement, and Agriculture Residue to Energy which obtained highest scored or were considered most preferable are selected as priority technology needs for climate change mitigation in the agriculture sector. These technologies are chosen according to the respective score in the criteria as well as its potential benefits on socioeconomic and environment including carbon sequestration and also alignment with national policies. Followings are summary of its potential and development status in Laos.

Organic Farming:

As mentioned, Organic Farming is also a key technology for reduction of the emissions from particularly emissions from soil and fertilizer. In addition, this technology also helps to reduce emissions from fertilizer and pesticide manufacturing elsewhere. Although most of agriculture in Laos is conservation agriculture or organic, to date, certified or verified organic farming is in initial stage and small scale in Laos. In addition, assessment and verification of socioeconomic and environmental benefits including climate change mitigation of different farming systems in regions are limited. However, prioritization of this technology in the TNA is expected to contribute to research and development of this technology as well as establishment of policies on the promotion of environmentally friendly technology, conservation agriculture and emissions mitigation.

The Biogas:

The biogas is amongst key technology for reducing emissions particularly from livestock manure. In addition, this technology also helps to reduce emissions from energy consumption and other environmental and health caused by improper manure management. However, to date, this technology is in small scale in Laos. As mentioned, in 2011, only 2,715 biogas digesters with total capacity of 12,950 m^3or less than one percent of the potential is used. This is due to lack of policy, financial and technical support for promoting biogas including for emissions reduction. However, prioritization of this technology in the TNA is expected to contribute to development and innovation of this technology for substantially reduction of emissions and environmental impact.

The feeds and feeding improvement:

The feeds and feeding improvement is a key technology for reduction of the emissions from particularly livestock enteric fermentation. As mentioned, the research elsewhere suggested that optimal feeding has potential for reduction of emissions due to reduction of feeds consumption, consuming period and over grazing while increase the productivity. In addition, this technology is also alternative livelihood improvement and income generation as well as reduction of the emissions in the areas of slash and burn agriculture, cutting trees for firewood, NTFPs for income. However, to date, this technology is under development in Laos; numbers of livestock raising including fodders improvement have been promoted through the country. However, research and systematic assessment of the performance of this technology, its optimal feed management for maximizing emission reduction and innovation are limited; so the prioritization of this technology in the TNA is expected to contribute to development of this technology as well as implementation of policies on the food security, poverty reduction, livestock raising and emissions mitigation.

Agriculture Residue to Energy:

This is an emerging technology that has great potential for reducing emissions particularly from crops residues burning and left to decay. In addition, this technology also helps to reduce emissions from energy consumption. However, to date, this technology is in initial stage and small scale in Laos,only one pilot project has been developed on generating energy from rice husks, with a capacity of 160 kW (MEM, 2011). The research and systematic assessment of live cycle of the technology is also limited. Prioritization of this technology in the TNA is expected to contribute to development and innovation of this technology as well as development and implementation of policies on the promotion such technology for emissions mitigation and other purposes.

Chapter 6. Summary and Conclusions

In general, the technology needs assessment for climate change mitigation was conducted though participatory process with the use of criteria, scoring and stakeholders consultation approaches. Overall, the assessment is divided in two main steps; sector selection and mitigation technology prioritization in the selected sectors. The sector selection was carried out through initial sector selection, review of the status and trend of emissions and then followed up with sector selection consultation workshop. The initial sector selection as well as review of the emissions and trends mainly focussed on review and summary of the emissions and trends described in the Second National Communication on Climate Change-SNC (MoNRE, 2012), Strategy on the Climate Change of the Lao PDR-SCC (WREA, 2010) and National Socioeconomic Development Plan of the Lao PDR 2011-2015 (MPI, 2011) including sectoral development plans and the results of the review is key references for stakeholders and inputs for sector selection. The sector selection workshop which basically aims for select two priority sectors for the assessment was held in February in 2012 with participation of stakeholders from 24 organizations and or disciplinary. In the workshop, multi-criteria and scoring were applied with consultation process to realize the priority sector namely forest and agriculture. Likewise the technology prioritization in the forest and agriculture was conducted through review of the existing mitigation technologies in the sectors and technology prioritization workshop. The review of the mitigation technologies focussed on the technologies that were particularly identified in the Initial and Second National Communication on Climate Change (INC and SNC) (STEA, 2000 and WREA, 2012),Assessment Report on Technology Needs and Priorities for Mitigation of Greenhouse Gas Emission (TNA) (STEA, 2004), Strategy on the Climate Change of the Lao PDR (SCC) (WREA, 2010), Forestry Strategy to the year 2020 of the Lao PDR (MAF, 2005) and Lao Agriculture Development Strategy2011-2020 (MAF, 2010) including Technologies for Greenhouse Gas Mitigation in the Agriculture Sector (UNEP, 2012) and ClimateTechWiki[27]. The technology prioritization workshop was organized in May2012 and aims to screen and select four priority technologies through consensus of stakeholders. 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 reach consensus on the priority technologies with the stakeholders. Through these process particularly scores in the criteria as well as assessment of technology alignments with policies and performances; four

[27]http://climatetechwiki.org/

technologies for both forestry and agriculture sector are chosen as priority technology for greenhouse gas mitigation. Those technologies are as follows:

Mitigation technologies for forestry sector:

- Effective Protection and Protected Area
- Optimal Agro-Forestry
- Optimal Plantation
- Sustainable Community Forest Management

Mitigation technologies for agriculture sector:

- Organic farming
- Biogas digester
- Feeds improvement
- Agriculture residue to energy

Effective protected area management: the effective protected area management which derived from the combination of multi-disciplinary approach which include the livelihood, incentive and ecosystem-based forest management including REDD plus and effective law enforcement. The chosen of this technology aligns with national policies on the environment protection, biodiversity conservation, ecotourism and climate change. For the effective protected area management, classification and demarcation of 22 National Biodiversity Conservation Areas (NBCAs) started since mid 1990s. In addition, zoning, patrolling the forest encroachment and hunting, promote ecotourism and introduction of REDD plus have been implemented for many protected areas. However, the management is ineffective; forest encroachment and conversion still occurs, due to insufficient resources for management, ineffective law enforcement, fail to address livelihood and ownership of forest dependent communities. So the selected effective protected area management is expected to address these mentioned issues and also contribute to maintain and or increase forest cover, biodiversity, local livelihood and being a source of carbon sink.

Appropriate agro-forestry system: has a great potential for carbon capture and storage, socioeconomic and other environmental benefits. This technology, is actually identified in the forest strategy to 2020 (MAF, 2005) and strategy on climate change (WREA, 2010), as a means for promoting appropriate agro-forestry system for enhancing climate change mitigation and adaptation. However, the development of agro-forestry system can lead to various impacts in different level depends on the site specific condition, combination, technique etc. so development of appropriate agro-forestry system which is carried out through research and demonstration is needed to assess the impact of different system and mechanism of agro-forestry, and then innovate and apply appropriate system for a setting. The prioritization of this technology in the TNA is expected to support to search for and innovation of the appropriate or climate change oriented agro-forestry system that maximize carbon capture and storage as well as substantially contributing to socioeconomic and environment benefits.

The optimal plantation: a market viable, cost-effective and ecosystem-based plantation which is one of the technologies that have a great potential of carbon capture and storage as well as contribution to the enhance conservation and reduction of the environment or ecosystem impact. The selection of this technology reflects the government policies and issues such as replacing dependence on wood from natural forest, afforestation for environment conservation, income and employment as well as maximizing benefits from particularly degraded land. At the present, 230,000 ha of the plantation has been established (FAO, 2010) and the majority are eucalyptus, teak and rubber. By 2020, the government targeted to increase the area of plantation up to 500,000 ha 2020 (MAF, 2005); so there is room for plantation to grow. However, the development of plantation should be more careful and more market-oriented, cost-effective, suitable species, certain ecosystem and also adds value to the degraded forest and land as well as carbon sequestration. So the prioritization of the optimal plantation in the TNA is expected to lead to innovation of this technology as well as promotion of appropriate species[28]and techniques for a certain ecosystem as well as sustainable plantation development.

The sustainable community forest management (SCFM): is the community-managed forest resources which aims for meeting both biodiversity conservation and sustainable livelihoods including changing climate mitigation. This technology is identified and aligned with recent government policies particularly forest strategy, rural development, poverty reduction and building villages as the development unit including decentralized forest and land management. To date, although the SCFM has been implemented In Laos for decades, particularly with support from international organizations (development projects) and the local governmental organizations such as Provincial Agriculture and Forest Office (PAFO) and District of Agriculture and Forest Office (DAFO); it is still in the initial stage and small. So the prioritization of this technology in the TNA is expected to contribute to development and innovation of this technology; leading creation of substantial impacts on the livelihood, biodiversity conservation and climate change mitigation.

[28] The appropriate species in the context refer to cost-effective, market viable, optimal carbon sequestration and storage, improve ecosystem and multi-purpose for use.

Organic farming: is an environmentally friendly agricultural practice and essential for reduction of the emissions particularly emissions from soil and application of fertilizer. In addition, this technology also helps to reduce emissions from fertilizer and pesticide manufacturing elsewhere. This technology is chosen due to its score in the criteria as well as its potential on income and employment for the farmers, preservation of environment and avoids emissions from soil and fertilization as mentioned above. Recently, although most of Lao farmers do the organic farming; certified or verified organic farming is in initial stage and small scale in Laos. However, prioritization of this technology in the TNA is expected to contribute to development of this technology to maximize benefits on the promotion of conservation agriculture, poverty reduction as well as emissions mitigation.

The biogas: is amongst key technology for reducing emissions particularly from livestock manure management and emissions from energy consumption. Development or implementation of this technology is a means of implementation national policies particularly policies on the promotion of environmentally sound technology, pollution control, poverty reduction and emissions mitigation. In addition, selecting this technology is also a means to provide alternative energy particularly for farmers. However, the development of the biogas depends on livestock manure inputs, manure management system, proper design of biogas and good maintenance which is key problems associates with biogas developers in Laos.

The feeds and feeding improvement: the feeds and feeding improvement is a key technology for reduction of the emissions under agriculture sector particularly addressing emissions from livestock enteric fermentation by improve quality of feeds and optimal feeding. This technology reflects that national policies on rural development and poverty reduction, sustainable livestock and climate change mitigation. To date, the feeds and feeding improvement is expanding in the country. However, it is still small scale and unsystematic; so the prioritization of this technology in the TNA is expected to contribute to development of this technology as well as application of appropriate technology for maximize benefits both productivity and emissions mitigation.

Agriculture residue to energy: is an emerging technology that has great potential for reducing emissions particularly from crops residues burning and left to decay or input to soil. In addition, this technology is also an alternative renewable energy. Development of this technology is an implementation of national policies on renewable energy, environmentally sound technology and low carbon or climate change mitigation. However, to date, this technology in Laos is in initial stage, small scale, lack of capacity and experience. In addition, the biomass input in the Lao PDR is generally dispersed and seasonal to be a viable feedstock (LIRE, 2010). So development of this technology requires the research and systematic assessment of emissions in its live cycle including its performance. In addition, development of this technology requires ensuring adequacy of crops residues, proper design of the plant and good maintenance.

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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 Ms. ChandaSouliya	Department of Environment Promotion, MoNRE	Government
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
Mr. PhimphacksomphanPhalakhone	Department of Livestock and Fishery, MAF	Government
Mr. SyammoneSisongkham	Department of Irrigation, MAF	Government
Mr. PhousithPhoumavong	Department of Agriculture and Forestry	Government

	Extension Services, MAF	
Mr.KhamphoneMounlamai	National Agriculture and Forestry Research Institute (NAFRI), MAF	Research Institute
Mr. SomesoukSomechai	National Agriculture and Forestry Research Institute (NAFRI), MAF	Research Institute
Mr. SomesoukSomechai	National Agriculture and Forestry Research Institute (NAFRI), MAF	Research Institute
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: Sectors and subsectors covered in the inventory and mitigation

Sector and sub-sector		
1. Energy sector		
	A. Combustion	
		1. Energy industries
		2. Manufacturing industries and construction
		3. Transport
		4. Residential sector
		5. Agriculture and forestry
	B. Production and supply	
		1. Electricity
		2. Coal
		3. Charcoal
		4. Oil
2. Industrial processes sector		
	A. Mineral products	
	B. Chemical industry	

	C. Metal production
	D. Consumption of halocarbons and sulphur hexafluoride
	E. Food and drink
3. Agriculture sector	
	A. livestock (enteric fermentation and manure management)
	B. Rice cultivation
	C. Agricultural soils
	D. Prescribed burning of savannahs
	E. Field burning of agricultural residues
4. Land-use change and forestry sector	
	A. Changes in forest and other woody and biomass stocks
	B. Forest and grassland conversion
	C. Abandonment of managed lands
	D. Forest soil
5. Waste sector	
	A. Solid waste disposal on land
	B. Waste-water handling
	C. Waste incineration

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. ImmalaInthaboualy	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	Research Institutes

		Institute, MoNRE	
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

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

No	Name	Organization/Institution	Type of organization/ institution
1	Mr. XayavethVixay	Department of Disaster Management and Climate Change, MoNRE	Government
2	Mr. SyamphoneSengchandala		
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
19	Mr. SithongThongmanivong	Faculty of Forestry, NUoL	Academic
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
1	Mr. SyamphoneSengchandala	Department of Disaster Management and Climate Change (DDMCC), MoNRE	Government
2	Ms. MonxamSothipmany	DDMCC, MoNRE	Government
3	Ms. ThounheuangBuiyavong	DDMCC, MoNRE	Government
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
11	Mr. MoneNouansyvong	Consultant, TNA project	Private
12	Ms. LathdavoneBuaphaseut	Faculty of Environment, NUoL	Academic
13	Mr. VanthonePhonnasan	Department of Disaster Management and Climate Change, MONRE	Government
14	Mr. SackdaPhixayavong	Department of Water Resources, MoNRE	Government
15	Ms. Chansouk Si Oudome	Department of Meteorology and Hydrology, MoNRE	Government
16	Mr. SyammoneSisongkham	Department of Irrigation, MAF	Government
17	Ms. VilaykhamLathsaad	National Disaster Management Office, MSWF	Government
18	Dr. Simone Nampanya	Center for Malaria Control, MPH	Government
19	Mr. LatsamyInthavongsa	Department of Water Sanitation and Hygiene, MPH	Government

