Current status on research on environment and climate change in CLMV countries

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Introduction

Thailand Research Fund (TRF) has initiated a project to establish research collaboration between Thailand and neighboring countries i.e. Cambodia, Laos, Myanmar and Vietnam. The main objectives of this initiative is to establish academic data and information on priority areas of common interest such as food security, ecosystem, water resources and climate changes as well as to set up a research network at both individual and institutional levels to respond to the need of this region.

The first phase of collaboration involved organization of consultative meetings among researchers from Laos, Vietnam and Thailand to identify potential areas for initial collaborative research. It was agreed that "Threats to Food Security" will be one of the important emerging issues for the initial phase. It was further agreed that the research should be focus on sustainable agriculture and involve linkages between food production and economic, social, and environmental factors.

Main activity for this phase is to conduct review on existing knowledge in each country to identify gaps as well as identify detailed topics for in-depth research in the future. The review papers will be presented at a conference to be held in May 2009 in Bangkok.

The main objective of this paper is to review current status on research on environment and climate change in Cambodia. Laos, Myanmar and Vietnam (these countries will be referred to as CLMV countries) and to recommend framework policy for research and guideline on the establishment of network of researchers in CLMV countries and Thailand.

Background

CLMV countries are situated in the Southeast Asia Region, with the area of about 1.4 million km^2 and population of about 155 million (2008 est.). Cambodia, Laos and Myanmar have borders with Thailand while Vietnam is connected to Thailand via the Gulf of Thailand (see Figure 1). These countries are very important to Thailand in term of economic, political and environment.

Figure 1: Map of CLMV countries

According to Table 1, Myanmar is the largest country with a total area of 678,500 km^2, while Cambodia is the smallest with a total area of 181,040 $km^{2.}$. All CLMV countries have coastlines except Laos. Vietnam has the longest coastline of 3,440 km while Cambodia has only 444 km. Although Laos is a land-locked country, Laos is connected to the sea via the Mekong River. Vietnam has the highest population of about 87 millions in 2008 which is about 12 times more than population of Laos. Cambodia, Laos and Myanmar are among the poorest countries in Asia, with more than 30% of population below the poverty line. Majority of people live in the rural area and engage in subsistence agriculture.

	Cambodia	Laos	Myanmar	Vietnam
Total area (km^2)	181,040	236,800	678,500	329,560
Coastline(2008)	443 km	0 km	1,930 km	3,444 km
Population (2008)	14,241,640	6,677,534	47,758,180	86,116,560
Population growth rate (2008)[1]	1.752% (2008)	2.344% (2008)	0.8% (2008)	0.99% (2008)
Population below poverty line (%)	35 (2004)	30.7 (2005)	32.7 (2007)	14.8 (2007)
GDP (2008 est.) :Agriculture	29.00%	39.20%	40.90%	19.00%
GDP (2008 est.): Industry:	30.00%	34.30%	19.70%	42.70%
GDP (2008 est.): Services	41.00%	26.60%	39.30%	38.40%
GDP – per capita (2008 est.)	USD 2,000	USD 2,100	USD 1,200	USD 2,800
GDP – real growth rate (2008 est.)				6.2%

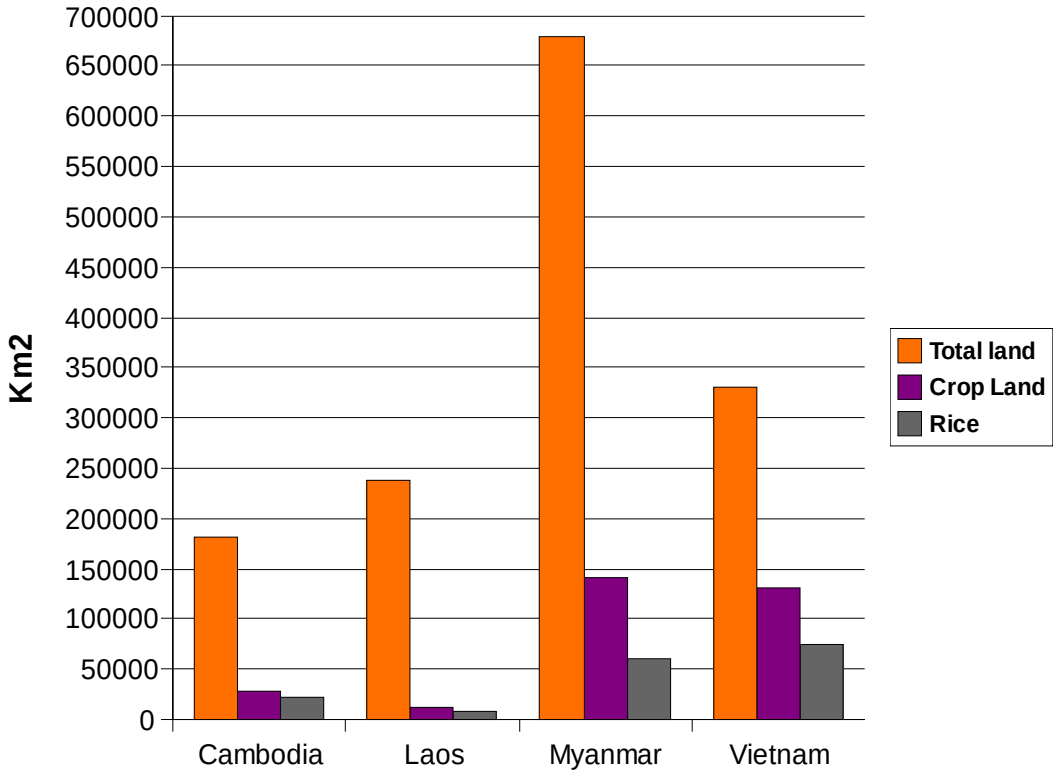
Table 1: Comparison of key indicators of CLMV countries

The economy of all CLMV countries is based on agriculture. However similar to other developing countries, the CLMV countries are experiencing a decrease in GDP from agriculture and an increase in GDP from industry. For example in Laos, GDP from agriculture dropped from 49.4% in 2004 to 39.2 % in 2008 while GDP from industry grew from 24.5 % in 2004 to 34.3 % in 2008 (CIA, 2009)

According to Table 1, the estimated 2008 GDP from industrial sector in Vietnam is more than double of the GDP from agriculture.

Due to the topography of the country, Laos has very limited areas for agriculture as most of the land areas are mountainous. Only 4% of total land area is suitable for agriculture. Rice is the most important crop for all countries. Paddy rice sown areas in 2004 are more than 50% of cropland in all countries except Myanmar (see Figure 2). Vietnam has the largest area of rice with 73,000 km^2 which is more than 9 times more than Laos and 3 times of Cambodia. Furthermore, Vietnam paddy rice area account for about 22% of the country area which is the highest among CLMV countries.

