The Republic of the Union of Myanmar
Ministry of Environmental Conservation and Forestry

MYANMAR'S INITIAL NATIONAL COMMUNICATION UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC)

GEF

MOECAF

Nay Pyi Taw, 2012

UNEP

FORWARD

On behalf of the Government of the Republic of the Union of Myanmar, I have great pleasure to present the Initial National Communication (INC) for Myanmar. It is the fulfillment of our commitment in this respect under the United Nations Framework Convention on Climate Change (UNFCCC). The National Communication has been prepared by 6 teams of experts involving a total of 55 multi-disciplinary scientists. This report is a result of long, tedious and creative work of these Myanmar experts working together and reflecting the most comprehensive outlook about climate change in Myanmar context. The exercise was coordinated by the Ministry of Environmental Conservation and Forestry.

The efforts in the preparation of the Initial National Communication have raised the awareness as well as enhanced the capacities of the 6 teams of experts in the different disciplines related to Climate Change. However, constraints and gaps still exist and financial and capacity building also need to be fulfilled to further improve upon the effort in our future National Communication.

The good work and efforts of all those who have been involved in the preparation of this report are greatly appreciated. Again, on behalf of the Government of the Republic of the Union of Myanmar, I would like to thank UNEP and the GEF for providing technical and financial support needed for the preparation of this report.

(H.E. Win Tun)
Chairman
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Union Minister
Ministry of Environmental Conservation and Forestry

Place: Nay Pyi Taw
Date: 5-9-2012

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NATIONAL CIRCUMSTANCES

The Republic of the Union of Myanmar is situated between latitudes 9° 55" and 28° 15"north and between longitudes 92° 10" and 101° 10" east, with a total land area of 676,577 Km^2. Myanmar constitutes 15 States and Regions. According to 2008 estimation, there are about 57.5 million people in which a total of 135 ethnic groups are living in the country. Most of the population are Buddhist and there is also a rich mix of religions such as Christian, Hindu, Muslim and Animist.

Myanmar has tropical monsoon weather with three distinct seasons; hot, rainy and cool seasons. Rainfall is influenced by monsoons and also by the locality. Annual rainfall of the coastal regions has about 5000 mm while the central dry zone areas have less than 750 mm. Myanmar has a temperature from 10ºC to 32ºC with an average mean value 21ºC in the northern low lands, sometimes dropping to -1ºC or 0ºC in the high lands and 32ºC in the coastal area. During the hot seasons, temperature sometimes reach 40ºC and over in central dry zone areas.

Myanmar land surface slopes gradually with undulating mountain ranges, hills and valleys from north to south. Khakabo-razi, the highest mountain in South East Asia, with its peak of 5881m is found in Northern Part of Myanmar. Running parallel from north to south, are 4 mountain ranges; the Chin hills, the Rakhine Yoma, the Bago Yoma and the Shan Plateau. There are 5 main rivers called Chindwin, Ayeyarwady, Thanlwin, Sittaung, and Mekong rivers. Wetlands, water springs, tube wells, deep tube wells, ponds and irrigated water systems contributed to water supply in many areas.

The composition and distribution of Myanmar's land resources in 2000 were described as reserved forests (18.7%) and other forests (31.5%), fallow land (1.8%), cultivated areas (13.5%), cultivable wasteland (11.7%) and others (22.6%).

Myanmar also possesses ample mineral resources, such as rubies, sapphire, jades and diamonds.

The environmental condition of Myanmar sea waters are still in pristine condition together with abundant aquatic resources.

Education system in Myanmar is built upon broad streams: such as general, professional, technical and vocational .

Medical care and health of the people are top of the national priority list. Transport and communication facilities have been extended and upgraded considerably compared to previous days.

NATIONAL GREENHOUSE GAS INVENTORY

Myanmar ratified UNFCCC on 25 November, 1994 as a non-Annex I Party. Article 12.5 of the UNFCCC requires non-Annex I Parties to make their initial national communications. Thus, Myanmar sought Global Environment Facility (GEF) funding in 2006 to fulfil its commitments and obligations for preparing and reporting its INC. Accordingly, the NCEA(hereafter referred to as Ministry of Environmental Conservation and Forestry - MOECAF) of Myanmar launched an INC-project in 2008 with the financial assistance from GEF/ UNEP.

Energy sector The national GHG inventory in energy sector covers three major GHGs: CO_2, CH_4, N_2O. The main sources of GHG emissions examined are fossil fuel combustion, traditional biomass fuel combustion, fugitive emissions from coal mining activities, and oil & natural gas system. The total GHG emissions from energy sector of Myanmar were estimated to be 7,863.47 Gg CO_2e most of which come from fossil fuel combustion.