Forestry Sector

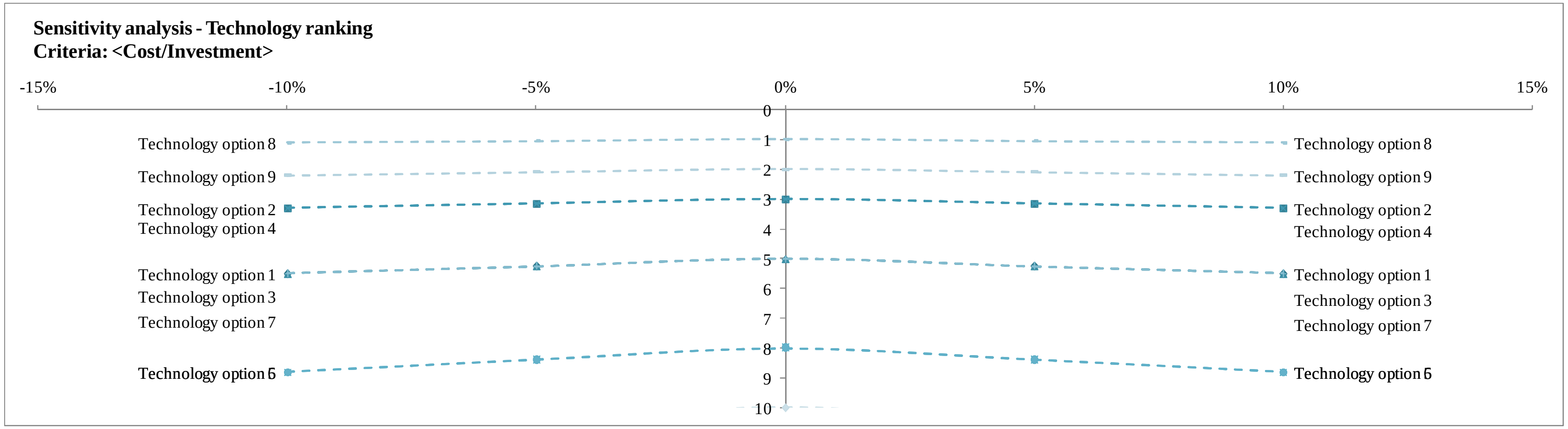
	Name	Organization/Institution	Type of organization/institution
1	Mr. XayavethVixay	Department of Disaster Management and Climate Change, MoNRE	Government
2	Mr. BountheeSaythongvanh		
3	Ms. ChindalakVilanon	DDMCC, MoNRE	Government
4	Mr. KeoKorakoth	Department of Forest Resources Management, MoNRE	Government
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
8	Mr. SengchanPhasaiyaseng	Department of Technology and Innovation, MST	Government
9	Mr. HoumphengTheuatbounmy	Renewable Research Institute, MST	Research Institute
10	Mr. HoumphengTheuadbounmy	Renewable Energy Research and Development Center, MST	Research Institute
11	Mr. OudonTavamixai	Faculty of Environment, NUoL	Academic
12	Mr.KaisonePhengsopha	Faculty of Forestry NoUL	Academic
13	Mr. PhouthasomeInthavong	Department of Urban and Housing, MPWT	Government
14	Mr. LamkhaXayasan	Public Work and Transport Research Institute, MPWT	Research Institute
15	Ms. KhamnangKhounphakdy	National Economic Research Institute, MPI	Research Institute
16	Mr. PhiengsavanhThammasith	Department of International Finance, MoFA	Government

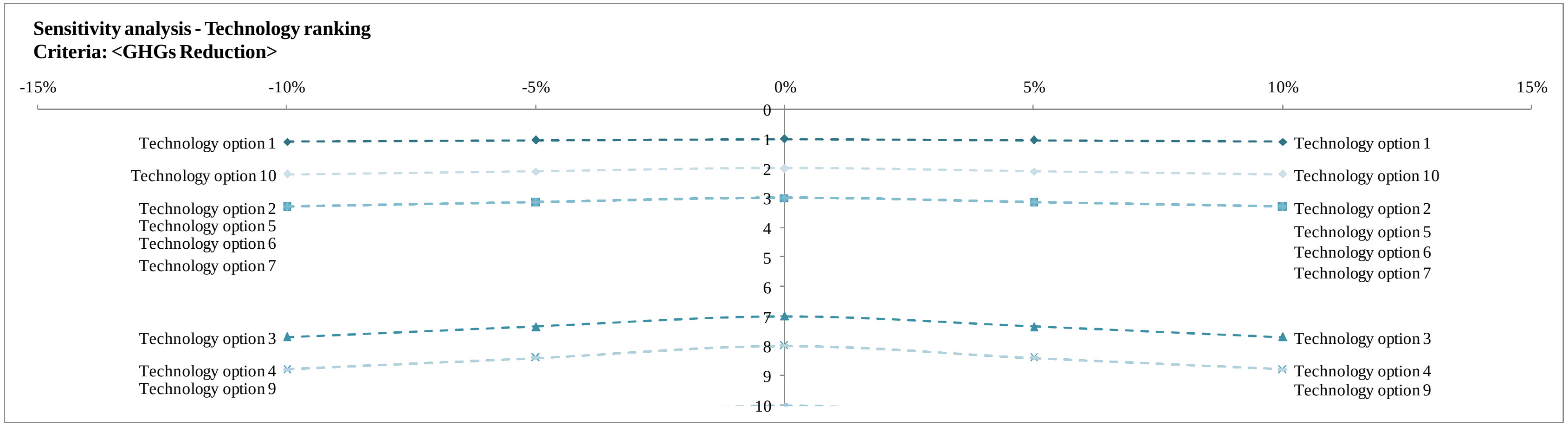
17	Ms. LathsoudaVilathxai	Faculty of Environment, NUoL	Academic
18	Ms. BounthanomePhimmasone	Center for Water Sanitation and Hygiene, MPH	Government
19	KhamphoneLueangvanh	MRC	International Organization

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

Forestry Sector:

Technology Rank	Technology Name
Technology option 1	Optimal forest plantation
Technology option 2	Effective law enforcement
Technology option 3	Optimal agro-forestry
Technology option 4	Effective forest fire control
Technology option 5	Sustainable production forest management
Technology option 6	Sustainable community forest management
Technology option 7	Effective conservation forest management
Technology option 8	Forestry and agro-forestry research
Technology option 9	Capacity building on GHGs mitigation
Technology option 10	Restoration of degraded forest




Sensitivity analysis - Technology ranking
Criteria: <GHGs Reduction>
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-10%
-5%
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Technology option 10
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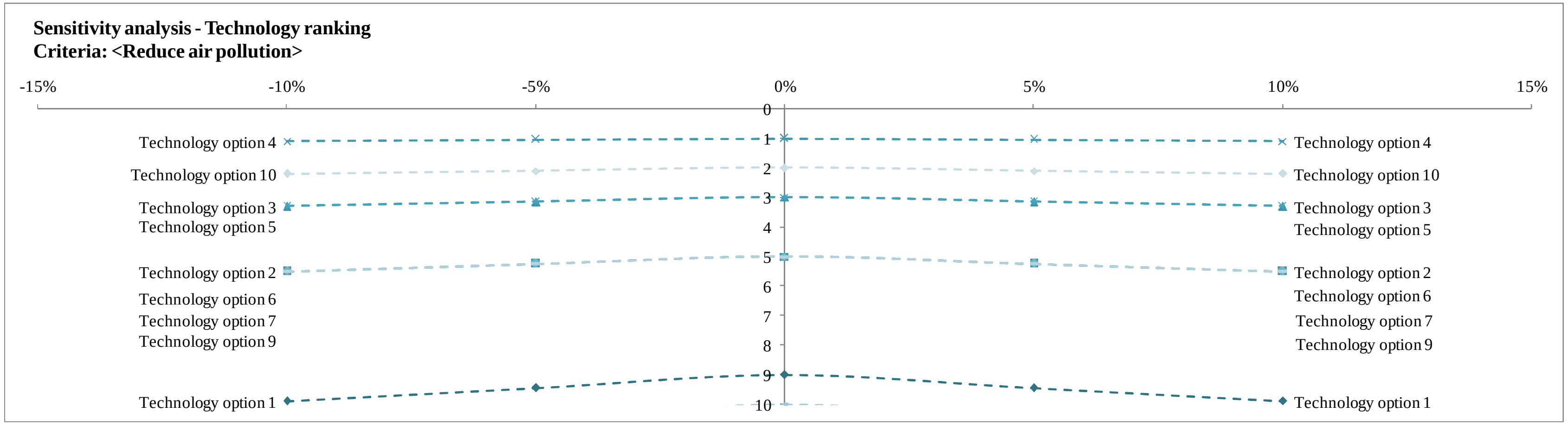
Technology option 4
Technology option 9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Criteria: <Reduce air pollution>
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Technology option 4
Technology option 10
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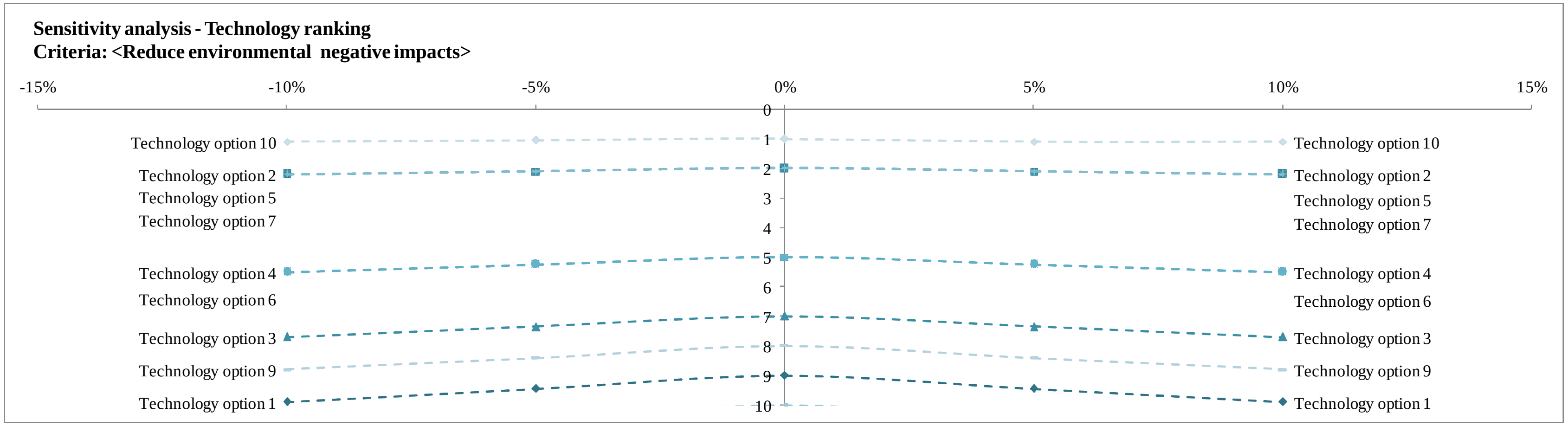
Technology option 9
Technology option 1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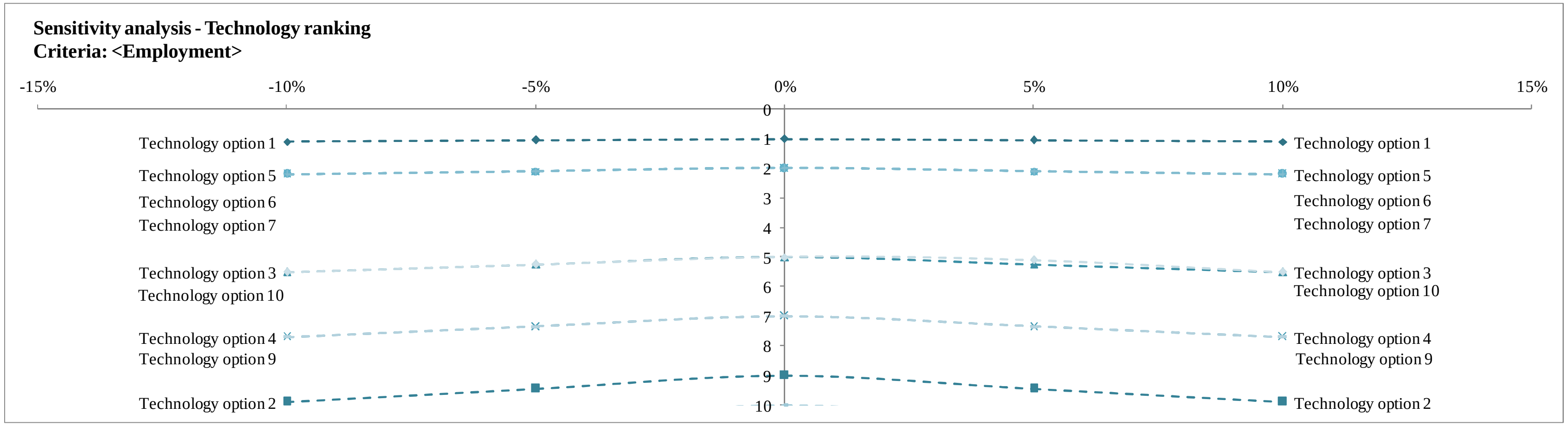
Technology option 9
Technology option 1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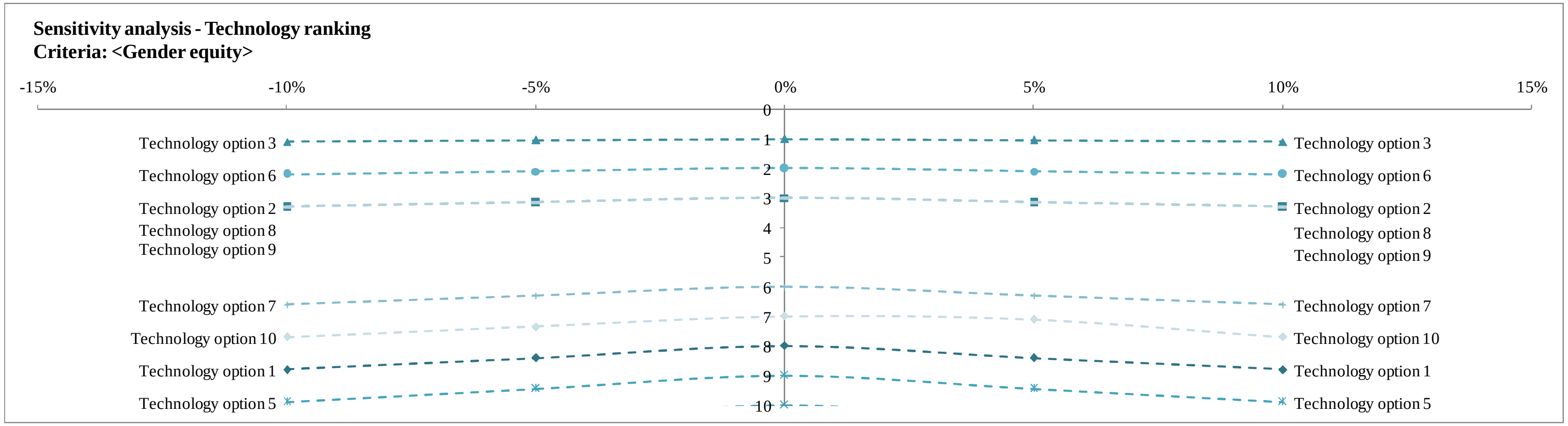
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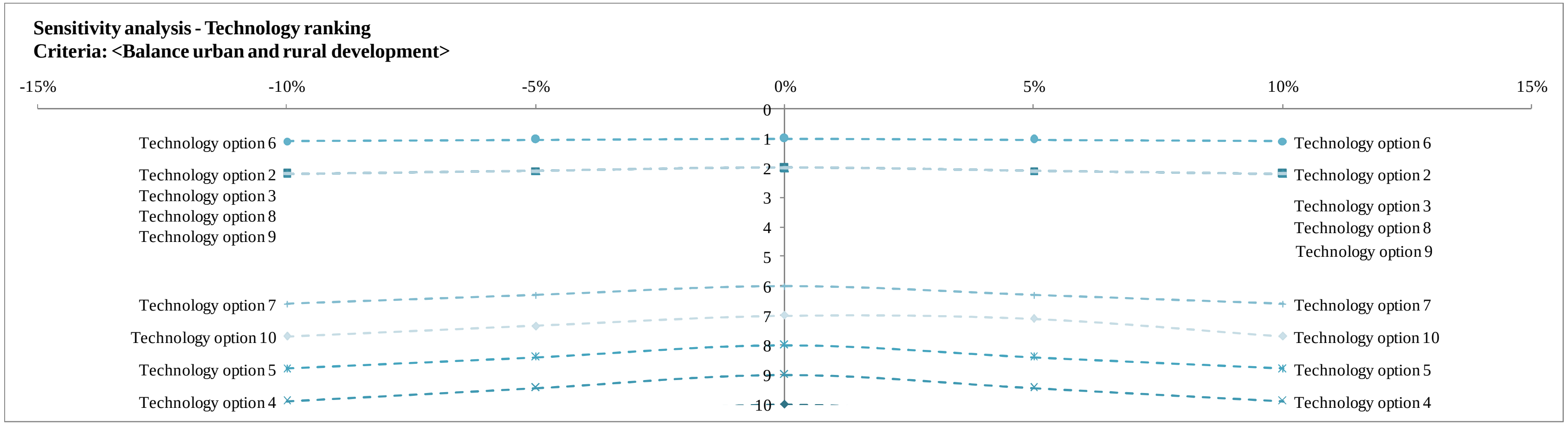
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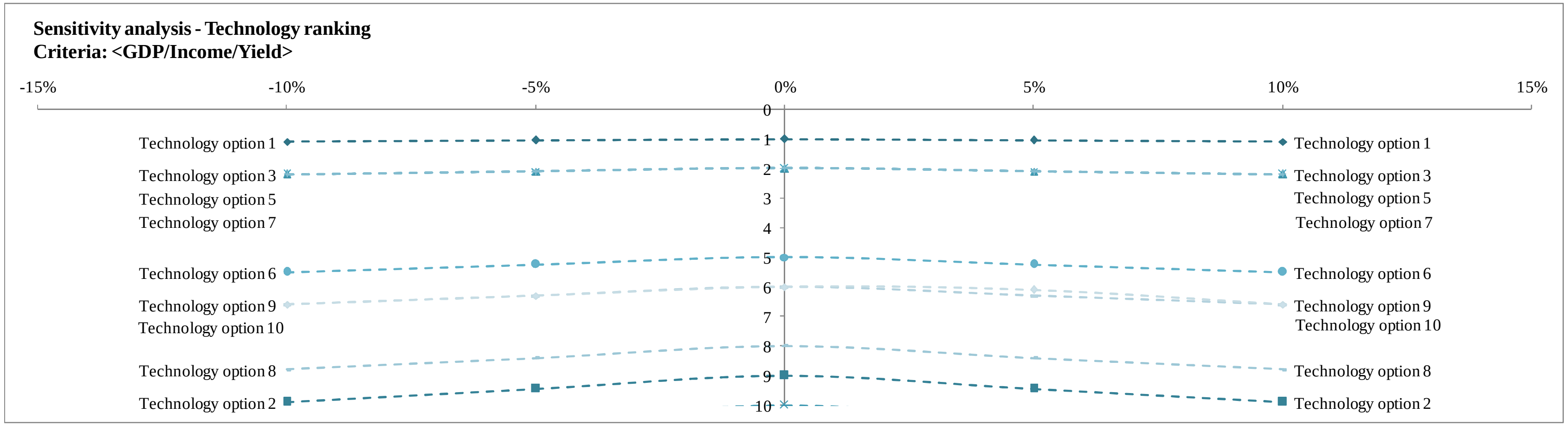
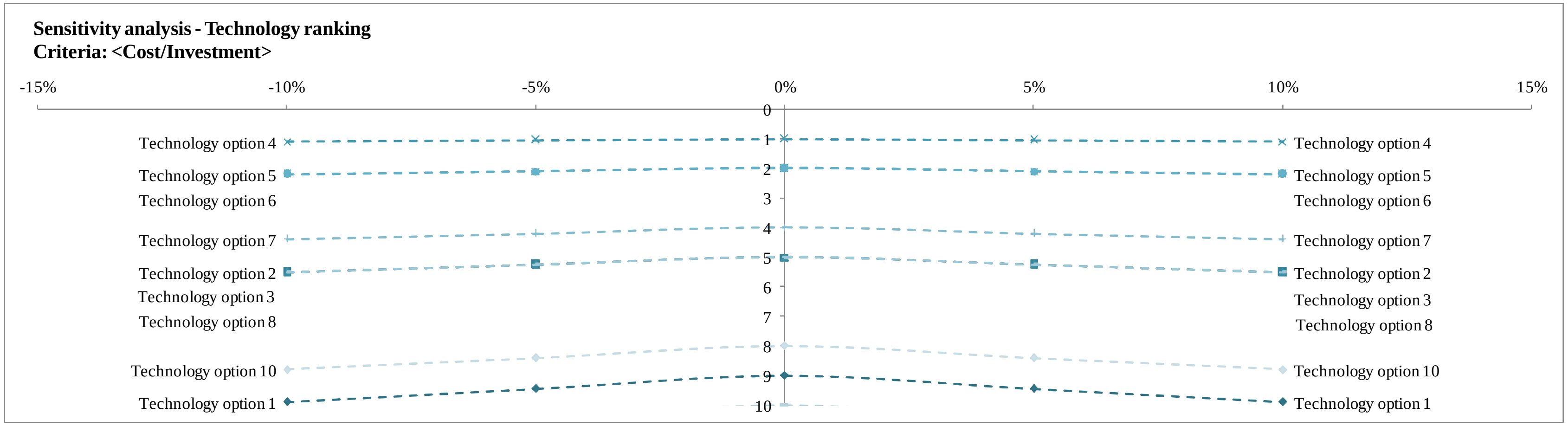