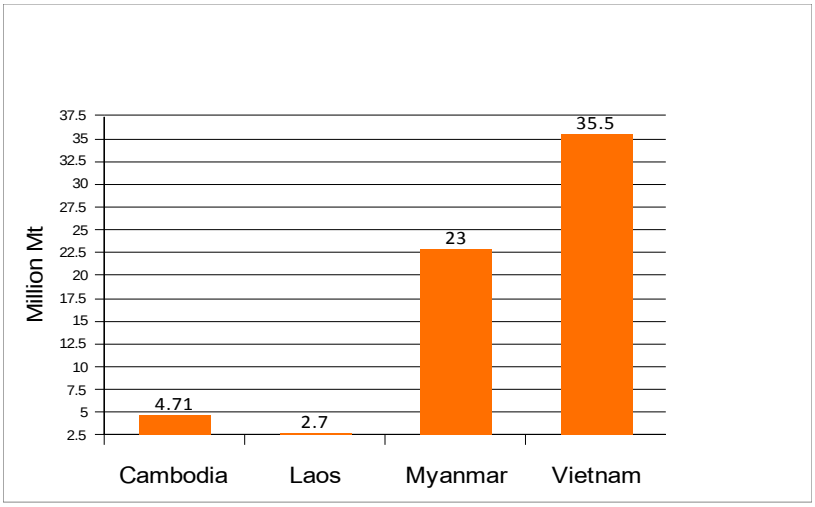
Figure 2: Comparison of crop land and rice areas



According to Figure 3, Vietnam has the highest rice production, which is 35.5 million tons. In general, rice production is mainly for consumption within the country. However, a large amount of rice

production in Vietnam is also for export. In 2004 Vietnam exported 3.9 million tons of rice, making Vietnam one of the lead rice exporting countries of the world.

Figure 3: Rice Production in 2004



All CLMV countries are experiencing rapid industrial development. It is estimated that industrial production growth rates vary from 7 to11 % in 2008 (CIA, 2009). In Laos, output from mining contributed to 19.5% of the industrial sector. It is expected that mining will continue to grow at a rate of approximately 11% per year during 2006-2010 (MINDECO 2006).

Forest products are important for Cambodia, Laos and Myanmar. A lot of forest areas have been under commercial concession for wood products.

Recently tourism in CLMV countries is also developed more rapidly. In Laos, number of tourists visiting Laos grew from 14,400 in 1990, to 1.1 million in 2005. It is expected that annual revenue from tourism will increase to USD 250-300 million in 2020.

Cambodia

Cambodia is a small country compared with other CLMV countries. The central plain covers about 75% of the whole country and is surrounded by mountains and plateaus. The central plain comprises the alluvial plain of

the Mekong River and the Tonle Sap Basin and coastal plain in the southwest. Over 80% of population live in rural areas, 52% of which live in the central plains. The country economy is dependent on agriculture, fisheries and forestry.

Presently, about 30 percent of Cambodia's population depends on the Tonle Sap Lake and its floodplain for their livelihood. It is the largest freshwater lake in Asia and the size of the lake is regulated by water flow from Mekong River. The lake is about 250 km long and 100 km wide during the rainy season and about 120 km long and 35 km wide during the dry season. The water surface expands from 250,000-300,000 ha during the dry season to 1.1- 1.3 million ha during the rainy season. The average depth of the Tonle Sap Lake increases from 1-2 m in the dry season to 8-10 m during the rainy season. The Tonle Sap is surrounded by a floodplain 20-40 km wide, which is dominated by inundated forests and rice fields. Tonle Sap Lake also provides an important fishing ground contributing about 53-68 % of the inland catch valued at USD 44-58 million a year which is about 5% of the country GDP. Tonle Sap Lake and Mekong River are the main sources for freshwater for irrigation and domestic uses. However, 60% of the people in the rural areas use ground water.

Garment and textile industry is one of the major contributors of the GDP from industrial sector. Revenue from tourism is also increasing as the Angkor Wat become more and more popular among international tourists. Electricity is still limited and the main source of electricity generation is diesel fuel. Alternative sources of energy such hydropower, clean coal, wind and solar is being considered.

Laos

Laos is the only landlocked country in the region and shares the borders with all CLMV countries. The landscape is mainly mountainous and is covered with forest. Forest cover is more than 50% of the total land area. About 4% of total land is arable land and 80% of this land is use for rice cultivation. About eighty percent of the population is employed in agriculture, mainly subsistent agriculture. Laos is dependent on natural resources such as water, forest and minerals. With plenty of water and suitable topography, Laos can

develop many hydropower projects which provide excess electricity for export to neighboring countries including Thailand. The country's economy is now developing more rapidly and is moving towards industrialization.

Myanmar

The Union of Myanmar or formally known as Burma is the largest country in Southeast Asia. Burma changed the name to Myanmar in 1989. The country is dominated by three mountain ranges running north to south and three major river systems. Myanmar's population comprises seven major ethnic groups, 68 % of which is Burmese. Majority of people live in Ayarawadi Valley. The country is still rich with natural resources such as forest. At present, it is estimated that forest covers more than 50% of the land area.

The top three export earnings are from agricultural, petroleum and forestry sectors. Ranking third, forestry constitute 10% of the total export earnings in 2001/2002 (CSO, 2002). Teak, ironwood and rosewood are the most valuable among forty-five commercial timber species (Forest Department 1994, pp: 14). Non-timber forest products included charcoal, bamboo, cane, resin, latex, honey, beeswax, edible bird nests, bat's guano, turpentine and orchids. Although Harvesting of non-wood products has been done on commercial scale it mainly supports livelihood of local people. The rate of deforestation was 2% between 1975 and 1989 and the loss was accelerated to 7% during 1989-1998.

As Myanmar is moving towards market economy, the country is likely to increasingly face many environmental problems. Rapid urbanization and industrialization since 1988 has created challenges for wastewater and solid waste management.

Vietnam

Vietnam is geographically different from the rest of the countries in the region. It has elongate shape with a long coastline of almost 3,444 km. running north to south. Three-fourths of the land is mountainous area with an elevation mostly from 100 to 1000 meters. There are 2,360 rivers in Vietnam but most of the rivers in Vietnam are small with less than 100 km^2 of basin area. The nine major river basins account for 90% of total river basin in the country (World Bank, 2005). Six out of nine major river basins are transboundary (World Bank, 2005). More than two third of the population live in the two low-lying deltas: the Red River Delta in the North and the Mekong delta in the south.

Vietnam population is the highest among CLMV countries. Population density is also the highest, which was about 260 people per km^2 in 2008. With family planning measures, Vietnam's population growth rate has gradually been reduced from 2.2 % in early 1990s to 1.7% in 1995 and 1.4% in 2000 (ADPC, 2003). The estimated population growth in 2008 is 0.99% compared to 2.34% in Laos (CIA, 2009).