Industrial processes and product use sector GHG emissions from various types of industrial processes are non-energy use related emissions. These emissions are related to physical and chemical transformation of materials, in which GHGs such as CO_2, CH_4, N_2O and other gases are released.

A total of 463.29 Gg of CO_2 equivalent and 4.57 Gg of NMVOC is estimated to have been emitted during the year 2000 from the industrial processes and product use.

Agriculture sector Seventy percent of the population reside in rural areas and are mainly engaged in agriculture, livestock and fishery for their livelihood. The net sown area was 10.12 million ha. Most farmers traditionally grow rice as a single cropping system under the rain-fed condition. However with the construction of dams and reservoirs by the Government,the total rice sown area reached 6,302,306 ha out of which 1,852,691 ha (29.4 % of the total rice land in Myanmar) were irrigated.

CH_4 emissions yr^{-1} by irrigated rice, regular rain-fed rice, drought prone rain-fed rice and deep water rice were estimated to be 220.46, 134.62, 34.75 and 117.40 Gg yr^{-1} respectively. The total emission of N_2O in the year 2000 was estimated to be 8.2 Gg yr^{-1}. Use of crop residues for animal feed and fuel wood are common for the smallholder farmers in Myanmar. Only a few portions burnt for land clearing. Total GHG emission of crop residues from field burning were 1.61 Gg CO_2 e.

<u>*Total GHG emissions from agriculture and livestock in 2000*</u> Total GHG emissions from the agricultural sector of Myanmar for the year 2000 were estimated to be 13,195.41 Gg CO_2e. The trend of CH_4 and N_2O emissions during 2000-2005 shows a rising trend because of increased agricultural land and more inputs of fertilizers. Among the domesticated livestock, ruminant animals, such as cattle, buffalos are the major emitters of CH_4 due to their unique digestive system. The total CH_4 emission from the livestock sector was 456.50 Gg. A considerable amount of N_2O was produced from the manure management systems. Because of the increased number of livestock, both CH_4 & N_2O were rising during 2000-2005.

Land use change and forestry sector Forests, if properly managed, are the main carbon sinks. On the other hand, deforestation and forest degradation processes became the source of carbon emissions. The forest resource assessment (FRA - 2000) conducted by the Food and Agriculture Organization (FAO) in cooperation with the Forest Department (FD) of Myanmar has indicated that Myanmar is still endowed with a forest cover area of about 52 % of the country's total land area of 676,577 km^2.

<u>*Annual Increase in Biomass Carbon Stocks*</u> The annual increases in biomass carbon stocks in the land use change and forestry sector were calculated for the natural forests, forest plantations, home garden trees and roadside trees. The CO_2 removal in 2000 from the natural forests, forest plantations, home garden trees and roadside trees were: 129,839 Gg, 11,750 Gg, 470 Gg, and162 Gg of CO_2 respectively.

<u>*Annual decrease in biomass carbon stocks*</u> Losses of carbon stocks due to wood removal and fuelwood removal were estimated for 2000 to be 2,176,888 $tCyr^{-1}$ and 26,936,418 $tCyr^{-1}$ respectively, while those due to site preparation for forest plantations, shifting cultivation and deforestation were estimated to be 1,863,207 tons of CO_2e, 1,200,674 tons of CO_2e and 37,340,974 tons of CO_2e respectively.

Therefore, the greenhouse gas emissions in the forestry sector for the year 2000 has been estimated to be at 40,404.855 Gg CO_2e.

<u>*Net CO_2 emissions/removals for the year 2000*</u> Total annual increase in biomass carbon stocks in the forestry sector was estimated to be 38,787.61 Gg of carbon, or 142,221.19 Gg of CO_2. On the other hand, total carbon loss by wood removal, fuelwood removal and Harvested Wood Products (HWP) accounted for 29,113.31 Gg of Carbon. The total GHG emission by biomass burning following land clearing was estimated to be 40,404.855 Gg of CO_2e. Therefore, the net annual CO_2 removals of the land use change and forestry sector of Myanmar for the year 2000 was estimated to be 101,816.38 Gg of CO_2e.

Waste sector CH_4 emissions from waste sector have been worked out from two different sources (1) disposal of solid waste and (2) treatment of domestic and commercial wastewater. For the base year 2000, the disposal of solid waste contributed 133.31 Gg (99 %); domestic and commercial wastewater contributed 1.198 Gg (1 %) of CH_4 emissions.