Agriculture Sector:

Technology Rank	Technology Name
Technology option 1	Biogas
Technology option 2	Appropriate Water Management for Paddy Field
Technology option 3	Promote Use of Adapted and High Production Cattle
Technology option 4	Agricultural Soil Carbon Management
Technology option 5	Organic Farming
Technology option 6	Integrated Farming
Technology option 7	Fodders Improvement and Appropriate Feeding
Technology option 8	Crop Land Management
Technology option 9	Land Suitability and Ecosystem Based-Agriculture
Technology option 10	Crops Residual to Energy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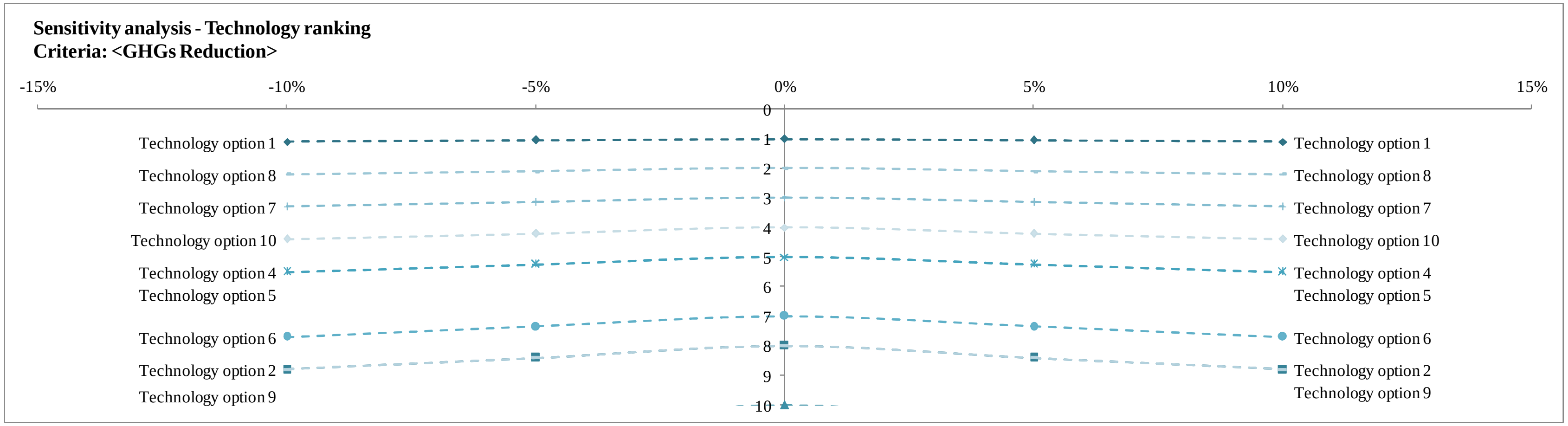
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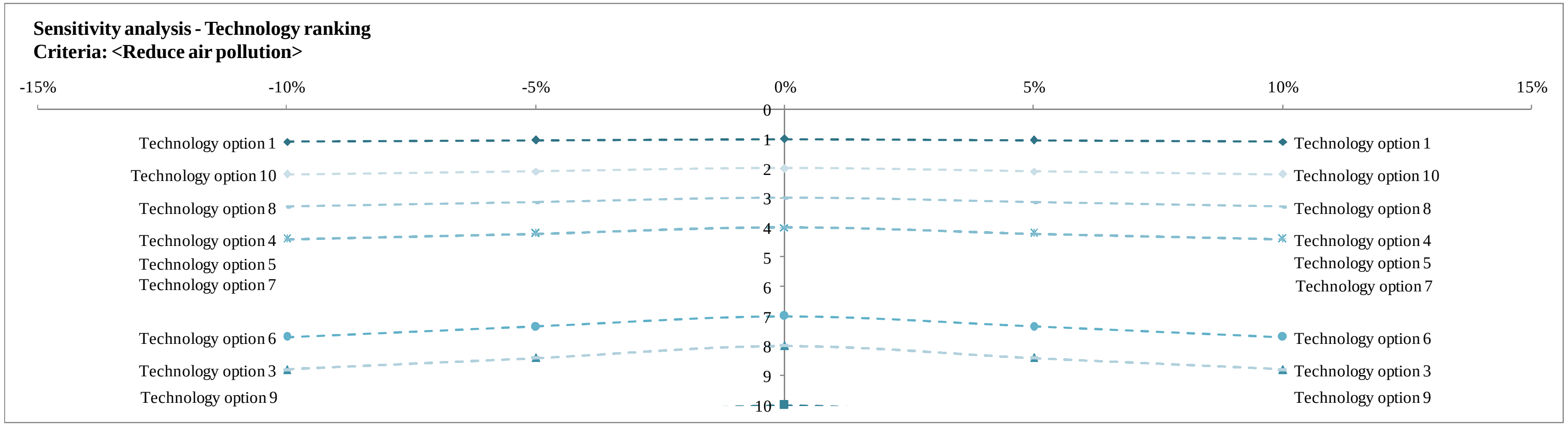
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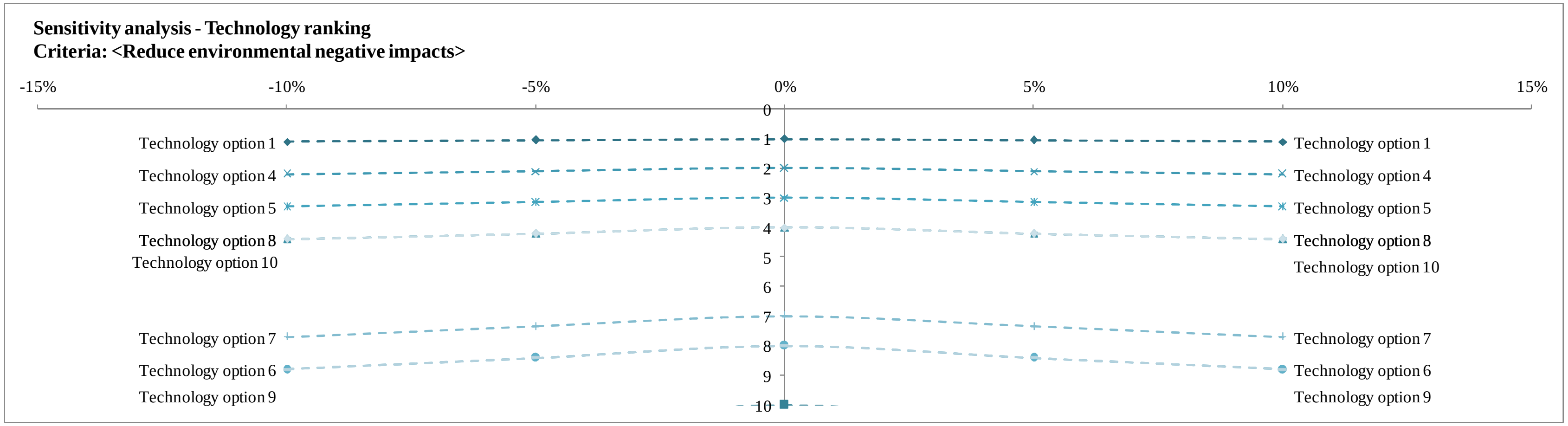
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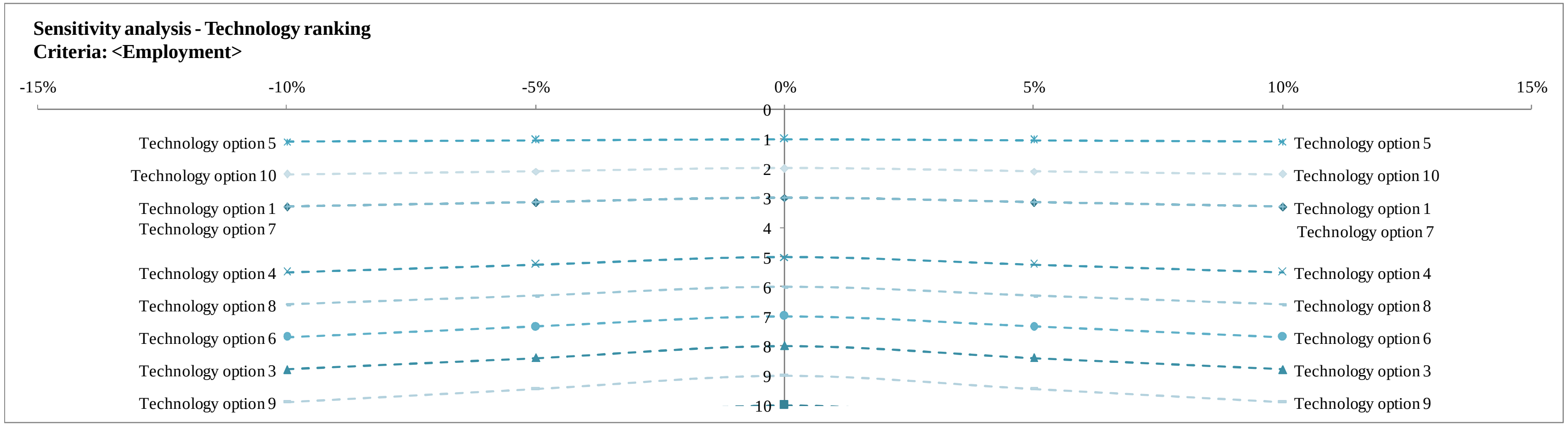
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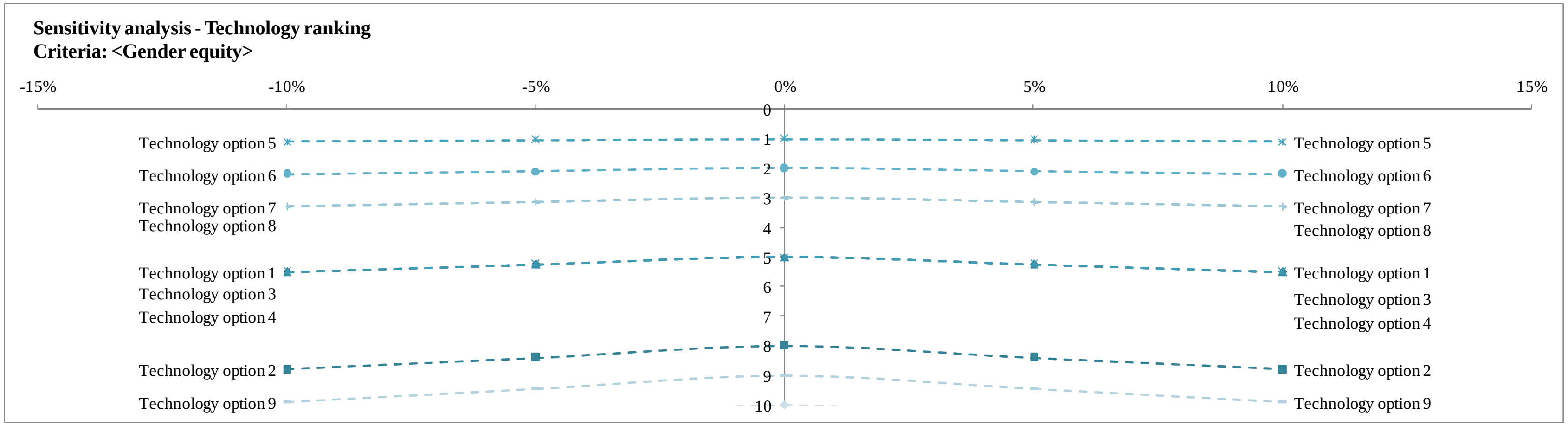
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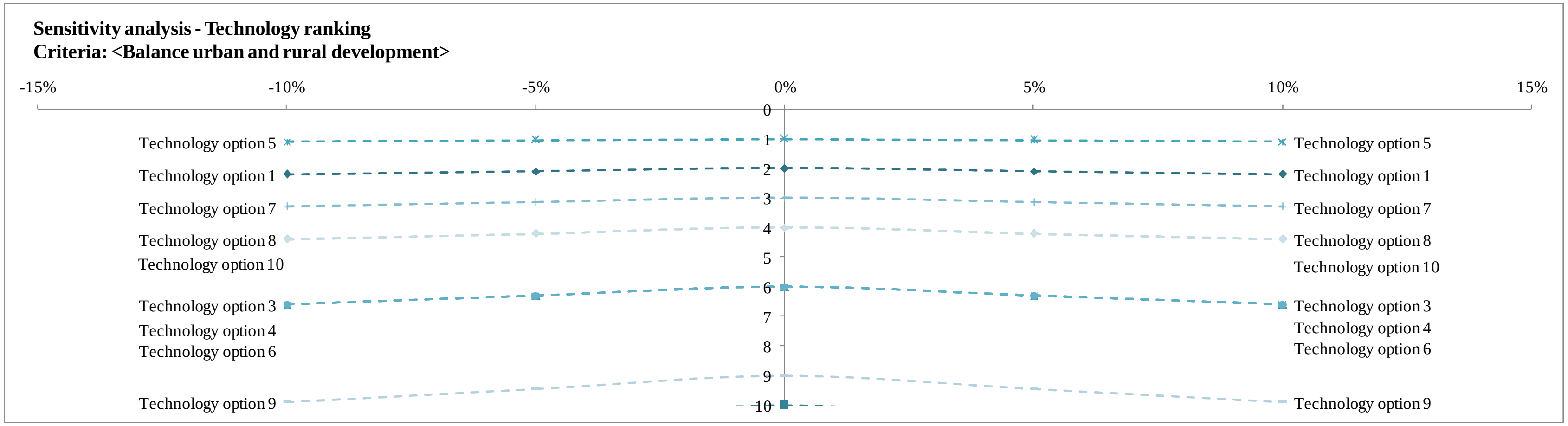
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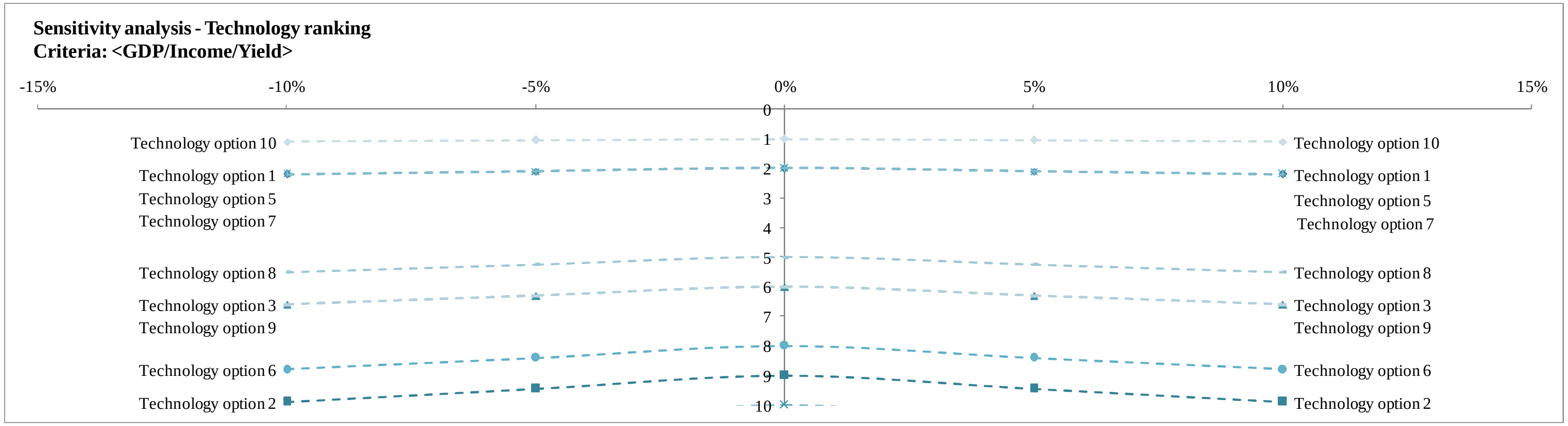
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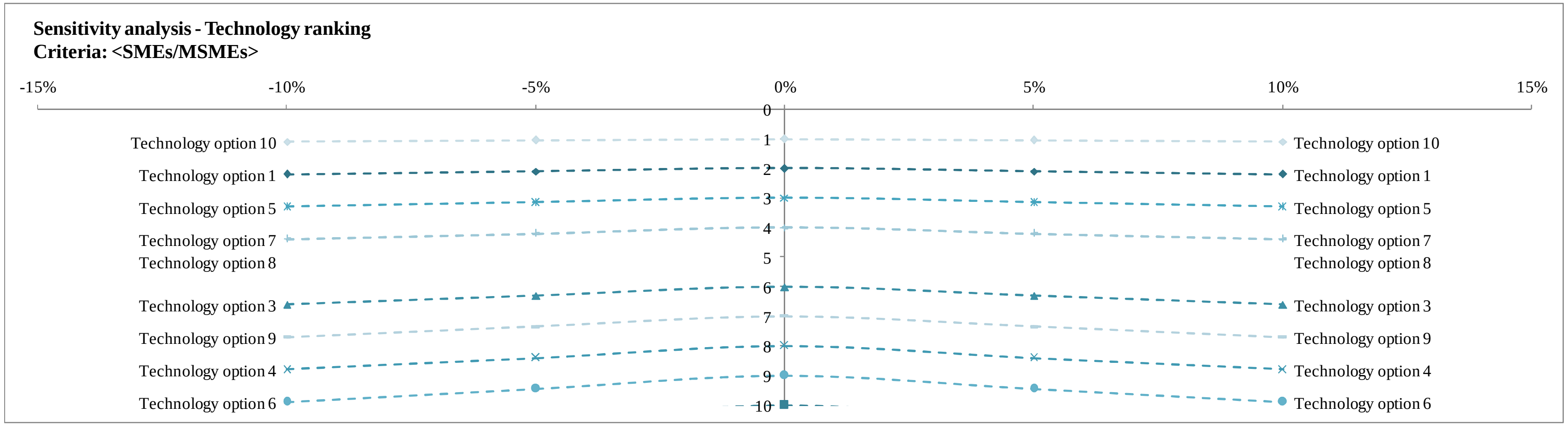
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Annex 6: Technology Factsheets for selected technologies