In addition to the long coastline, there are about 3,000 islands in Vietnam. As a result the country economy is highly dependent on the marine resources. Vietnam has played an important role in marine transport in the region. Vietnam's sea has been used as navigational channel for commercial ships connecting the Indian Ocean and the Pacific Ocean. Vietnam also is one of two CLMV countries besides Myanmar that export oil. Oil production is based on offshore oil reserves.

Regional and Sub-regional mechanisms

CLMV countries have established a close collaboration for many years. They are all the member of the Association of Southeast Asian Nations or ASEAN. Vietnam was the first countries to join ASEAN in 1995, followed by Laos and Myanmar in 1997. Cambodia is the last country to become a member of

ASEAN in 1999. In addition, they also jointly established several sub-regional cooperation frameworks such as the Mekong River Commission.

Mekong River Commission (MRC)

The Mekong River Commission was established in 1995 by the Governments of Cambodia, Laos, Thailand and Vietnam aiming at joint management and development of the Mekong River Basin. Based on the principle of Integrated Water Resources Management, MRC's programme have been conducted in irrigation and drought management; navigation; hydropower; flood management; fisheries; watershed management; environment and tourism.

Association of Southeast Asian Nations (ASEAN)

ASEAN has established many collaborative programmes including agriculture and forestry, economics (trade), energy, environment, finance, health, information, investment, labour, law, regional haze, rural development and poverty alleviation, science and technology, social welfare, telecommunications, transnational crime, transportation, tourism, youth. ASEAN initiated an environmental cooperation programme in 1977 through the formation of the ASEAN Expert Group on Environment (AEGE) under the ASEAN Committee on Science and Technology (ASEAN COST). In 1989, the AEGE was elevated to become the ASEAN Senior Officials on Environment (ASOEN) at the same level as the (ASEAN COST). The ASOEN provides operational policy guidance on the various environmental programmes under ASEAN, which are implemented by its working groups. ASOEN submit their recommendations to the ASEAN Ministerial Meeting on Environment for endorsement. At present ASEAN focuses it cooperation based on the Vientiane Action Plan.

In November 2000, the ASEAN Leaders agreed to launch an 'Initiative for ASEAN Integration' (IAI) programme, aiming at narrowing the development gap between ASEAN's older and newer members. Later,

the ASEAN Leaders, at their Summit Meeting in Phnom Penh in November 2002 endorsed a Work Plan to implement 48 projects. Funding for IAI projects are provided by the six ASEAN's old member countries as well as other donors.

The programmes, activities and projects under the current six-year IAI Work Plan (July 2002 – June 2008) are directed at strengthening the CLMV countries' capacity and capability in meeting the challenges ahead such as reducing poverty, preparing them to face global competition and also assisting them to gain some competitive edge in world markets. The current IAI Work Plan for CLMV focuses on four priority areas, namely infrastructure development, human resource development, information and communication technology and promoting regional economic integration in the CLMV countries.

Greater Mekong Subregion (GMS)

The Greater Mekong Subregion Programme was initiated in 1992 to promote economic cooperation in six countries bordering Mekong River namely Cambodia, China, Laos, Myanmar, Thailand and Vietnam. Various projects in transport, energy, telecommunications, environment, human resource development, tourism, trade, private sector investment, and agriculture have been implemented with support from the Asian Development Bank (ADB) and other donors. As a major donor, ADB finance 179 technical assistance projects focusing on human resource development, tourism, environment, trade and investment.

State of Environment

In general, CLMV countries share common environmental problems but the extent of the problems varies within each country. These problems include: deforestation, soil erosion, loss of biodiversity, Pollution in urban and industrial areas, depletion of fisheries resources due to illegal and overfishing, destruction of habitats.

Deforestation

In the past, the CLMV region was covered with extensive forest. According to Figure 4, 1990 forest covers in all countries (except Vietnam) were more than half of the total land area. However, forest in the three countries areas have continuously been decreasing since 1990 while forest area in Vietnam has gradually been increasing during 1990-2005.

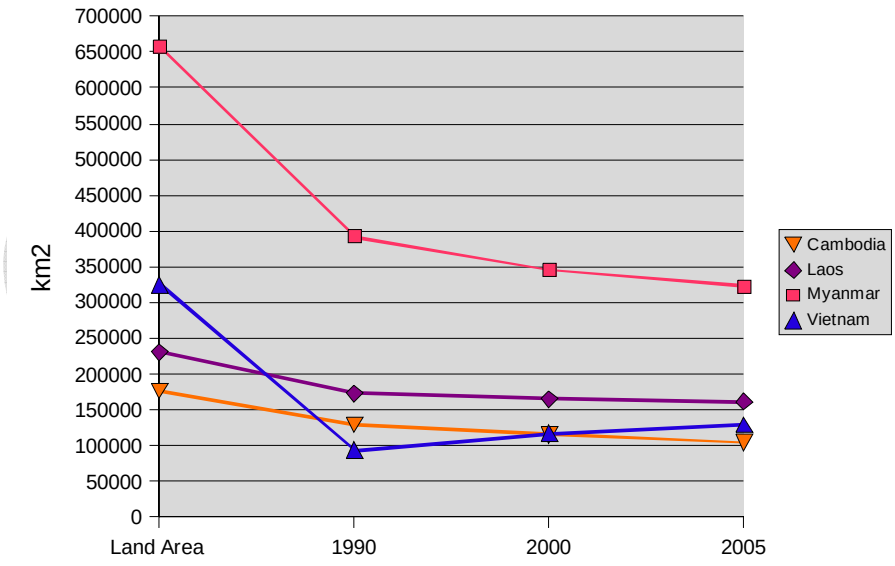


Figure 4: Forest cover in CLMV countries, 1990-2005

In these three countries commercial forest production was a major contribution to the economy. Local people also depend on non-timber forest products such as fuel wood, construction wood. In

Cambodia there is a demand for firewood account for 82% of the energy consumption of the country. In the past two million hectare of forest in Vietnam has been destroyed by war.

The common causes of deforestation are:

- adequate forest management of commercial forest
- illegal logging and
- slash and burn agriculture
- encroachment land clearing caused by increasing population
- impact from mining and queries

Soil erosion:

Soil erosion, which is common in all countries, is mainly caused deforestation in the upland areas. Furthermore clearing forest for shifting cultivation is believed to be the main cause of soil erosion, especially in Laos and Myanmar as there are many people live in the upland areas. These people are mainly poor and depend on subsistent agriculture.