<u>*Solid waste*</u> Waste includes Agricultural waste, Livestock waste, Industrial waste and Domestic waste. In 2000, solid waste was 0.278 kg per capita according to the YCDC data issued. It is assumed that solid waste disposal to site (SWDS) which generated 1,514.12 Gg and municipal solid

waste (MSW) to site was about 1,211.9 Gg in the year 2000. The dumping of this amount of solid wastes released about 133.31 Gg of CH_4, equivalent to emitting around 2,799.51Gg of CO_2 into the atmosphere.

Waste water In year 2000, urban population is taken as approximately 30% of the total country's population, which is 15.3 million. By expert estimate, net methane emission from domestic and commercial wastewater is 1.257 Gg.

Emission of Methane from waste sector in 2000
The total methane emission from the Waste Sector in the year 2000 in Myanmar is altogether 134.57 Gg. The trend in this study clearly shows that CH_4 and CO_2 emissions in this sector are increasing due to the increase of total population especially in urban areas.

GHG emissions in Myanmar for the year 2000
The total GHG emission in Myanmar for the year 2000 was estimated to be -67,820.1 Gg CO_2e. Total CO_2 emission in Myanmar for the year 2000 was estimated to be 41,563.75 Gg, while CH_4 emission accounted for 1,248.62 Gg. CO, N_2O and NOx emissions were estimated at 2,216.18 Gg, 12.94 Gg and 34.1 Gg respectively.

Emissions from energy sector amounted to 7,863.47 Gg CO_2e. Emissions from traditional biomass burned for energy accounted for 28, 297.82 Gg CO_2e. However, these emissions are not included in the calculation of national totals since they are far less than the total net emissions and within the range of sustainability.

Most CH_4 emissions were observed in agriculture sector with 963.73 Gg when combined with livestock. Forestry sector showed the most GHG emissions with the value of 40,404.73 Gg CO_2e.

GHG removals in Myanmar for the year 2000
Due to the biomass growth in natural forests, forest plantations, road side trees and home garden trees, land use change and forestry sector is the only sector that can absorb 142,221.20 Gg of CO_2. Therefore, the country's net emission figures turn out to be minus 67,820.10 Gg CO_2e, which means 67.8 million tons of CO_2 are being absorbed by forestry sector in Myanmar in 2000.

The Trend of GHG emissions in Myanmar The trends for CH_4 and N_2O emissions in agriculture sector clearly highlighted a sharp increase during 2000-2005. Waste sector showed an increase in CH_4 emissions due to the population growth. Land use change and forestry sector is also a major source of GHG emissions mainly due to deforestation, shifting cultivation and land clearing. Moreover, total annual CO_2 removals by natural forests are gradually declining due to the decrease of natural forest areas.

GHG emissions and removals in Myanmar for the year 2000

Source / Sink	CO_2 Removal	CO_2 Emission	CO	CH_4	N_2O	Nox	CO_2 Equ. Total Emission	CO_2 Equ.Net Emission
Energy Sector		7,658.65	-	5.62	0.28	-	7,863.47	7,863.47
Industry Sector		248.59	-	-	-	-	463.29*	463.29
Agriculture Sector			0.81	963.75	8.4	0.022	22,843.67	22,843.67
(a)Agriculture			0.81	507.25	8.2	0.022	13,195.17	13,195.17
(b)Livestock				456.5	0.2		9648.5	9648.5
Forestry Sector	142,221.20	33,656.51	2,215.37	144.85	4.26	34.08	40,404.73	-101,816.50
Waste Sector				134.57			2,825.97	2,825.97
TOTAL	**142,221.20**	**41,563.75**	**2,216.18**	**1,248.79**	**12.94**	**34.102**	**74,401.13**	**-67,820.10**

* Other gases NMVOC, ODS and SF6 amounted to 214.7 Gg CO2e.

VULNERABILITY AND ADAPTATION ASSESSMENT

Agriculture, water resources, public health, forestry, coastal zones and biodiversity sectors are the most vulnerable areas to climate change in Myanmar.

Climate change scenarios

The MAGICC/SCENGEN model results on climate scenario were: (1) The temperature for 2001-2020 shows 0.5-0.7ºC increase during the whole year in lower parts of Myanmar and record high maximum temperature may be expected. There is an increase in precipitation of about 4% during March-November in the whole country. (2) The temperature for 2021-2050 shows 1.4-1.7ºC increase in the months June-November in the whole country. From March to November there is an indication of about 10% increase of precipitation in the whole country. (3) The temperature for 2051-2100 shows the warming trend throughout the year especially in the cool season. The whole country will generally receive about 10% increase of precipitation during March to November and deficient rain of up to 80% is likely during the cool months from December to February.