Forestry Sector

1.

Technology Name:	**Effective Protected Area Management**
Introduction	
The national protected areas are new allocated in Laos. The system has been legally setup in 1993 and has been developing to the present. According to evidences, in 1986 there are some priority sites for protected areas. Between 1988 and 1991, Department of Forestry (DOF), Lao Swedish Forestry Programme (LSFP) and International Union for Conservation of Nature (IUCN) conducted reconnaissance surveys of potential protected areas in Laos. By 1991, there are eight suitable areas were identified and recommended for management planning and additional areas are identified as priorities areas for assessment. In 1993 the Lao prime minister's decree 164 established for the first 18 national biodiversity conservation areas and the LSFP begins management planning in four NBCAS. In year 1995 and 1996 there were two more NBCAs added in the system, XeXap and Dong PhouVieng, which there are totally 20 NBCAs in Laos (William Robichaud *et al.* 2001).	
Technology characteristics	
Generally, all protection forests belong to the government, which includes five main level organizations from national to local levels: Ministry of natural resource and environment, ministry of national security, provincial agriculture and forestry, district agriculture and forestry and local village authority. The process of protected area organizing and managing is conducted following four main steps. 1. Identify priority areas for biodiversity conservation 2. Define approximate boundaries and secure the areas legally 3. Consult with local stakeholders to determine their use boundaries 4. Calabortively define the final, specific NBCA boundaries Resource: (William Robichaud *et al.* 2001)	
Status of technology in the country	

Laos is one of the few countries in South East-Asia that still allocated a large area of national protected zones since early 1990s for major roles of biodiversity conservation and watershed management. There are 20 protected areas in the country and covered over 12% of the total country area. These national protected areas distribute in all parts of the country (southern, central and northern), See map 1. There are four level managements of protected areas in Laos: National, Provincial, District and Village. All protected areas are places allocated for variety purposes of forest management, which included forest and forestland conservation, preserving plant and animal species, forest ecosystem, water resources and other valuable sites of natural, historical, cultural, tourism, environmental, educational, and scientific importance (National Assembly 2005). Furthermore, protected areas are also important for land and biodiversity conservation, which are necessary for the world environmental development, especially climate changes from the reducing emission from deforestation and forest degradation (REDD+). The pressure on Lao forests has increased in recent years due to its location next to Cambodia, China and Vietnam, whose forest industries demand big amounts of wood. However, there is an opportunity for protected areas to be developed to participate in a global mechanism called Reduction of Emission of Deforestation and Degrade Forest **(**REDD+). In good condition of forest management is great opportunity to sell the credit Carbon to Western countries in order to remains forest and its biodiversity in the future. They do so, because deforestation contributes to climate change, which poses a serious threat to mankind in Western countries and in Asia.

Figure 1: Laos NPAs (http://www.mekong-protected areas.org/lao_pdr/pa-map.htm)

Benefits to Economic development

According to data recorded, national protected areas management in Laos shares largely benefits to both national and local people in terms of income, food security and infrastructure. The process and activities of national protected areas management involve a variety of land allocation, which locate a clear land boundary between to village to village and as well as divided land use planning in the villages for their agricultural production. The activity of land use planning is one of the factors to give sufficient agricultural lands for the local people in order to support food security for the villagers. National protected area management also conducts activities of linking local villagers to the markets, supporting natural resources management in sustainable use in the village. For example supporting non-timber forest products management and utilization in the areas, the process also emphasise increasing income and improving the quality of life and livelihood for the local people. In the rural area where the average per capital income is less than $ 400, the values of non-timber forest products consumed annually per family has been estimated at $ 280, which represents of 20% of the nationwide GNP (William Robichaud *et al.* 2001). Furthermore, ecotourism is another activity, which was first organized in the northern part of Laos at Namha national protected area, Louangnamtha Province. This kind of activity shows great potential to benefit of the local stakeholders, who live in the national protected area. It can be an important key of local people poverty alleviation together with a strong link between income generation and biodiversity conservation in the site (Figure 1). The Lao national tourism authority reports that while most tourists to Laos concentrate about 70 % extraction in natural tourism (William Robichaud *et al.* 2001). This great potential is strong to gradually expand ecotourism to other national biodiversity conservation areas. At the same way, national protected areas development also gains a great potential development of infrastructure, example, road, local help service station, school and as well as accessing electricity to the villages.

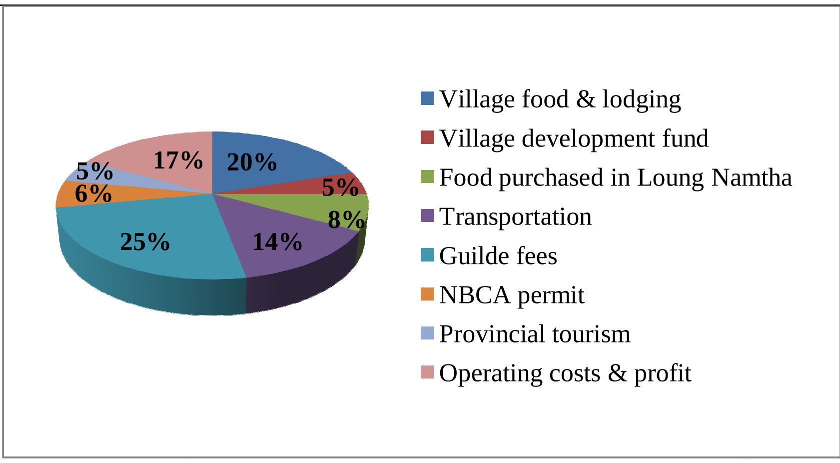


Figure 1: socioeconomic impacted from Namha national protected area edited from (William Robichaud*et al.* 2001)

Benefits to Environment development

National protected areas benefit not only on social-economics, but it also contributes greatly on hydropower and environmental development in terms of watershed protection and carbon dioxide reduction. Reports confirm that national protected areas have significant impactson some hydropower productivity, example water flow. According to landscape and geographic, Laos has a huge potential development of hydropower based on dams construction. However, it also needs other activity supporting for its productivity, example, and natural forest management relating to national protected areas. This is in order to protect watershed and environmental development. The Government of Lao PDR recognized that water resource of 60.400 m^3/year/capita have impacted from national protected areas management (William Robichaud *et al.* 2001). Mostly, national protected areas are located at the rural areas where they are mountainous with high slopes, therefore, forest and biodiversity that are good management in the areas can protect land erosion. As national protected areas contribute great benefits for hydropower development and as this reason the government has to deduct some annual gross income of hydropower for national protected areas management. Example, the Namthuen Two hydropower has agreed to pay $1 million per annum supporting for national protected areas management (CIEM 2003).