The cultivated areas which are susceptible to soil erosion are located at altitudes of 1000 feet and above with the slopes of 10 degrees and above. The Myanmar Forests Department estimated that total vulnerable farming area with slopes of 10° and more in these upland areas in 1998 was 4.8 million acres. However, there is a lack of scientific information, for example sedimentation to demonstrate the real impact of shifting cultivation on soil erosion.

Loss of Biodiversity

Rapid economic development has threatened the region which is among one of the high biodiversity region in the world. Table 2 shows number of threaten and endangered species.

	Cambodia	Laos	Myanmar	Vietnam
Mammal species	123	172	300	213
Threatened mammal species	23	30	31	38
Wildlife diversity (2004) Total species Endemic species threatened species	 775 11 60	 - 10 66	 1,709 80 100	 1,534 126 121
Native tree species (2004)	862	1,457	2,000	800
Endangered (number) (2004)	13	7	12	36

Table 2: Number of some threatened and endangered species

Degradation of Water resources and Water Pollution:

Being agricultural based economy, countries demand for irrigation is high. In Vietnam, economic expansion in the Northern and Southern Economic Focal Region has resulted in a completing demand for water in agriculture, industrial and domestic uses. Inadequate supply of water in Cau River and the Nhue-Day River sub-basins in the North and the Noi dai river basin in the South is worsen by the poor quality of water in these rivers. It is envisaged that the current and future rapid development is going to make the problems worse.

Compared to other countries in the region, water quality in Laos is currently quite good and is not significantly affected by human activities. However localized degradation to some streams, rivers, and wetlands has occurred due to increased sedimentation caused by soil erosion from land clearing. Water quality in urban areas is declining due to wastewater discharges from domestic and industrial sources.

Air Pollution

Rapid urbanization in CLMV countries has caused increasing air pollution, mainly from transportation and energy. The number of motorcycles and cars is increasing in most of the big cities such Ho Chi Minh City, Hanoi, Phnom Penh, Vientiane and Yangon. Furthermore, import of second-hand vehicles in many countries is also contributed to increase in air pollution. Power generation is also a main contributor to air pollution in urban areas in Cambodia. Electrical supply is inadequate. Power generators are, often a second hand machine small and scattered.

There is a lack of regular monitoring system for air pollution in Cambodia, Laos and Myanmar. Air quality monitoring has been carried out for the key pollutants i.e. total suspended particulate (TSP), Particulate Matter smaller than 10 micron (PM_{10}), sulfur dioxide (SO_2) and nitrogen dioxide (NO_2). Most monitoring has been carried out on a project basis with a few monitoring stations and a short monitoring period. The limited air quality data conducted in most big cities showed that air quality parameters except Total Suspended Particulates (TSP) are within the international guidelines for ambient air quality.

The lack of air quality standards and effluent standards has caused the problem to rise as it is difficult for authorities to implement pollution control measures. Although Cambodia has established mobile emissions standards, these standards are limited to only 3 sets, two sets for motorcycles (2-stoke and 4-stoke motorcycle) and one set for other vehicles. There is a need for emission standards for certain type and size of vehicles. Similarly monitoring data is quite limited to accurately assess the air pollution.

In Ho Chi Minh City and Hanoi, the main source of air pollution is transportation which account for 70 % of air pollution (Tung, 2004). In Hanoi, the number of car increased more than double from about 60,000 in 1995 to 130,000 in 2000 (Tung, 2004). The number of motor cycles in Hanoi increased from 600,000 to 1.2 million which is about ten times more than cars. Other important sources of urban air pollution are industry and construction. In the rural area, air pollution is from forest fire.

Solid waste

CLMV countries share the common problems of increasing amount of solid wastes form urban area due to rapid urbanization. The amount of solid waste has been increasing due to increasing urban population. Lack of adequate collecting and disposal was identified in all countries. Yangon's daily amount of solid waste of about 1,400 ton compare to about 100 tons/day in Vientiane, Lao PDR and 6000 tons in Bangkok.

Water Pollution

Transboundary environmental issues:

All CLMV countries share borders with other countries therefore countries are likely to experience environmental problems caused by other countries. Transboundary environmental issues include

water pollution in shared inland water bodies such as Mekong river, marine pollution in share ocean water bodies i.e. the south China Sea and Gulf of Thailand and the Andaman Sea and air pollution such as haze and acid rain.

The Mekong River, 4,200 km in length, is the twelfth longest river in the world, starting from the snow melts of the Himalayan Mountains in China, passing through Myanmar, Laos, Thailand, Cambodia and Vietnam before discharging in the South China Sea. The transboundary issues in Mekong River include quantity and quality of water, fisheries and migratory species, loss of biodiversity and water pollution from agricultural chemicals.

Transboundary haze pollution is another emerging problem in the region as open burning of agricultural waste has commonly practiced in all countries. Forest fire is another major cause of transboundary haze pollution as the region is still covered with extensive forest areas. Both clearing land for agriculture by open burning and forest fire also contribute to the increase in emission of Green House Gasses. At present there is no report of the acid rain incident in the region.

Climate Change

The problem of climate change is the result of the Greenhouse effect caused by emission of Greenhouse Gases (GHGs) into the atmosphere by human activities such as burning of fossil fuel, mining, transportation, deforestation, agriculture. Impact of climate change is at global scale and need corrective effort in mitigating the problem. Climate change causes many negative impacts on forestry and agriculture which are important sectors of the CLMV countries. Impact of climate change includes change in temperature and precipitation, hydrological pattern, frequency and intensity of cyclone storm surges. The change in weather both temperature and precipitation cause adverse impact on

forest productivities as well as biodiversity. Similarly, climate change has direct impact on agricultural sector.

Future trend and Challenges

It can be concluded that common environment problems among CLMV countries are:

- decrease in forest areas caused by commercial logging, slash and burn agriculture in highland areas and forest encroachment caused by increasing population;
- Soil erosion and land degradation caused by unsustainable practices in agriculture and deforestation
- decreasing water quantity and quality due to construction of hydropower projects and agriculture in the rural area;
- increase in air pollution in urban and industrial areas, particularly from transportation
- increase in solid waste in urban area due to rapid urbanization
- increase in water pollution caused by domestic and industrial wastes

Although deforestation problem still exists, the extent of the problem has become less. For example the percentage of forest in Cambodia decreased significantly from 73% in 1965 to 60 % in 1993. There is a very slightly increase of the percentage of forest cover from 58% to 61 % during 1993-2006. The slow rate of deforestation occurs in most countries because the governments have initiated forest planting programmes. The success such initiative has been recorded with a slight increase in forest cover in Vietnam (see Figure 4 above). There is the need to evaluate the impacts of reforestation on biodiversity.

The CLMV governments have developed and implement policies, projects and activities to respond to environmental problems. Although the trend in environmental management in the region has

continuously been improved for several decades, the problems still exist. At present all governments still express the need to enhance mitigation measures in several priority areas identified above. There are challenges facing countries combating the environmental problems in the following areas:

- demarcation of forest protected area
- sustainable management of forest concession
- forest monitoring including impact on biodiversity
- sustainable agricultural development
- Institutional and legal arrangement
- improve law enforcement
- increase in rural and urban population

Although most countries have laws and regulations in protecting forest, lack of clear delineation of forest protected areas has been one of the major obstacles to combat forest encroachment. However demarcation of forest required considerable amount of budget. Degradation of forest resource is also caused by commercial logging. There is still a lot of forest concessions in Laos and Myanmar. Although replanting is required after logging, implementation is not so effective. This has caused degradation of natural forest. There is a need for both effective management of commercial forest and law enforcement.

Forest monitoring provides an important input to effective management of forest in the country. At present countries lack capacity to monitor the change in forest land. There is often a lack of up to date information to get the accurate assessment of forest cover. Therefore the capacity of countries should be further strengthen in the areas of remote sensing and GIS.

At present, soil erosion is identified as the environmental problems caused by slash and burn agriculture in the upland area and inappropriate farming method. However, the more detail assessment of the extent of the problem is lacking. There is not much data and information in term of the amount of agricultural waste that disposed to the environment and their fate. The assessment of waste from agriculture such as fertilizer, pesticides and other chemicals has been done through the estimation of chemical use.

As most countries still depend on agriculture, there is a need for more effective development of agriculture. Lack of environmental monitoring data is the main obstacle to effectively evaluate environmental impact from agriculture. Similarly the impact of agriculture and deforestation on biodiversity is still lacking. In the long term there is a need for sustainable method of agriculture to reduce the impact to ensure the adequate supply of food to meet the need of people especially the poor.

In term of pollution from domestic sources, there is a general lack of monitoring data to determine the extent of water pollution solid waste and air pollution as well as the impacts on these pollutants on the environment. The CLMV countries are now facing the challenge in mitigating the increasing level of pollution as the countries moving toward market economy.

Industrial pollution also posts a threat to all countries as the level of industrial development rises. Inadequate laws and regulation is a major constraint in dealing with industrial pollution.

Although CLMV countries share many environmental problems such as deforestation, soil erosion, loss of biodiversity, the level of problems are different each country has specific problems and concerns. This is mainly because of the differences in certain social, economic and environmental conditions.

For Cambodia, water and energy supply will not be able to meet the demand in the future.

Because Laos has a low population density and limited industry, the country is not faced with the same problems experienced in the other countries. However, some of the constraints due to its

geography and topography is likely to create a threat to the environment in the future. Lack of flat land and an increasing demand for food production will create environmental impact from agriculture. As a land-lock country Laos has to depend on inland fisheries. As a result inland water bodies have to be properly managed to prevent pollution from waste water.

Coastal and marine environment is very important to the well being of Vietnamese people. Twenty seven provinces are located in the coastal areas covering the area of 41.3 % of the country. Coastal population is about 51.7% (Tung, 2004). With the rapid development, marine pollution from land based sources is major problem of Vietnam as it threatens the rich coastal and marine resources such as coral reef, mangrove and seagrasses. Sea based pollution is also a major problem as Vietnam seas are used for international commercial shipping. Oil pollution from spills and shipping operation will increase as oil has become important export recently. Production of crude oil rose from 40,000 tons in 1986 to 16,500,000 tons in 2000 (Tung, 2004). There were a total of 31 oil spills during 1995-2000, the highest number of spills occurred in 1999 was 10.

Climate change

Similar to other developing countries, CLMV countries will face with the increasing Green House Gas emission due to the increasing demand for fossil fuel for transport and energy. In addition increase in deforestation is threatening the sink for CO_2. The GHG emission from agricultural sector is going to rise because the increasing demands for agricultural land, especially for rice farming. With regard to adaptation, Vietnam is the most vulnerable country because of its long coastline and extensive low-lying coastal areas. Vietnam is very vulnerable to sea level rise and extreme weather events. Furthermore, poor people are the most vulnerable to natural disasters both in term of lost of lives and their livelihood.

As climate change relates to many sectors there is a need of multi-disciplinary initiatives. Various sector such as energy, transport, industry, agriculture and forestry contribute to the emission of GHGs. Therefore to solve the problems, cooperation among related sectors and among different levels very critical. Support of donor community to strengthen the active readiness of VN is very important.

Institutional and legal arrangement

In response to the rising problems, all the governments have established policies, plans and strategies to mitigate and prevent the problems. Many laws and regulations related to natural resources and environment has been established and revised. New organizations responsible for environment management have been established. There is a positive trend in the development of institutional and legal arrangement but the level of development varies among the countries. The trend is similar with regard to research on the environment.

Cambodia

Cambodia has recognized the importance of natural resources and environmental management, the government has established the following key national policies:

- National Environmental Action Plan (NEAP) covering the period from 1998-2002;
- Second Five Year Socio-Economic Development Plan (2001-2005);
- Land and Forest Policies;

In addition to policies, the following laws have been promulgated:

- Royal Decree on the Creation and Designation of Protected Areas, 1993;
- Environmental Protection and Natural Resources Management Act 1996;
- Sub-decree on Water Pollution Control, 1999;
- Sub-decree on Solid Waste Management, 1999;
- Sub-decree on Environmental Impact Assessment, 1999;

- Sub-decree on Air Pollution and Noise Disturbance Control, 2000.
- Sub-decree on Community forest
- Sub-decree on Forest Concession Management

There are a lot of government departments involve in the management of environment. Main government agencies are describes in Table 3 below:

Agency	Responsibility
Ministry of the Environment (MOE)	Environmental management
Ministry of Agriculture, Forestry and Fisheries	Agriculture, forestry and fisheries issues
Ministry of Industry, Mines and Energy	Pollution from industries and mines, energy generation
Ministry of Public Works and Transportation	Construction of roads and other related infrastructure
Council for the Development of Cambodia	Promotion of public sector investment, reconstruction of Cambodia, foreign investments
National Committee for Land Use and Urbanisation	Land use and urban management issues

Table 3: Government agencies responsible for environmental affairs in Cambodia

Laos:

The Government has passed several numbers of laws on natural resource management and protection and pollution control since 1990 including:

- Law on Water and Water Resources (1996),
- Law on Forestry (1996),
- Land Law (1997) and
- Environmental Protection Law (1999)

Furthermore, Ministry of Industry and Handicraft is in the process of seeking approval from the Peoples' Assembly in issuing new law on industry.

There were several action plans related to sustainable natural resources management such as the National Tropical Forestry Action Plan (1991) and the Environmental Action Plan (1993).

Science Technology and Environment Agency (STEA) is the central agency within the Prime Minister's Office, in charge of environment of the whole country while cooperating with line ministries and specialized agencies such as Ministry of Communications, Post, Transport and Construction, Ministry of Energy and Mining, Ministry of Agriculture and Forestry and Ministry of Public Health in implementing government policies and projects.