Climate change mitigation potential

There are varieties potential factors applications for national protected areas in Laos such as, law and regulation. Laos has a clear supporting law and regulation for organizing and managing of national protected areas in the country. According to the Prime Minister’s Degree 164 established national protected areas or National conservation forests, which mapped at 1:500 000 scales. The national protected areas management

systems have three main objectives: (i) protection of forests, wildlife and water, (ii) maintenance of natural abundance and environmental stability and (iii) protection of natural beauty for leisure and research. The decree has prohibitions on the following activities in the national protected areas: (i) any cutting and removal of any of timber except for research purposes; (ii) hunting, fishing or NTFP collection without specific authorization each time from Ministry of Forestry (MOF) and Department of Forestry (DoF); any activity of mining, and construction of reservoirs or roads without government permission. Another forestry law established in 1996, article 42 also provided more detail for national protected areas, which defines the role of protection forests as watershed protection, erosion control, national security and prevention of natural disasters. The system has highly potential contribution to biodiversity conservation. Furthermore, there are other international agreements, United Nation Convention on the protection of biodiversity (CBD) and ASEAN Membership, which all agree on the principal legal instruments for conservation of Nature and Natural resources, as well as world heritage convention under the auspices of UNESCO.

2.

Technology Name:	**Optimal agro-forestry**
Introduction	
Optimal forest plantation, in the TNA context refers to the agro-forest that promotes in the suitable area and generates maximum benefits and in sustainable manners for the area or land use. However, it lacks of information and assessment of such system in order to define what types of agro-forestry is optimal in the regions. So instead of assessment and describes such optimal agro-forestry system, this factsheet provided information on agro-forestry in general as a mean for further exploration of optimal forest plantation. The agro-forestry is defined differently from one user, practitioner and evaluator to another. Nair 1989 defined that agroforestry is land-use systems and technologies where woody perennials are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. As in the Wikipedia, agro-forestry is an integrated approach of using the interactive benefits from combining trees and shrubs with crops and/or livestock. It combines agriculture and forestry technologies to create more diverse, productive, profitable, healthy, and sustainable land-use systems or a trees on farms in short.	
Technology characteristics	
Agro-forestry is an integrated approach which generally, includes composition of trees with crops (agrosilviculture), trees with crops and livestock (agrisilvipasture), trees with pasture and livestock systems (silvopastoral) on the same piece of land. This combination is to maximize the benefits from the system and or	

provide products all year round. So the trees, crops, pasture and/or livestock can be diversified and grown together at the same, mean time, in rotation, or in separate plots but they can be perennial or long term. This depends on design including suitability of the system and location. However, all the compositions suppose to be compatible and benefit one another from interactions. On the other hand, it is necessary to balance and or complimentary between the functional (productive, protective and multi-purpose) and ecological (beneficial composition and interaction) based approach.

Overall, the agro-forestry are developed through the following stages and tasks:

Stage	Basic tasks
Diagnostic	1. Definition of the land-use system, land/site suitability and selection. 1) Setting/Physical characteristics (including altitude, climate mate (temperature, rainfall etc), slopes, water supplies, soil condition, visible erosion) in order for evaluating the need and suitability for agro-forestry system and techniques 2) Existing land use, tenures and agro-forestry systems, technologies, local knowledge and perception on the agro-forestry including its benefits (for suggesting the kind of subsistence products that an agro-forestry system would enhance) 3) Market including sales and purchases of agro-forestry products (fruit, fodder, firewood etc.). This provides data for economic analysis, and indicates opportunities to replace purchased items or to expand sales by raising agro-forestry products. 4) Constraints and opportunity for access to technology and finance, farmer capacities and markets 5) Site selection based on the assessment mentioned above and also other criteria. For example if agro-forestry is designed for carbon sequestration via Clean Development Mechanism (CDM), CDM's specific criteria or requirements are needed to be considered for site selection.
Design and planning	2. How to improve the system or agro-forest could provide? 1) List potential benefits of an agro-forestry system 2) List agro-forestry production needs (meet food security, increase production to meet market demands, conservation, carbon sequestration and so on) 3) Adoptability considerations: social and cultural acceptance; importance of local knowledge, practice and capacity; as well as equity and gender issues 4) Characterise and plan for the compositions or systems (trees, crops, grasses,

	livestock desired by minimum space requirements, water and fertiliser needs, shade tolerance etc). The planning should consider whether the system is temporary or long term/permanent so that the system can be adjusted according to the desire. The design and planning should follow the format or requirements if it is for CDM and REDD+ mechanism. 5) Evaluate the environment, socioeconomic of each system or composition 6) Select the system or composition to be used
Implementation	On-farm trials of proposed agro-forestry models and analyse impacts of the system including testing harvesting regimes
Monitoring and evaluation	1) Measure the inputs and outputs of the system 2) Socio-economic benefit assessment 3) Soil nutrition, moisture, land use/tenure and watershed impacts and carbon sequestration

Source: modified from Raintree, 1986; Martin and Sherman, 1998; FAO, 1991

Potential application in the country

The agro-forestry especially Taungya system would be one of the most potential applications of forest plantation in Laos. First reason is that agriculture production sector is being one heading sector focusing in development by the government. This is in order to have sufficient food for Lao people and increasing agriculture products for exporting. Taungya system is model that grows forest mixed with some shorter rotation cash crops, example, rice, pineapple, pasture, chilli and banana. This system will create local people income for both short and long terms. The short term incomes are from agricultural crops and the big long term benefits are from tree products. Furthermore, 80% of Lao people are still poor and they need income for every day for food and healthcare and by the way, they have limited land for grow tree and plant cash crops, therefore, Taungya system of forest plantation would be a good for the local people. In addition, forest plantation in Laos would be better selected for right species which are suitable growing well in the Laos geographical conditions, and as well as a stable price and both high demand from national and international markets in the future.

Status of technology in the country

The agro-forestry has been applied by Lao famers for years. The practices vary in degrees of intensity which ranges from just a simple to advanced or complicated silvicultural system with different crops and trees.

The Taungya, intercropping, home garden and living fences is also a common practice. The alternative agro-forestry systems that aim for improving plant nutrient management and soil erosion control such as contour hedgerows, alley cropping, and biologically enriched fallows are recently introduced (Hansen P.K and

Sodarak. H, 1996). The main practice are in the form of home gardens, rotational or intercropping systems, NTFP-plantations, improved fallow practices, fishpond systems and livestock grazing practices (Sodarak H et al, 2003). Some of the composition or systems are as described below.

Taungya system, in Lao, has established growing mixed with others term agricultural crops, such maze, chilli, banana and some fruits tree species (Table 1). This system has been practised mainly by private households with small scale areas. The system has also grown mainly with teak and rubber tree species in the northern and central parts of Laos.

Table 1: Teak intercropping plantation system in Laos(Rodew *et al.* 1995)

Teak intercropping with other crops	Percent of respondents (%)			
	Year 1	Year 2	Year 3	Year 4
Rice	52	20	5	-
Banana	5	5	-	-
Rice + Banana	4	5	-	3
Sugar cane	7	16	18	-
Banana + sugar cane	4	5	5	-
Pineapple	3	2	2	-
Fruit trees	2	2	2	3
Other annual crops	9	5	5	-
No inter crop	14	43	63	93

Another form is teak-based rice and paper mulberry cultivation. Most plantation teak intercropping in Laos is conducted in a space of 3 x 3 m. When planting with rice, teak trees are planted one–two months after planting the rice crop. The field preparations for the rice provide a good environment for teak but competition from rice can reduce teak growth rate in the first year. The intercropping system reduces labour required for field preparation as well as weed management. The system also provides extra benefits from short term crop products for farmers and also provides a good opportunity to add more value in the same area (Rodew *et al.* 1995). In contrast, Sihaphon (2007) outlined claims that there is no significant difference between the growth rate of pure plantation teak and plantation mixed with paper mulberry (*BrussonentiapapyriferaVant*). Details of the study are shown in Table 2.

Table 2: Pure teak and mixed growth rates in Laos after 6 months (Sihaphon (2007)

Plot	Number of trees		Diameter (cm)		Height (cm)	
	Teak + paper mulberry	Teak	Teak + paper mulberry	Teak	Teak + paper mulberry	Teak
1	23	62	0.87	0.68	37.21	30.77
2	32	53	0.62	0.47	40.09	29.30
3	34	58	0.55	0.85	25.88	42.17
4	31	57	0.66	0.55	28.32	28.07
Average:			0.68	0.66	32.87	32.58

Home garden usually mix up of fruit trees such as mango, papaya, banana, citrus, jackfruit, plum, peace, pear, and crops such as sugar cane, eggplants, chilli, cabbage, beans and pineapples. Intercropping includes intercropping among job's tears, paper mulberry, rice, maize, pineapple. Sometime cassava, sesame, banana, chilli and also tree and orchard are planted in proximity. Living fence includes trees and crops such as jastropha, eucalyptus, bamboo, cassava and banana in proximity.

However, in general, the majority is small scales; data on the composition, economic return and environmental and social benefits from each system including good practice is limited and or unclear.

Benefits to Economic development

The economic benefit of the agro-forestry includes:

- Maximizing use of the land and land-use efficiency;
- The productivity of the land can be enhanced as the trees provide forage, firewood and other organic materials that are recycled and used as natural fertilizers;
- Increased yields. For example, millet and sorghum may increase their yields by 50 to 100 per cent when planted directly under Acacia albida (FAO, 1991);
- Promotes year-round and long-term production;
- Employment creation – longer production periods require year-round use of labour;
- Reduce needs for purchased inputs such as fertilizers as nutrient can be maintained by legume; crop diversity, rotation and residues.

Benefits to Social development

Qualitatively social benefits of the agro-forestry can be summarized as following

- Agro-forestry promotes year-round and long-term production.
- Employment creation – longer production periods require year-round use of labour.
- Livelihood diversification.
- Provides construction materials and cheaper and more accessible fuelwood

Benefits to Environment development

Qualitatively environmental benefits of the agro-forestry can be summarized as following; • Protection and improvement of soils (especially when legumes are included) and of water sources. • Conservation of natives species and biodiversity • Can be a good production system for carbon sequestration
Climate change mitigation potential
As for Laos, the actual potential of the agro-forestry have not been explored. However, refers to study elsewhere, agroforestry can play be a key carbon sequestrator (Sharrow and Ismail 2004; Kirby and Potvin 2007; Nair et al. 2009) and it is also perceived applicable to Laos.
Financial requirements and costs
The financial requirement for investment in the agro-forestry though the country is unclear for Laos. This is due to lack of data on the area and agro-forestry system to be promoted including estimate of investment cost. The forestry strategy to the year 2020 of the Lao PDR (MAF, 2005) merely stated that the agro-forestry is the high priority under plantation development and Non-timber forestry product (NTFP) management and required technical and financial support. While an agro-forestry project namely development of agro-forestry for watershed protection and erosion reduction in steep hill with total cost of USD 1.9 million is proposed under National Adaptation Programme of Action (2009). However, compare to an agro-forestry project proposed elsewhere, the proposed agro-forestry under NAPA of Laos is relatively low. An agro-forestry (Silviculture) namely "healthy and well-managed forest plantation" that proposed under NAPA of Eritrea expected that total cost of over US$$5 million, a five-year project included in the NAPA of Senegal aimed at promoting agro-forestry at total budget of US$ 258,000 for establishing community nurseries, plant growing, installation of plantations and rejuvenation of regional forests (UNFCC, 2008a).

3.

Technology Name:	**Optimal Forest Plantation**
Introduction	
Optimal forest plantation is not yet welled defined and assessed or lack of information. So instead of assessment and describes such optimal forest plantation system, this factsheet provided information on forest plantation in general as a mean for further exploration of optimal forest plantation. Forest plantation is a form forest development which, in principle, is defined or designed to preserve and to develop forest resources in order to supply timber and other forest products in a sustainable manner including preserve water resources, soil, aquatic life, wildlife and ecosystem. The development of the plantation is usually follow the following principle: 1) Survey the situation of reproductive conditions of trees species in the forest area that would be planting; 2) Demarcate the area by marking boundary with signs;	

3) Select tree species suitable for the forest area;
4) Formulate forest plantation plans or projects. The project is required for registration so that source of the products can be checked, leading to ease of commercialization and transportation of the products;
5) 5. Implement the project, management and maintenance;

Technology characteristics

Forest plantation in Laos uses both agro-forestry or integrated (Taungya) and mono plantations systems. However, describe below is mainly on the mono plantation.

The mono forest plantation system means forest plantation for purely species (one species only at an area). This model has been implemented mainly by companies and international plantation investors with a larger scale area. This system has conducted frequently with Eucalyptus and eagle wood species, which are based in the central and Southern parts of Laos.

The spacing of forest plantations depends upon rotation, for a long or short rotation and mono or integrated planting. Generally, for a long term harvesting and integrated planting purposes, tree is grown more widely spaced. Furthermore, the spacing for forest plantation is highly depended on tree species; some trees species prefer wider space for its growing for example rubber tree. On the other hand, some tree species prefer narrower space for its higher growth and as well as reducing for its branches, for instance teak and eucalyptus tree species. However establishing tree plantations in Laos, 2x2, 2.5x2.5, 2x3, 3x3 and 3 x 7 m are usually practiced in Laos (Phimmavong 2004). The planting hole is dug in advance at 30-45 square width and depth, which is sufficient to allow addition of manure or organic matter for the trees, especially for teak and eucalyptus tree species. It would bigger hole for rubber tree. The best time to plant trees in Laos is at the beginning of wet season at the end of May (Laos). The optimum tree seedling for planting is around 30-50 cm in height which takes at least three months growing at a nursery. The number of seeding depends on the spacing of plantation. For example, teak planting at different spacing: 2 x 2 m (2500 trees/hectare), 2.5 x 2.5 m (1600 trees/hectare) and 3 x 3 m (1111 trees/hectare). Spacing does not appear to be related to tree properties, productivity and is dependent upon the number of seedlings and the land area available. There is no scientific documentation for the best spacing of plantation teak (MAF 2001)(Ministry of Agriculture and Forestry and Department of Forestry 2001).

Forest plantation thinning and pruning are technical terms which are very important factors for a faster growth rate of tree as well as wood quality. The purpose of thinning and pruning is to reduce the number of trees planted in an area, increase dimensional growth rate (diameter and height) and straightness and improve wood quality. In theory, wider space planting allows greater light for trees and allows trees to grow much faster. However, tree stems are not straight and not as high as trees from narrower plantings. Thinning and pruning also aims to eliminate defective or infected trees from an area and is commonly practiced as a form of plantation management. There are different global practices in terms of plantation tree age. The practices depend upon the factors of tree growth rate, rotation harvest plan and market use for the thinning trees. Generally, the first thinning should be conducted when trees are four-five years old or when their canopy becomes dense. It is recommended to apply a low thinning method and selection cutting system by cutting deformed trees and leaving vigorous well formed trees. Further thinning is carried out when the tree crowns in the stand start to touch each other (Chadiphith 2006).