Myanmar

Until 1989, Myanmar has no central governmental agency responsible for environmental matters. Different government departments are responsible for their respective resources and activities. For example, management of forest resources is under the Ministry of Forestry. Several government departments sometimes share their responsibilities, for instance, City/township Development Committees, Government Affairs Department, Department of Human Settlement and Housing Development, Department of Health, and Directorate of Industrial Supervision, and Inspection share their responsibilities in managing urban environment. In 1990, the National Commission for Environmental Affairs (NCEA) was established to act as a central agency for environmental management. In 2005, supervision of NCEA was transferred from the Ministry of Foreign Affairs to Ministry of Forests.

There is no environment law enacted in Myanmar. There are however many laws related to the environment. These laws include Forest Act, Wildlife Protection Act, Fisheries Act, and agricultural laws such as Insects and Pests Act, Canal Act, Underground water Act and Water Hyacinth Act

Vietnam

The Ministry of Science, Technology and Environment (MOSTE) was in charge of environmental protection since 1993. It was replaced by the Ministry of Resources and Environment (MONRE) in July 2002. MONRE has an overall mandate for resource and environmental strategy, legislation and policy formulation, resource and environmental institution building, environmental impact assessment, resource and environmental research, environmental quality standards, data collection and management. MONRE is also in charge of inspection, development of guidelines for provinces and international cooperation for resource and environmental protection.

Under MONRE, Vietnam Environment Protection Agency (VEPA) has been set up in 2002 responsible for facilitating the Minister in state management in environmental protection in the following fields: inspecting, monitoring, preventing, remediating environmental pollution and degradation; environmental quality improvement; biodiversity conservation; environmental monitor; technology application; environmental data and information, integrated coastal zone management; environmental education and awareness raising.

As a principal government agency responsible for resource and environmental policy, planning and management, the ministry cooperates with various ministries and General Departments in managing natural resources and environment in relevant sectors as described in Table 3Table 3 below.

Agency	Responsibility
Department of Natural Resources and Environment (DONRE)	provincial environmental management
Ministry of Science and Technology (MST)	cooperation with MONRE and other ministries for introducing advanced science, technique and technology application to effectively manage resources and environment, and to control polluting sources.

Agency	Responsibility
Ministry of Agriculture and Rural Development (MARD)	State management in agriculture, forestry, water resources and rural development, terrestrial national parks and protected areas, including coastal wetlands; control and diminution of pollution sources from agriculture activities and control the use of chemical fertilizes.
Ministry of Construction (MoC)	spatial planning and building water supply and sanitation facilities, and managing solid wastes from construction sites.
Ministry of Fisheries (MoF)	aquaculture and aquatic processing factories, protection of aquatic resources including the coastal and marine resources.
Ministry of Education and Training (MOET)	cooperation with MRE in arising awareness and knowledge on environment.
Ministry of Industry (MOI)	environment problems related to industry, monitoring and control pollution from factories and assists industrial firms in solving environmental problems.
Ministry of Planning & Investments (MPI)	overall planning projects related to environmental issues in collaboration with MOSTE and NEA.
Ministry of Public Health (MOPH)	managing hospital wastes, raising awareness relating to environmental health issues.
Ministry of Transport (MOT)	overall planning, implementation of infrastructure and control of air, land, railway and maritime transport, controlling pollution from port and shipping activities.
National Center for Natural Sciences and Technology (NCNST)	networking with other research institutes in the line of ministries in conducting research on environmental issues, developing technology for mitigating pollution
Environment Associations	Assist state agencies in supervising activities controlling polluted sources, providing recommendations on developing strategy, legislation on environmental protection.

Table 4: Government agencies and areas of responsibilities in Vietnam

Establishment of Protect areas

All CLMV countries have established protect areas as one of the measure to conserve and protected important ecosystems of the region. For example, Cambodia has established 23 protected areas: 7 national parks, 10 wildlife sanctuaries, 3 protected landscapes, 3 multiple use zones. Table 5 summarizes the numbers and areas of protected areas in CLMV countries.

Country	Total number of nationally designated protected areas	Total area protected (km) of all nationally designated protected areas	Total territorial area (%) protected per country/territory
Cambodia	30	43464.85	21.92
Lao PDR	25	37545.13	15.86
Myanmar	50	45789.56261	5.52
Viet Nam	117	22551.10287	3.64

Table 5: All nationally designated protected areas (terrestrial and marine)

Source: WDPA (http://www.unep-wcmc.org/wdpa/mdgs/index.cfm)

In 1984 six ASEAN member countries signed the ASEAN Declaration on Heritage Parks and Reserves to designate conserve areas of uniqueness, diversity and outstanding values that deserve the highest recognition as the ASEAN Heritage Parks Reserves so that their importance as conservation areas could be appreciated regionally and internationally. At present there are 13 Heritage Parks and Reserves in CLMV countries as listed in Table 6

Country	ASEAN Heritage Park/ Reserve
Cambodia	Preah Monivong National Park
	Virachey National Park
Laos	Nam Ha National Biodiversity Conservation Area
Myanmar	Alaungdaw Kattapha National Park
	Indawgy Lake Wildlife Sanctuary
	Inlay Lake Wildlife Sanctuary
	Khakaborazi National Park
	Lampi Marine National Park
	Meinmahla Kyun Wildlife Sanctuary
Vietnam	Ba Be National Park
	Chu Mom Ray National Park
	Hoang Lien Sa Pa National Park
	Kon Ka Kinh National Park

Table 6: List of ASEAN Heritage Parks in CLMV countries

Regional and sub-regional cooperation on Environment and Climate Change

Under existing regional and sub-regional cooperation programmes, cooperation on environment management and research have been established.

ASEAN Working Group on Multilateral Environmental Agreements (MEAs)

At present ASEAN cooperation on the environment is guided by the Vientiane Action Plan 200-2010. Nine priority areas were land and forest fires and transboundary haze pollution, coastal and marine environment, sustainable management of biodiversity, freshwater resources, public awareness and environmental education, promotion of environmentally sound technologies and cleaner production, urban environmental management and governance, and, sustainable development, monitoring and reporting/ database harmonization.

To implement these priority areas, ASEAN has established several working groups.

- ASEAN Working Group on Nature Conservation and Biodiversity (AWGNCB)
- ASEAN Working Group on Coastal and Marine Environment (AWGCME)
- ASEAN Working Group on Multilateral Environmental Agreements (AWGMEA)
- ASEAN Working Group on Environmentally Sustainable Cities (AWGESC)
- ASEAN Working Group on Water Resources Management (AWGWRM)
- ASEAN Working Group on Environmental Education

AWGMEAs was established to deal with the global environmental issues including climate change.

ASEAN Center for Biological Diversity (ACB)

Established in 2005, ACB is the continuation of the ASEAN Regional Centre for Biodiversity Conservation (ARCBC) with the support from the European Union (EU). The center established a fund for research related to biological diversity.

The mandate of ACB is to facilitate cooperation and coordination among the ASEAN Member States and with relevant national government, regional and international organizations, on the conservation and Sustainable use of biological diversity and the fair and equitable sharing of benefits arising from the use of such biodiversity in the ASEAN region.

Current thematic areas include Ecosystems services and economic valuation of biodiversity, invasive alien species, protected Area management, climate change and biodiversity, ecotourism and biodiversity conservation, access and fair and equitable sharing of benefits from biological and genetic resources.

ASEAN Agreement on Transboundary Haze Pollution

ASEAN adopted **the ASEAN Agreement on Transboundary Haze Pollution** to solve of the problem of transboundary haze pollution first occurred in 1987 as a result of forest fire in Sumatra. The impact of haze has been recognized by Singapore, Brunei, Malaysia and Thailand.

The Agreement was signed by the ASEAN Environment Ministers during the 9th ASEAN Ministerial Meeting on Haze (AMMH) on 10 July 2002, in Kuala Lumpur, Malaysia. To date, eight ASEAN Member Countries has ratified the Agreement, namely, Brunei Darussalam, Cambodia, Lao PDR, Malaysia, Myanmar, Singapore, Thailand, and Viet Nam.

The Agreement provide guidance on monitoring and assessment; prevention; preparedness; national emergency response; joint emergency response through provision of assistance; procedures for deployment of people, materials and equipment across border in the event of transboundary haze pollution and technical cooperation and scientific research.

The Agreement also necessitate a country to provide quick response, such as information, forest fire mitigation resources or consultation to the requesting party during critical land and forest fire incidents; facilitate the establishment of ASEAN Coordinating Centre for Transboundary Haze Pollution (ACC) ; p rovide a framework for the member countries to strengthen and refine its national policy in land and forest fire mitigation; and provide a framework to develop the national standard operating procedures.

Existing research on environment and climate change

In most CLMV countries, research has been focused in the field of Agriculture and forestry. Most of the research were carried out with the support from many international organization such as UNDP, UNEP, FAO, WHO, World Bank, Asian Development Bank and other donor agencies. There have been a number of projects carried out by international NGOs including Wildlife Conservation Society (WCS), WildAid, World Wildlife Fund, Wetland International, IUCN, International Crane Foundation, Fauna and Flora International. There are number of research on agriculture and forestry which touch upon environmental issues but not much research that directly deal with environment. However, this review report may not reflect the real situation as it did not review research that published in local languages.

National academic and research institutions

National agencies involve in conducting research included government departments and academic institutions. As discussed in the previous chapter, environmental issues have not been recognized by these countries only during the several decades. Table 7 shows the list of government department and universities with environmental programmes and research.

Country	Government agency	University
Cambodia	Ministry of Agriculture, Forestry and Fisheries - Cambodia Agricultural Research and Development Institute (CARDI)	Royal University of Phnom Penh (RUPP), - Department of Environmental Science
	Ministry of Water Resources and Meteorology	Royal University of Agriculture (RUA): Faculty of Forestry - Department of Forest Management, - Department of Forest Conservation
	Ministry of Environment	Prek Leap National School of Agriculure (PNSA)
Laos	Technology Research Institute of STEA	National University of Laos (NUOL)
	National Agriculture and Forestry Research Institute (NAFRI)	
Vietnam	Ministry of Natural Resources and Environment	Can Tho University (CTU)
	National Academic of Science - National Center for Natural Sciences and Technology (NCNST)	Vietnam National University (VNU)
		Vietnam National University (VNU)Ho Chi Minh City (VNU-HCM)
		Hanoi Architectural University
		Hue University Institute of Resources, Environment and Biotechnology (IREB)
		Nong Lam University (University of Agriculture and Forestry) - Environmental Technology and Management Center
		Hue University of Agriculture and Forestry
		Hanoi University of Agriculture - Department of Environmental Technology

Table 7: list of governement agencies and univeristies involved in research on the environment

Existing university network

The Greater Mekong Sub-region Academic and Research network (GMSARN) is a network of academic and research institution in a Grester Mekong Sub Region. The mission of the network is to carry out activities in human resources development, joint research and dissemination of information in

the region emphasising complementary linkages between technological and socioeconomic development issues. The CLMV members include Institute of Technology of Cambodia, Royal University of Phnom Penh, National University of Laos, Yangon Technological University, Hanoi University of Technology, Hochi Minh City University of Technology.

The ASEAN University Network (AUN) was founded in 1995 with members comprising 13 universities in 7 countries. The member grew to 21 at present with the joining of Cambodia, Laos and Myanmar. The main objectives of AUN is to strengthen cooperation among universities in the ASEAN region by promoting collaborative studies and research programmes. It also promotes cooperation and solidarity among scientists and scholars to enhance human resources development as well as to promote and disseminate scientific knowledge and information. Funding for the activities of the network come from participating universities and ASEAN "dialogue partners" such as EU, China, Korea, Japan, India and Russia. CLMV members include Royal University of Phnom Penh, National University of Laos, University of Yangon, Yangon Institute of Economics, Vietnam National University, Hanoi and Vietnam University, Ho Chi Minh City.

International organizations

There are several UN agencies involve in research and development in CLMV countries. The main one is UNDP was the main agency which provide technical and financial support to these countries as they are among the poor developing countries. Although initially the assistance was in the form of development projects, recently many UNDP projects focus more on environment and sustainable development.

Many development agencies such as World Bank

Based on limited information on existing research. Table 8 summarized the areas of research conducted in each country.

Institution	Agriculture	Forestry	Air pollution	Water Pollution	Marine Pollution	Solid waste	Hazardous waste	Biodiversity	Climate change
Cambodia		x	x	x		x		x	
Laos	x	x						x	
Myanmar	x	x							
Vietnam	x	x	x	x	x		x	x	x

Table 8: Existing areas of research in CLMV countries

Existing research on climate change

As non-Annex I parties, CLMV have been provided with a lot of funding for climate change related research projects on both mitigation and adaptation. The example of such research projects cover a wide range of topic such as alternative energy, integrated water resources management, bio fuel, wet rice plantation, agro-biodiversity, renewable energy for rural energy services, small scale hydropower potential, solar energy, climate-related health issue.

State of the environment reporting

State of the environment reports provides valuable sources on research related to environment as they present data and information on status of natural resources and environment in the countries. It comprises statistical and scientific data that provide a useful input to the development of environmental policies and measures to policies makers.