In Laos, over 80% of forest growers do not thin and prune their own tree plantation (Ministry of Agriculture and Forestry and Department of Forestry 2001).The main reasons for this may be that the farmers have small areas of trees and therefore need to keep all the trees, there is no market for their thinned trees and/or there is a lack of scientific data available to the farmers describing the advantages of thinning and pruning. In contrast, some Lao farmers have conducted teak thinning at different tree ages (4-15 years, 1-3 times). There is no market for small trees from thinning at four-seven years. Therefore, it is preferred to thin plantation teak after 14-15 years. Cut trees can be used and sold for other purposes (fuel wood and materials for new house building), however late thinning will affect tree growth as well as quality (Ministry of Agriculture and Forestry and Department of Forestry 2001).

Two thinning systems exist, mechanical thinning (cutting in system) and selection thinning. The selected cut is the defective tree, the trees too close to others and sometimes the smallest or biggest trees. In system thinning sees whole lines of trees cut to increase spacing for the remaining trees. Theoretically, plantation trees can be thinned up to two-three times (depending upon the rotation purposes). The percentage of thinning trees varies between 25% and 60% (Midgley *et al.* 2007).

Recent research in Laos by Kham An (2010) investigated the average productivity per tree in plantation teak aged 15 years and grown with three different thinning models (selection, mechanical and non-thinning systems). Results are presented in Figure 1.

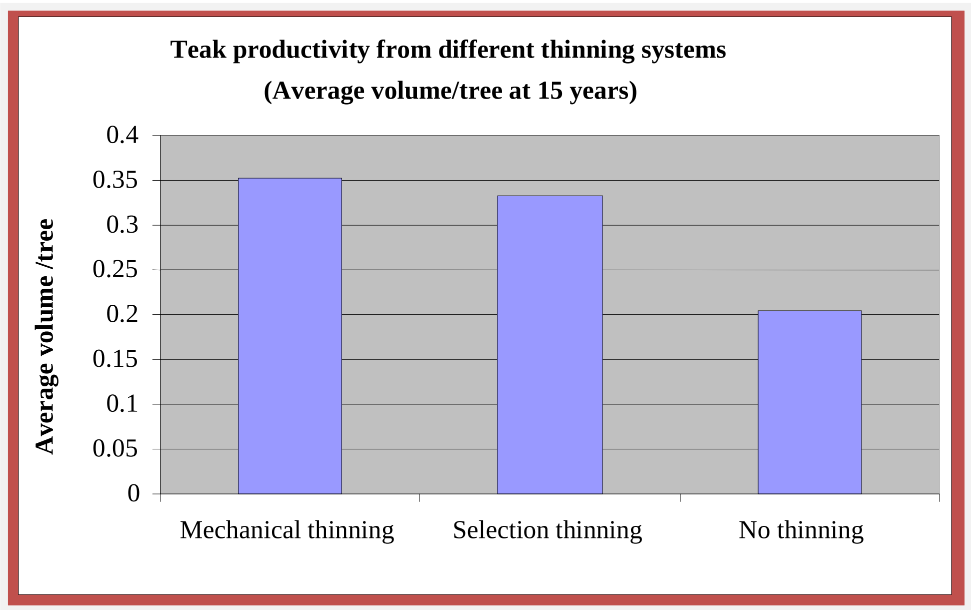


Figure 1: Teak plantation productivity with different thinning systems (Kham An 2010)

Plantation spacing is the most important factor for controlling the number, size and distribution of branches and knots in plantation trees. Wide spacing is favorable for the appearance of more knots and branches (Ngueho 2005).
Potential application in the country
Plantation is anticipated to be a fast growing of forest sub-sector due to policy supports, wood demand and also potential area for the plantation. Plantation forests have become a priority development since the government realized that the total forest area had decreased dramatically from 70% to 41.5%(MAF 2005). Tree planting has therefore been strongly supported by the government (in 1980 the government set up a national tree planting day on June 1 and each year several tree seedlings are provided to provincial and district offices, farmers and private sectors to grow trees nationwide). Furthermore, the Lao government has several incentives supporting plantation forest such as exempting land taxes and fees, supporting loading credit and gaining rights of land use over 35 years for plantation forest investment (MAF 2001). Recently the Lao government has a target to rehabilitate forests or increase forest plantation up to 500,000 ha by 2020 (MAF 2005), increased from 223 000 ha of plantation (FAO 2006). The demand for wood for both domestic use and export is increasing (MAF, 2005) is one the driver for future development of plantation. In addition, availability of land such as large degraded forest, forest land and bare forest area also indicates a potential for the plantation. However, the development of the plantation is required for a careful planning and approval or optimal plantation is required as previous land concession and expansion of the plantation was criticised by various stakeholders (Phimmavong. S, Ozarska. B, Midgley. S and KEENAN. R 2009 and Voladet. S 2009). Furthermore, Laos needs a vision to guide the sustainable forest plantation; and also improvement of legal, administrative procedures, management standards, human resources, community participation, research and information, marketing and financial support (Midgley, 2006).
Status of technology in the country
Forest plantation in Laos has started for over 90 years. Rubber tree (*Hevenbrasiliensis*) and teak (*Tectonagrandis*), which have been grown in Laos in the early 1900s, were introduced by French colonialists. Eucalyptus species were brought to Laos in the late 1960s (Phimmavong 2012). The forest plantation during 1900s and 1990s were conducted on a small scale, mainly for experimental purposes. However, presently there has been increasing investment in plantation by many sectors: private, national and multi-national companies. There have been three main tree planting booms in Laos since 1993. The first occurred in mid 1993 and consisted mainly of teak planting by small farmers in the northern part of Laos. The second took place in 2000, consisting predominantly of *Eucalyptus (globules* and *cladocalyx)* planting (led by an Asian Development Bank loan project), and took place mainly in the southern and central parts of the country. At present, tree planting includes many species (rubber "*Heveabrasiliensi*", eaglewood "*Aquilaria*" and teak) which are used in a variety of sectors including international, national and private sectors as well as local farmer investment (Table 1). The total estimate of plantation forest in Laos is over 146,600 ha, mainly grown in the middle part of the country (MAF 2006). However, the figure of Laos natural forest and plantation areas were updated by

FAO (2010) that total forest area in Laos is 16. 14 million ha, comprising of natural forest 14.43 million ha and 223,000 ha of plantation.

Table 1: Industrial plantation species of Laos (Midgley*et al*. 2007)

No	Tree species	Area (ha)	Main site growth
1	Teak (*Tectonagrandis*)	15,000	Mainly in Luangprabang Province (98% belongs to farmers and small private sectors)
2	Rubber (*Heveabrasiliensis*)	12,000	Every part of the country (farmers, private sectors and Chinese investors)
3	Eagle wood (*Aquilaria*)	-	Mainly grown in the middle part (Vientiane, Bolikhamxay Provinces) involving farmers and private sectors.
4	*Eucalyptus globules* (blue gum)and *Eucalyptus cladocalyx* (sugar gum)	100,000 (expected to 2012)	Central and southern parts, involving mostly foreign investors.

Benefits to Economic development

Plantation forest development has high potential, contributes to the national economy and is an important source of labour in Laos, especially in rural areas (Phimmavong *et al.* 2009). The cost of plantation establishment consists of labour for planting, seedlings, fertilization, weeding and many others. These are the predominant source of income for rural workers in Laos. SomvangPimmavong (2004) reports that the gross revenue for timber sale of Eucalyptus tree plantation of a rotation of 7 years plantation bringing a net benefit of 6,531,202 Kip per hectare for the company, which is equivalently US$628 (Table 4). Midgley et al (2007) notes that in Luangprabang Province, it is about 15% of annual local household income was derived from the timber sale of teak plantation. And the research also concludes that in the villages, teak wood production was the second most important agricultural source of income, which ahead of livestock (Figure 4).

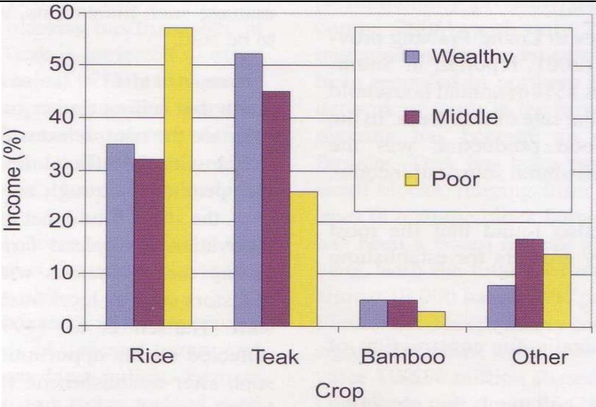


Table 5: Cost structure of Eucalyptus plantation in Laos

Catalogues	Costs (Kip/ha)	Revenues (Kip/ha)
Net benefits (timber sale at 7 years)		6,531,202 ($628)
Clearing of ground (degraded forest)	2,236,000	
Wage to farmers: planting, fertilization, fencing and fire brake	1,424,320	
Wage for farmers: Weeding	300,000	
Annual costs (Kip/year)	173,056	
Other extra costs	1,554,535	
Capital (interest =7%/year)	10,321	
Land tax (net revenue*15%)	440,231	
Income tax (net revenue*20%)	586,975	
Sum	6,725,438 ($646.67)	

Source from (Phimmavong 2004)

Benefits to Social development

Economic aspect of forest plantation

The cost of forest plantations depend on several factors such as topography, soil type and remoteness of the area, as well as labour costs, plantation technology and the intensity of management and rotation of management. Furthermore, cost of forest plantation also depends on the spacing for growing per hectare. Midgley*et al.* (2007)reported that the cost of a teak plantation in Laos was estimated between US$1000-1500 per one ha of three year old plantation. However, a research conducted by SomvangPhimmavong (2004) confirmed that the cost of Eucalyptus plantation in the Southern part of Laos is about US$ 671.50 per one ha for the first year planting. This cost not includes for the land cost (Table 5).

Table 5: Cost structure of Eucalyptus plantation in Laos

No	Practices	Year 0	Year1	Year2	Year3	Year4	Year5	Year6	Year7
1	Land	266.50							
2	Fire break	50.00							
3	Road	15.00							
4	Seedling	100.00							
5	Planting	80.00							
6	Fertilizer	110.00							
7	Weeding		100	100	50	50	0	0	0
7	Fencing	30							
8	Other costs	20	20	20	20	20	20	20	20
Sum Total cost:		**671.50**	**120**	**120**	**70**	**70**	**20**	**20**	**20**

Resource: Modified from Somvang Phimmavong (2004)

In contrast, the cost of tree plantations in regional countries, the cost teak plantation in Costa Rica with 3 x 3 m spacing without genetically improved seedlings is $US1052 and with genetically improved seedlings is $US1150, calculated as the average per year for the first five years (Ball *et al.* 1999). The cost of a teak plantation in Indonesia, based upon seed planting spaced 3 x 1 m and 3 x 2 m, with about 25% lose replacement in the first and second years, is $US1400 per ha (Ball *et al.* 1999). In northern Australia, the investment cost of a teak plantation is US$1 6000/ha (1000 trees) with rotation at 20 years and a growth rate of around 14 m^3/ha/year (ITC professional tree farming 2006). In Vietnam, the estimated cost of tree plantation is about US$539.38 per ha, however, this cost not includes the cost of fertilizer transportation and seedling (Phimmavong 2004)

Benefits to Environment development

The forest plantation not just benefits for local people social-economics for poverty reduction in the rural area, but it also improve for environmental issues development in terms of climate change, water resource and stocking for quantities of carbon in the atmosphere. According to the report of MAF (2011) states that forest plantation at degraded forest areas as an integral part of rural livelihood improvement. About 40% of the 3.1 million ha of Production Forest Areas is badly degraded, but has sufficient stock, which with protection and management, will re-grow and sequester substantial quantities of carbon. Other areas of Production Forests and parts of Watershed Protection and Conservation Forest Areas are too degraded to regenerate naturally and require substantial investment for enrichment planting or re-stocking (Ministry of Agriculture and Forestry (MAF) and Department of Forestry 2011). Both forest plantation and natural forests are bringing to bear on the core objective of ‘reduced greenhouse gas (GHG) emissions from deforestation and forest degradation, which can be brought about by sustainable management of forests and conservation and enhancement of forest carbon stocks’. Attainment of the core objective has become a global concern in view of the effect of increased GHG concentration in the atmosphere on global warming and climate change. Nevertheless, global efforts to

reduce GHG emissions must continue, since vulnerable populations are already facing severe consequences from changing climate and impacts may multiply and impact social, environmental and economic systems that sustain global populations if global temperatures were to exceed 2^{o}C and approach 5^{o}C above pre-industrial levels.
Climate change mitigation potential
The forest plantation plays important roles for climate change mitigation or carbon sequestration. The increase of forest plantation could increase the carbon sequestration. Based in the 2nd greenhouse inventory for the year 2000 for SNC, plantation is one of two sources of carbon sink and if the 500,000ha of forest plantation is realized as targeted (MAF, 2005), the carbon uptake by forest plantation would be about 3,625kt or 13,292 Gg of CO_2 by 2020 (MONRE, 2012). However, carbon offset depends on the area, forest plantation planning and management schemes or techniques and also existing land use where the plantation is located. This means good planning and effective plantation development would increase the carbon uptake or otherwise.

4.

Technology Name:	**Sustainable Community Forest Management (SCFM)**
Introduction	
Lao People's Democratic Republic (Lao PDR) or Laos is a landlocked country, located in the central heart of the Southeast Asia with a total land area of 236,800 square kilometres. About 80% of the total population usually live in the rural areas and depend heavily on forests for their basic needs, such as firewood, timber, fodder and pasture, foods medicines, water for drinking and irrigations. Natural forest management and use are recognized that local forest villagers can also be the resource managers as they live near by the resources and they will have more relationship forests in terms of benefits and participation forest management. Generally, there are many different definitions of community based forest management by different researchers across the world, one definition given Khamphay Minivong and Sophathilath (2007) is commonly used, which states that community based forest management is the basic of community forest science at local levels, as well as it would be an initiative of sustainable community forest management. When talking about sustainable community forest management, it would be discussed for the relationship between people and natural resources for both biodiversity conservation and sustainable livelihoods. Sustainable Community Forest Management is under a detailed plan developed and agreed to by local communities playing a central with all concerned stakeholders to develop the natural forest products to meet with the present needs without compromising the ability of future generations to meet their own needs (Maureen H. McDonough *et al.* 2002). The approach of community based, which is the communities	

managing the resources, have the legal rights, the local institutions, and the economic incentives to take substantial responsibility for sustained use of these resources. Under natural resource management plans, communities become the primary implementers, assisted and monitored by technical services (European union project *et al.* 2004). Others definition a Community Forest is "any area of Government Reserved Forest designated for management by a local community". Community Forestry is therefore the control and management of a forest by local forest users as part of their livelihoods system.

Sustainable Community Forest Management (SCFM) is very important for the natural resources management, biodiversity conservation and securing the livelihood of stakeholders, including poor and ethnic minority groups. This is because forests are mainly used for households of local groups, who live nearby forest. They depend mainly for the natural forest for their livelihood development, medicine, construction and income; therefore, it is necessary to involve local community in the process of natural forest management and sustainable in use.