There have been several reports on the state of the environment in the CLMV region. At national or country level, most of the reports have been developed with support from various international organizations such as UNDP, World Bank, ADB and UNEP. Furthermore, state of the environment

reports have been done at a sub-regional, regional and global levels. Table 9 summarized various types of reports by various agencies.

	Cambodia	Laos	Myanmar	Vietnam
World Bank	Environment Monitor 2003: General Environment	Environment Monitor 2003: General Environment		Environment Monitor 2004: Solid waste Environment Monitor 2005: Biodiversity Environment monitor 2006: Water Quality
Asian Development Bank/ UNEP under GMS programme	Cambodia National Environmental Performance Assessment (EPA) Report	Lao PDR National Environmental Performance Assessment (EPA) Report	Myanmar National Environmental Performance Assessment (EPA) Report	Vietnam National Environmental Performance Assessment (EPA) Report
UNEP /Norwegian Agency for Development Cooperation (NORAD)	in production	State of environment, Lao PDR 2001	in production	State of Environment report, Vietnam 2001

Table 9: Published National State of Environment Reports

Environment Monitor is a series of environmental reports prepared by the World Bank. The objective of this report is to present a snapshot of environmental trends across a range of issues. Its purpose is to engage and inform interested stakeholders of key environmental changes as they occur. The format is intended to be easy to understand and accessible to a wide audience.

In addition to national state of environment reports, reports have been developed at regional and sub-regional levels.

The State of the Environment in Asian and Pacific has been published every five years by UNESCAP since 1985, with the generous support of the Government of Japan, and in collaboration with partners such as the ADB and UNEP. The reports present an overview of sustainable developments issues, environmental conditions and trends and response in Asia and the Pacific. The latest report is for 2005 focusing on Green Growth.

ASEAN has published two state of the environment reports with collaborative efforts among ASEAN Member Countries, the United Nations Environment Programme (UNEP) and individual experts under the supervision and coordination of the ASEAN Secretariat.

The First ASEAN State of the Environment Report 1997 (SoER1):

SoER1 is the first in the series of state of the environment reporting of ASEAN. The SoER1 takes stock of environmental conditions and their impact and interrelationship with other sectoral areas in ASEAN. The SoER1 also identified challenges facing the region and highlighted what ASEAN has done to protect the environment and promote sustainable development. The SoER 1 covered the seven countries which were then member countries of ASEAN, i.e. Brunei Darussalam, Indonesia, Malaysia, Philippines, Singapore, Thailand and Viet Nam.

The Second ASEAN State of the Environment Report 2000 (SoER2):

The second in the series of state of environment reporting of ASEAN, the SoER2 presents the status and condition of the environment and natural resources in ASEAN during 1998 – 2000. The SoER 2 coverage expanded to ten member countries as three new members - Myanmar, Lao PDR and Cambodia.

National Communications (for UNFCCC)

As a non-Annex I party, most of the CLMV countries have no commitment in reducing emission of GHGs for the first commitment period (2008-2012). These countries are committed to submit its national communications (NC) to the convention secretariat. The NC include inventory of GHGs, GHG projection and mitigation analysis, vulnerability and adaptation assessment, government plans, policies and measures, research and systematic observation, education, training and public participation, financial resources, technology transfer and capacity building. Cambodia, laos and Vietnam have already submitted their first NC. Cambodia submitted it first NC in 2002, the NC consisted of the GHG inventory for 1994. Laos developed the first GHG inventory for the year 1990. The inventory cover only four sectors namely energy, land use change and forestry, agriculture and waste. Vietnam submitted its first NC in 2003 with 1994 GHG inventory. Table 10 shows that agriculture is the main source of emission of both countries, but emission from agriculture in Vietnam account about 50% of the total emission while it account only 15.5% for Cambodia.

Sector	Cambodia	Vietnam
Energy	1881 (2.8%)	25,637.09 (24%)
Industrial process	50	3807.19 (3.7%)
Agriculture	10560(15.5%)	52,450 (50,5%)
Land use change and Forestry	-55216(81.2%)	19,380 (18.7%)
Waste	273 (0.4%)	2565.02 (2.4%)
Total	67980	103,839.30
Net emission	-73122	103,839.30

Table 10: Comparison of GHG inventory between Cambodia and Vietnam

Suggestions and Recommendations

The review of existing research is mainly based on the information provided in various state of environment reports (described in the previous chapter) shows that there is a lack of scientific knowledge in many areas which is necessary to enhance the management of environment and climate change in the country.

Areas for future research

Based on the gaps in research identified in the relevant reports, the areas for future research can be summarized below.

- monitoring of changes in forest covers (Remote sensing and GIS)
- Impact of deforestation on biodiversity and forest ecosystem
- Monitoring of sedimentation caused by deforestation
- Monitoring of urban pollution such as waste water, solid waste and air pollution
- Establishment of the ambient water and air quality standards
- Establishment of effluent standards for specific types of vehicles
- Appropriate technology for waste water treatment system
- Establishment of laws and regulation related to control of pollution from specific industrial sector such as mining,
- Establishment of data for GHG emission

- Sustainable farming method
- Alternative energy sources
- Impact of climate change on agriculture sector
- impact of climate change on forest productivity and biodiversity

Framework for future collaborative research

CLMV countries share a lot of similarities in term of socioeconomic circumstances. First of all, all countries are moving towards market economy, Majority of people are living in poverty and dependent on agriculture. Industrial development is becoming more and more important. Percentage of rural people is decreasing while urban population is on the rise. All of these changes have created a lot of adverse impact on the environment and degradation of natural resources. Common environmental problems are deforestation, degradation of land, loss of biodiversity, increase in urban and industrial pollution such as air pollution, solid and hazardous wastes. With regard to climate change, countries are vulnerable to the impact of climate change. Adaptation measures are needed to mitigate impact on agriculture water resources disaster management and health. At present, CLMV countries are not responsible for GHG emission reduction, trend in rapid development will inevitable increase the level of GHG emission. As a consequence, mitigation measures will be needed. At present the lack of scientific information has been identified as a major constraint in combating with climate change and environmental problems. All CLMV countries have an opportunity to learn from their neighbours. Exchange of data and information on research and development will facilitate and enhance capability of countries in tackling with increasing problems. Cooperation has already established through existing regional and sub-regional framework such as ASEAN, MRC and GMS.

At present many research studies are carried out both by researchers from government departments, universities and NGOs. Collaboration in research related to environment and climate change can be built upon existing frameworks established between government organizations ASEAN, MRC and GMS. The collaboration can also be established through the existing network of universities in the region. Focal points of researchers should be established to identify research gaps and needs within the country. At the same time a regional network of researchers should be established to build collaborative research programmes and projects as well as to provide a forum for information exchange and sharing of experiences. The initial phase has laid a good foundation in establishing future collaboration on research on the environment and climate change.

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