Technology characteristics

There are many different characteristics of sustainable community forest management (SCFM) based on the styles and tools of participation process and management planning as well as the scale-site and ownership of the site. There is a case study in Philippines classified the SCFM in three categories based upon the basic of managements (Lucreciao L. Rebugio *et al.* 2010). 1). Self-initiated sites: this kind of category consists of indigenous management systems predating any SCFM interventions in the area. It means that this type of SCFM is developed privately at household level with any local government and stakeholder involvement in the process. 2). locally assisted site: This covers site-specific SCFM initiatives in which the development of SCFM efforts could be largely attributed to partnership with external entities, sponsors or facilitators in the process. 3). National programs: This category included all the SCFM sites under the nine national programs of the national level of SCFM development program.

In Laos, the sustainable community forest management is classified for 7 levels of participations based on the process of SCFM planning and management (Khamphay Minivong and Sophathilath 2007): 1). passive participation, 2). participation in information giving, 3). participation by consultation, 4). participation for material incentives, 5). functional participation, 6). interactive participation and 7). Self - mobilization.

In Thailand, the characteristics of SCFM are defined by different local community forest and the local ethnic minority of the region, Table 1:

Region	Characteristics
North	The area is largely mountainous and inhabited by various ethnic minorities. Most community forests in the North are original forests and managed through traditional beliefs and cultures.

Northeast	Villagers conserve patches of forest at the edge of their cultivated fields to provide source of food and medical plants
West	This area is inhabited mostly by the Karen, who have a long tradition of forest care
East	Most community forests are mangroves. They were set up when forest degradation through commercial logging activities and farming
Central Plain	The region, the community forest are managed based on traditional belief
South	The community forest in this region is conserved of original forest trees, left growing intermixed with cultivated practicing at the family level.

Source: (Sritanatorn 2009)

Potential application in the country

According to the previous practiced, achievements, lessons-learned and as well as some experiences shared from others neighboring countries, we can recognize that there are many reasons potential application for SCFM in Laos, such as lesser of cost for forest management and silviculture options, enhancing not just only forest products, but included of plant diversity in the area, a clear of forestry law, regulation supporting from the government, and final potential application of SCFM is the Lao local people, who have already the background and traditional knowledge of natural forest management.

Cost for forest management and enhancing plant diversity in the area

One of the most important reasons for application SCFM in the country is to reduce forest restoration costs. As many practices at the past, the costs of SCFM activities are much lower than forest plantation. It is only application for SCFM in the country to expedite ("speed up") forest restoration based on the governmental restoration forest 70 % in 2020. SCFM takes advantage of wild seedlings already growing in an area. Root systems of these seedlings are already in place. Therefore, the trees can grow rapidly when the area is managed competition is removed or reduced by silvicutural practices of SCFM in the villages. A third important reason for applying SCFM is to enhance plant diversity. Naturally-regenerated vegetation will almost always comprise a mixture of species. Therefore, SCFM produces a more diverse and multi-layered vegetative cover than plantation reforestation. This diversity helps ensure environmental stability and is very desirable in areas intended for watersheds (pagasa 2010).

Potential applicability for SCFM based on law and regulation supporting

Sustainable community forest management (SCFM) is based upon the activity of land use planning and land allocation (LUP) in villages. In most villages where LUP is completed, additional rules and obligations on the utilization of land, including forest resources are agreed upon in land use agreement between the district and the village authorities is formed. In most cases, the participation SCFM regulation for natural forest resource management and sustainable use are already formed based on the general forestry law and regulation for the Lao PDR. Community involvement in sustainable forest management has been recognized and strongly encouraged by the Government of Lao PDR since the first National Forestry Conference in 1989, emphasizing that the maintenance of healthy and productive forests is central to the rural livelihoods and reduction poverty. This is in order to: (i) to preserve, improve, and increase biological capacity of the existing forests by improving existing systems of management and protection; (ii) to rationally use forests and associated\ resources to improve the country's economy and increase income for local poor; and (iii) to link forest rehabilitation, preservation and expansion with food security, commodity production and creation of permanent economic activities for upland populations. The policy directions were then backed up by the National Forestry Action Plan (NFAP) which was developed in 1990 and approved by GoL in 1991. In addition, a number of legal instruments were developed and promulgated to form a legal framework for the implementation of the programs identified in NFAP and support community participation in forest management. The most relevant of these instruments regarding community participation, include the Council of Minister's Decree No. 117 (1989); Prime Minister's Decree No. 169 (1993); Prime Minister's Decree No. 186 (1994); and the Forestry Law (1996). Provisions of these legal instruments were interpreted into a number of ministerial instructions, orders, and guidelines (Khamphay Minivong and Sophathilath 2007).

Potential application based on Lao traditional natural forest management

Basically Lao people formerly have a good system of traditional ownership of the land and forest resources within each village boundaries. The government legally recognizes using rights for local people based on their traditions within the village boundary. Village authorities have the right and duty to form local rules for specific traditions and customary use of the natural forest resources, and as well as to regulate land use in the village boundary. However, the past practices of natural forest use and management was implemented individually or house based, without a proper sustainable plan management and use for CBFM, as well as lacking of collaboration external sectors to support in terms of forest management techniques. However, after getting experiences from the previous practices, it has been realized that SCFM has a great potential in the future for the government to continue supporting this kind of activity for three main potential reasons, 1). Local villagers, who live closer in the forest and they should have the right to sustainable use and management their own forest, 2). The local people should more involve in the process of SCFM and have rights to share for the forest management benefits, such as fuel wood, wood for house construction and income from Non-timber forest products, etc. The use of those village forests was based on villager's decisions. Most forests were distinguished according to simple classifications, such as village production forest. In addition, the local people have already basic knowledge of traditional natural forest management, example village protection

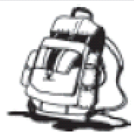
forest, village conservation forest (spirit forest) and Cemetery forest.
Status of technology in the country
During the last decade, the SCFM has been organized widely in Laos (northern, central and southern parts). However, the processes are involved mainly for international development organizations, supporting both fund and techniques. Lao-Swedish Forestry Program (LSFP) (1996-2001) was the first project of village forestry in the southern part of Laos. It tried to develop specific management plan for forests outside state production forests in one village from the technical guidance of RECOFTC, 1999. During the planning process, the assessment for forest management and use was conducted in a participatory way with the local villagers. The assessment identified villagers' problems, natural resource situation and potential development in the village. The community based forest management committee/group was formed, which facilitated by the DAFO, PAFO and LSFP consultants. However, the village forest management plan was not completed as the activities were developed toward the end of the project period. In the northern part of Laos, in Xayabouly province was also carried the activity of community based natural resource management by (FOMACOP, NAFRI-IUCN) during 2002-2004. The model focused of village land use type-wise management planning. Implementing was facilitated by outside consultants developing community natural resource management and related mechanisms and services in all aspects. The model also used participatory tool for the process of forest management plan and multiple forest resource use in sustainable ways in order to improve villagers' income and livelihoods (Khamphay Minivong and Sophathilath 2007. Unfortunately, a full testing of the model was terminated after the ending of the project in 2004. However, the model and methodology developed from the project was continued to use by CARE other projects. In Louangnamtha Province, northern part of Laos, there was another development project called (GTZ) or rural development in mountainous areas program also implemented of village forestry, Non-timber forest products (NTFP) and nature fish management two Districts, Sing and Nalae during 2004-2007. The approach was based on land use planning and land allocation (LUP/LA) as the starting point of community based natural resource management (CBNRM). The model development planning and process used both Participatory Rural Appraisal (PRA) and Rapid Rural appraisal (RRA) tools. The process implementing consisted of over 5 steps: 1) Village orientation for the concept of SCFM, community forestry group/committee group forming in the village, 2) Forest boundary delineation based on the land use planning and land allocation, implementing for forest inventory in the area, 3) Participation for sustainable forest management planning by the sustainable community forest management groups, facilitating from outside national and international consultants, 4) setting up participation rule and regulation in the community for SCFM harvesting and use proving by the District of Agriculture and forest office, and 5) Participation SCFM evaluation and monitoring (Bounnyong Thongmalay and Phongxiong Wanneng 2007).

Benefits to Economic development

Under the CBFM program, socio-economic improvement was realised through provision of temporary employment and additional income, but to a limited number of participants. In a number of cases, these benefits were not sustained after the project completion. One of the challenges for CBFM, therefore, is to sustain and spread the benefits to a greater number of poor people in the forest communities. There is a need to further develop viable and resilient enterprise and other economic opportunities, particularly for forest-dependent communities

Benefits of Community Based Tourism

Development Area	Potential Development Benefits
Economic	Sustainable and independent source of funds for community development Creates employment in tourism Increases household income Embeds development in local culture
Educational	Promotes the acquisition of new job skills Creates new professions in the village Imparts and encourages use of new knowledge in the village Cross-fertilisation of ideas with other cultures - promotes respect Fosters and promotes respect for local knowledge and skills
Social	Raises quality of life Promotes gender and age equality Builds capacity for community management organizations Fosters cultural exchange
Health	Promotes good hygiene Increase in and diversification of food production for tourists will improve nutritional status
Environmental	Promotes environmental responsibility Raises awareness of the need for conservation for tourists & villagers Promotes management of waste disposal



(Source: Khamphay Minivong and Sophathilath 2007)

Climate change mitigation potential

During the early 1990s, Laos has been reformed for policy and regulation for implementing of land use planning and land allocation, which recognized the rights accessing to local people to gain benefits and manage the natural resources, where they live nearby in sustainable ways (Khamphay Minivong and Sophathilath 2007). Over the last decade, Laos has implemented for sustainable community forest management, which was supported mainly from international organizations (development projects) and the local governmental organizations, especially District of Agriculture and Forest Office (DAFO), Provincial

Agriculture and Forest Office (PAFO). A case study of SCFM, which practiced by Rural Development in Mountainous Areas Programme (GTZ) in Lounagnamtha Province, Northern part of Laos, implemented for the SCFM in five main stages: 1) Village orientation for the concept of SCFM, community forestry group/committee group forming in the village, 2) Forest boundary delineation based on the land use planning and land allocation, implementing for forest inventory in the area, 3) Participation for sustainable forest management planning by the sustainable community forest management groups, facilitating from outside national and international consultants, 4) setting up participation rule and regulation in the community for SCFM harvesting and use proving by the District of Agriculture and forest office, and 5) Participation SCFM evaluation and monitoring (Bounnyong Thongmalay and Phongxiong Wanneng 2007).

Agriculture Sector:

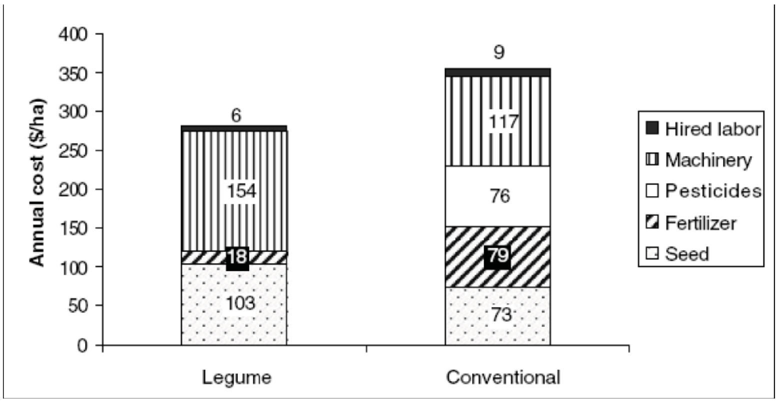
1.

Technology Name:	**Organic Farming**
Introduction	
Organic farming is an agriculture system which excludes the use of synthetic fertilisers, pesticides and growth regulators. Instead it promotes the use of crop rotations, green manures, compost, biological pest control and mechanical cultivation for weed control.	
Technology characteristics	
As mentioned, the organic farming practice involves with restriction of artificial fertilisers and pesticides use while it promotes the use of crop rotations with crop variety and legumes, cover cropping, reduced tillage, green manures and compost, biological pest control, and mechanical cultivation for weed control for enhancement of productivity. In Laos, the organic can be broadly divided into two aspects; organic farming by default and certified system. The organic farming by default refers to the traditional organic farming practices that have Lao farmers have been applied for long but it is not officially or formally certified. The certified organic farming system is the agriculture practices that meet the organic farming standard and good agriculture practice defined by Lao Certificate Body (a third and autonomous organization).	
Country specific applicability and potential	

The specific applicability and potential of the organic farming in Laos are indicated in term of policies support, local skills/awareness and geographical strength. The national socioeconomic development plan 2011- 2015 recognises the importance of organic farming and products as a unique product and promotes organic farming and products for domestic consumption and exportation. The strategy for agriculture development 2011-2020 recognises organic agriculture or farming as a promising agriculture practice. The certified organic farming is a value-added and accessible by the poor and can contribute to meet MDG goals. National growth and poverty eradication strategy (2003) also considered organic farming as a means for income generation and poverty reduction. Strategy on climate change of the Lao PDR (2009) promotes organic farming as a means for GHG mitigation and soil conservation. Environment strategy to the year 2020 considered the organic farming as environmentally friendly practice and expected to employ organic farming as a means for soil and water conservation or sustainable practice. Tourism strategy pointed out the linkage between organic farming and ecotourism as well as seeing the organic farming as a tourism attraction. These integration and promotion of the organic farming in these strategies and plans indicated the potential of the organic farming. As mentioned, Lao famers have been practiced organic agriculture for decades although it is not formally certified. The involvement of organic farming practice could mean that Lao farmers have knowledge and skills or familiar with such practice and this is a strength indicating the potential of the organic farming to be grown. In addition, availability of large land area and diverse geography and climate of Laos is another indicator of the potential. Similarly, base on the survey of the stakeholders by Helvetas 2003, they perceived that there is potential for organic farming in Laos because of growing market and demand for organic products, favourable production conditions, experience in organic farming and existing products such as fruits, vegetables, mulberry tea, rice, coffee and cotton.
Status of technology in the country
Four different systems for organic production are common. 1) The upland fallow rotation (slash-and-burn) system the production is largely used for producing rice for home consumption, with job's tear, sesame and maize the most important crops exported. Although not formally certified, they are often referred to as "organically grown".; 2) Wild products collected in the forest and fallow lands for home consumption, local markets and for exports. Important products include bamboo shoot, banana inflorescence, and wild cardamom (Amomum sp); 3) Fruits, mostly produced without any external inputs, and 4) Market driven organic production. The systems 1-3 are largely "organic by default" but products are usually not certified as "organic".
Benefits to Economic development
The economic benefits of organic farming include low energy and cost of investment. Research finding by Kimble et al. (2007) and also cited in UNEP (2010) indicated that the organic agriculture requires less energy

than conventional systems about 28% to 32%. Input costs for seed, fertiliser, pesticides, machinery, and hired labor for example in a rotation system with a leguminous crops are also approximately 20% lower than conventional rotation system does. Figure 6.2 is a comparison input cost between organic farming using rotation system with legume and conventional one. ,

Figure 6.2 Annual input costs for the legume and conventional grain rotations.



Source: Kimble et al., 2007

Furthermore, an example of UK's case, if all agriculture were organic, the elimination of nitrogen fertilisers would save substantial emissions or 1.5% of national energy consumption and 1% of national greenhouse gas emissions would be saved (Mae-Wan and Ching, 2008). Earlier studies showed that GHG emissions would be 48-66% lower per hectare in organic farming systems in Europe. The lower emissions were attributed to zero in put of chemical N fertilisers, less use of high energy consuming feed stock, low input of P (phosphorus)and K (potassium) mineral fertilisers, and elimination of pesticides. However, it requires careful design and implementation as in some areas that productivity could be lower.

Benefits to Social development

1) Provides income and employment opportunities for Lao farmers due to it is a labor intensive production system and implementable by local/farmers. In addition, organic products can be a unique, competitive and advantageous product for export for Lao farmers compare to other products.
2) Low risk on health due to restriction of chemical pesticide and herbicide while promote healthy consumption.

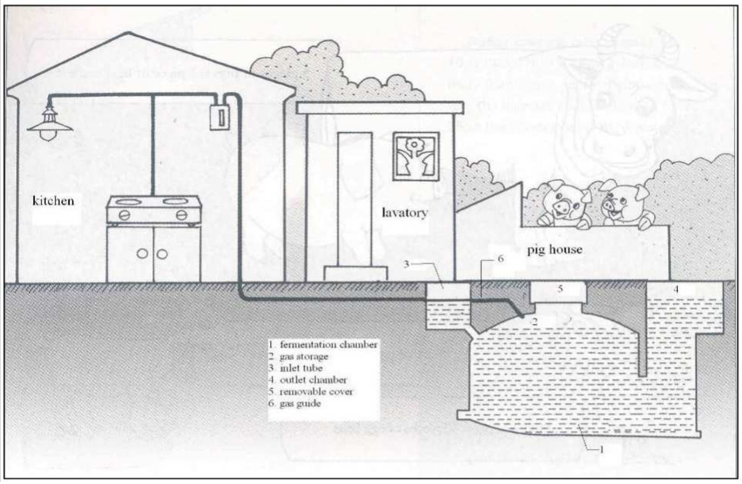
Benefits to Environment development

1) Improve soil organic matter, fertility and N supply due to application of manure, leguminous crops, crop residues and cover crops; leading to enhancement of soil C retention, sequestration of CO2 into

soils while eliminating fossil fuel used to manufacture N fertilizer elsewhere. 2) Highly adaptive to climate change due to the application of traditional skills and high degree of crop diversity. 3) Reduces pollution due to the absence of pesticides and chemical fertilisers.
Climate change mitigation potential
As mentioned above, the annual sequestration rate increases up to 3.2tonnes of CO^2/hectare per year by organic farming (Smith et al., 2007). However, if this practice applied worldwide emission reduction can be significant. Smith et al.(2008) estimated that annual global sequestration potential of organic agriculture amounts to 2.4-4Gt CO_2-e yr-1, and it can be improved to 6.5-11.7Gt CO_2e yr-1 by using new technologies in organic agriculture. On the other hand organic agriculture has lower methane and nitrous oxide emissions of 0.6-0.7Gt CO_2-e yr-1 in comparison to conventional agriculture, which includes the burning of crop residue (Smith et al., 2007).
Financial requirements and costs
Overall, promotion of organic farming requires substantial and continuous financial support as it can take time to realize or prove its sustainability. Of cause the financial requirement can be different from one to another system. However, quantifying financial requirement is challenges because of there are various forms of organic farming, time consuming and can be costly. It is same for Laos. To date financial needs for promoting organic farming through the country is lacking. In addition, it also lacks of basic data for financial projection such target of organic farming development for example the area, system and also timeframe.

2.

Technology Name:	**Manure-Based Biogas digesters**
Introduction	
Manure-based biogas digesters is animal manure treatment and fermentation system which includes fermentation tanks, manure input and fermentation via anaerobic environment. The methane concentration of biogas is around 60%, so the recovery and utilisation of biogas from digested slurry in a biogas digester will reduce CH_4 emissions from the manure. In addition, the biogas can be used to provide electricity, d energy and reduce CO_2 emissions from fossil fuel (coal) displaced by biogas.	
Technology characteristics	
A biogas digester is usually composed of six parts: fermentation chamber, gas storage, inlet tube, outlet chamber, removable or sealed cover, and a gas pipe line (see in Figure 1). **Figure 1Example of a schematic of 'Three in One' combination of household biogas digesters**	



The mechanics of biogas generation is similar to practice elsewhere which can be described as follows:

- The captured gas is stored in the upper part of the digester tank (gas storage area), which is constructed as an arc ship. The generation of biogas will gradually increase the pressure in the stored area. When the volume of the captured gas is larger than the amount consumed, the pressure in the gas storage will increase and slurry will be pushed into the outlet chamber. If the gas consumed exceeds gas availability, the slurry level drops and the fermented slurry flows back into fermentation chamber.
- The placement of the digester tank (underground fermentation) keeps the temperature in the tank relatively stable ensuring that the slurry can be fermented at adequate temperatures throughout the year without requiring additional heating.
- The bottom of the digester inclines from the material-feeding inlet to the material-outlet, allowing free flow of the slurry.
- The digester has been designed to allow the effluent to be removed without breaking the gas seal, taking the effluent liquid out through the outlet chamber. As pointed out in technology definition biogas fermentation is a process in which certain bacteria decompose organic matter to produce methane. In order to obtain normal biogas fermentation and a fairly high gas yield, it is necessary to ensure the basic conditions required by the methane bacteria are met for them to carry out normal vital activity (including growth, development, multiplication, catabolism etc.).

1) Strict anaerobic environment

Microbes that play a major role in biogas fermentation are all strict anaerobes. In an aerobic environment, the decomposition of organic matter produces CO_2, however, in an anaerobic environment, it results in CH4. A strict anaerobic environment is a vital factor in biogas fermentation. Therefore, it is essential to build a well-sealed, air-tight biogas digester (anaerobic digester) to ensure a strictly anaerobic environment for artificial biogas production and effective storage of the gas to prevent leakage or escape.

2) Sufficient and suitable raw materials for fermentation

Sufficient raw materials for biogas fermentation constitute the material basis for biogas production. The nutrients that methane bacteria draw from the raw materials are carbon (in the form of carbohydrates),nitrogen (such as found in protein, nitrite, and ammonium), inorganic salts, etc. Carbon provides energy, and nitrogen is used in the formation of cells. Biogas bacteria require a suitable carbon-nitrogen ratio (C:N).The suitable carbon-nitrogen ratio for rural biogas digesters should be 25~30:1. The carbon-nitrogen ratio changes with different raw materials, and one must bear that fact in mind when choosing a mix of raw materials for the digester.

3) Appropriate dry matter concentration

The appropriate dry matter concentration in the raw materials for biogas fermentation in rural areas should be 7%~9%. Within this range, a low concentration of raw materials may be selected in summer, while in winter a higher value is preferred.

4) Appropriate fermentation temperature

Biogas fermentation rates depend greatly on the temperature of the fermenting liquid in the digester. Temperature directly affects the digestion rate of the raw materials and gas yield. Biogas fermentation takes place within a wide temperature range (XuZengfu, 1981). The higher the temperature, the quicker the digestion of the raw materials will be, and the gas production rate will also become higher. Based on real fermentation conditions, we have identified the following three temperature ranges for fermentation:

• High temperature fermentation: 47°C~55°C

• Medium temperature fermentation: 35°C ~38°C

• Normal temperature fermentation: ambient air temperature of the four seasons. Selecting the temperature range for bio-gas fermentation depends on the type, sources, and quantities of raw materials; the purposes and requirements of processing organic wastes; and their economic value. Most household biogas digesters are normal temperature fermentation.

5) Appropriate pH Value

The pH value of the fermenting liquid has an important impact on the biological activity of biogas bacteria. Normal biogas fermentation requires the pH value to be between 7 and 8. During the normal process ofbiogas fermentation in a rural digester, the pH value undergoes a naturally balanced process, in which it first drops from a high value to a low value, then rises again until it almost becomes a constant. This process is closely related to the dynamic balance of three periods of biogas fermentation. After feeding the biogas digester, the time that the pH value takes to reach its normal level depends on the temperature and the kinds and amounts of raw materials that are fed in.

Country specific applicability and potential

Status of technology in the country
Benefits to development
Economics and mitigation potential The economic and mitigation potential has not been analyzed and unclear for Lao context. However, according to the practices and findings elsewhere, biogas technology can reduce emissions is efficient if price ranges from US$12-40 per tCO_2e or suitable for mitigating GHG emissions if there are adequate manure inputs and price of approximately US$12 per tCO2-e (Wassmann and Pathak, 2007). Overall household biogas digester (8~15 m^3) costs between US$500-1,000 though depending on the digester size. It is estimated that an 8m3 household biogas tank can treat the manure from 4 to 6 pigs, yielding $385m^3$of biogas annually. It can save 847kg of coal based on the calculation of effective heat equivalent. According to the methodology recommended by IPCC in 2006, if a household biogas digester treats the manure of 4 pigs, it can reduce GHG of 1.5~5.0 tonnes CO_2e. **Increasing local incomes** It will reduce expenditures for household energy (fuel wood and electricity). It will also increase employment locally for skilled labor during installation, operation, and for the maintenance of biogas digesters. **Improving local environment and public health** It will replace traditional fuel wood-base cooking stoves. Indoor air pollution will be significantly reduced, thus reducing the incidence of respiratory diseases, eye ailments etc., caused by fuel wood burning. Also, through improved manure management, it will reduce ground and surface water contamination. It will also reduce spreading of zoonotic diseases and odor caused by animal manure. Biogas recovery can also diversify the sources of the rural energy supply reducing deforestation.
Climate change mitigation potential
As mentioned, biogas can substantially reduce CH4 emissions from manure management and CO2 emissions from energy consumption elsewhere. IPCC (2006) suggested that if a household biogas digester treats the manure of 4 pigs, it can reduce GHG of 1.5~5.0 tonnes $CO^{2-}e$. As for Laos case, MoNRE (2012) predicted that if this technology is applied for emissions reduction from 2015 to 2030 for 50 percent to 70 percent of total livestock which raised in farm system such as liquid, paddock and so on, where manure is used for methane recovery, and 30 percent to 50 percent of emissions can be reducible as estimate, the emissions reduction by 2030 will be 194.93 $GgCO_2e$ CH_4 or 12.18 $GgCO_2e$ CH_4 per annum on average.
Barriers
Similar to elsewhere, the development and dissemination of biogas digesters in Laos faced investment and

technical barriers.

1) Investment Barrier

With the cost of each household biogas digester (8~16 m3) ranges from US$500 to US$1,000 while most rural households have low disposable income and weak financial capacity, so it is difficult for making such a large investment. In addition, the household will continue to pay a biogas digester maintenance cost. By contrast, the current practice of deep-pit treatment method is by far considered the most attractive option for manure treatment given that it requires very limited additional investment and labor input.

2) Technical barrier

The biogas digesters have to be located in many cases in the remote rural areas, where farmers lack ready access to improved technologies and management methods. According to current experiences, the performance of some digesters is unstable, with varying levels of gas production. This is due to the lack of experience among the individual households, limited resources for biogas service support, and insufficient farmer training and maintenance. Expertise is required to ensure that the digesters function properly, so maintenance and management of biogas digesters require adequate support services and trained staff, which is not available in rural areas.

3.

Technology Name:	**Biomass combustion and co-firing for electricity and heat**
Introduction	
Biomass can be used to produce power and electrification especially in rural area. Several feedstock and conversion technology combinations are available to produce power and combined heat and power (CHP) from biomass. Two technological options involve burning biomass; standalone units and co-firing it with fossil fuels in standard thermal power plants.	
Technology characteristics	
What is practiced in Laos is stand alone biomass-based power plants for electricity production. It is a common technology that converts solid biomass fuels to energy through combustion. In the biomass-based power plants, electricity is produced by direct biomass combustion in a boiler and via a steam turbine or engine. It is reliable and low cost technology although electrical efficiency of the steam cycle is not high (IEA Bioenergy, 2009).	
Potential of application in the country	
The national strategies, policies, energy demand, availability biomass and existing practice can indicate potential of application of this technology in Laos.	

The long term strategy on renewable energy, strategy on climate change, agriculture development and forestry recognize that biomass is one of the potential sources of energy in future and defined promotion and development biomass is one of the priorities. In addition, the policy positioning Laos to be battery of ASEAN countries as well as increase demand for energy implies that Laos would use most energy sources or potential in order to realize the goal. Of which, biomass can be the source. Based on the estimate made by ministry of energy and mining (2010), biomass including agricultural residues-based energy has a potential of electricity production of 938 MW throughout the country. This also means there is great potential for biomass-based electricity to be developed compare to current situation which only 160 kW of electricity is be produced with the use rice husk. In addition, the policy on the promotion of foreign investment and growth of private sectors in Laos can also be opportunity for the development of this technology.
Status of technology in the country
The development of agricultural residues based power plant is in its nascent in Laos and lack of information. Only one pilot project which generates energy from rice husks, with a capacity of 160 kW was recorded (MEM, 2011). However, based on the estimate by ministry of energy and mining (2011), biomass including agricultural residues-based energy has a potential of electricity production of 938 MW throughout the country. And this technology is identified and promoted in the strategy on renewable energy development (MEM, 2011).
Benefits to Economic development
• Enhance energy security while reducing the dependence on fuel wood, coal and other energy sources. • Diversifying the industrial sector and enterprises; • Supporting rural electrification with all its developmental benefits.
Benefits to Social development
• Increased income and jobs in the agriculture and forestry sectors, which now supply part of the feedstock used in power and heat production (agricultural and forest residues) • Job creation in the industrial sector for designing, building and operating the plants. • Increasing inclusion in the economic system: well-organized farmers unions can gain access to energy markets.
Benefits to Environment development
• Reduced GHG emissions from the power sector. Many agricultural and forest residues can be assumed to be carbon neutral, which leads to significant attributable GHG emission reductions. • Reduced NOX and SOX emissions compared to coal combustion. NOx emissions can be further reduced by implementing primary and secondary emission reduction measures.
Climate change mitigation potential
The climate change mitigation potential includes reduction of GHGs from agricultural residues burning, left to

decay and direct input to soil. In addition, this technology also reduce energy consumption elsewhere especially coal, oil and fuel wood. MEM (2011) stated that there are huge amount of agro-forestry residues or wastes generated every year from agro-forestry production, such as rice straws/husk, sawdust, corn cobs which can produce and generate around 500 MTOE.
Financial requirements and costs
Although the renewable strategy is in place, but estimate of financial requirement is unclear. However, the practice in other country suggest that investment cost is about 3,500 Euro/kWe for a 5 MWe plant, but goes down to about 2,000 Euro/kWe for a 25 MWe plant. One example of sugar manufacturer in Kenya, which developed Co-generation agricultural residues power plant based on the conventional steam power cycle involving direct combustion of biomass (bagasse) in a boiler to raise steam to offset 1,295,914 tCO_{2e}under CDM in the period of 10 years required USD 20,000,000 for investment.

Annex 7: Picture of the workshops