The PRECIS model results on climate scenario were: (1) The standard deviation of mean temperature for 2001-2020 is generally less than 0.5ºC in the whole country except Mandalay and Myitkyina. Annual rainfall will deviate more than 18% at Mandalay, Sittwe, Pathein and Dawei, more than 14% at Myitkyina, Kengtung and Yangon. (2) For 2021-2050, there is an increasing trend in temperature from 1ºC to 1.4ºC at Yangon, Pathein, Myitkyina, Sittway, Dawei, Kengtung, and Mandalay. A large standard deviation at Sittway indicated 1,130 mm, compared to 891 mm in 1971-2000. (3) For 2051-2100, the scenario indicates increases of 2.8°C to 3.5°C in many places from 1971-2000 baseline data due to decreasing cloudiness coverage. Periods of drought are likely at Myitkyina, Mandalay, Sittway, Pathein and Yangon where the standard deviation of mean temperature is generally about 0.9ºC.

Vulnerability and Adaptation (V & A) assessment

Myanmar is situated under the high potential hazard levels. Cyclone and strong winds, flood and storm surge, intense rain, extreme day temperature, drought, and sea level rise are the six natural hazards identified in Myanmar.

Vulnerability Indices (VI) and maps " Using the specified equation of the Vulnerability Index (VI), Sector scores (S) and their Mean score (SM) were worked out for all Regions and States . For In Myanmar, the highest sector score for Vulnerability is in public health sector, followed by biodiversity, water resources, forestry, coastal zone and agriculture sectors.

The Public Health sector score is maximum in Ayeyarwady Region followed by Rakhine State, Tanintharyi Region, Bago Region and in Mon State. It is minimum in Chin State.

In Biodiversity sector, score is maximum in Sagaing Region followed by Rakhine State, Bago, Ayeyarwady and Tanintharyi Regions, and in Mon State and minimum in Yangon Region.

In Water Resources sector, maximum score was observed in Mandalay and Bago Regions while the minimum was found in Kachin and Rakhine States.

In Forestry sector, score is maximum in Magway Region followed by Mandalay, Bago and Ayeyarwady Regions and Kayah State. It is minimum in Tanintharyi Region.

In Coastal zone sector, score is maximum in Ayeyarwady Region followed by Rakhine State, Yangon and Bago Region and Mon State. It is minimum in Tanintharyi Region. There is no score in the eight inland States and Regions.

In Agriculture sector, Ayeyarwady Region has the maximum score followed by Bago, Sagaing, Mandalay and Magway Regions while Chin State has the minimum.

Vulnerability index is maximum in Ayeyarwady Region and minimum in Chin State. The index is relatively high in Ayeyarwady and Yangon Regions followed by Mandalay Region, Mon State and Bago Region. It is relatively low in Sagaing Region and Rakhine State and it is lowest in the remaining States and Region with minimum in Chin State.

Targeted researches Research programs in the areas of (i) Climate variability, (ii) Climate change, (iii) Tropical storms, (iv) Drought and precipitation trends and (v) Extreme climates in relation to El Nino, among others, are to be targeted.

The policy options for adequate adaptation and response strategies are to improve socioeconomic conditions across the country in accordance with the national economic objectives.

MITIGATION OPTIONS ASSESSMENT AND STRATEGIES

Myanmar is under no obligation to quantify reduction of greenhouse gas (GHG) emission. However, GHG emission mitigation options assessment was made and strategies were developed for the key socio-economic sectors.

Energy sector - CO_2 emission reduction from the energy sector can be focused on (i) energy conservation and efficiency, (ii) replacing carbon-intensive energy sources with less intensive sources, and (iii) promoting new and renewable sources of energy. In Myanmar, it can be done by increased utilization of hydropower, increased use of solar power, use of electric vehicle, recycling of used engine oil through refining, and by recovering and recycling of HFCs. For transportation, primary mitigation options will include road maintenance, and fuel switching from petroleum to CNG.

Agriculture and livestock sector - GHG emission mitigation in agriculture can be effected through (i) mitigation of CO_2 emissions from crop lands, biomass, crop residues and by-products, (ii) mitigation of CH_4 emissions through fertilizer management, water management, and selection of high yielding rice cultivars, (iii) mitigation of NO_2 emissions from agricultural soils through the use of slow release fertilizer, sulphur addition and surface application of liquid manures, and also by developing organic farming, and (iv) mitigation by reducing field burning of crop residues via compost making and organic agriculture. Mitigation of methane emissions from livestock could be done by decreasing the number of ruminant animals, by improving manure handling, and by improving enteric fermentation process in ruminant animals.

Land use change and forestry - Forestry mitigation measures include forest protection, afforestation, reforestation, improvement of tree species and stands, natural regeneration, conservation of natural forests, community forestry, agroforestry, dissemination of improved cooking stoves and use of forest products on sustained basis.

Waste sector - In Myanmar, approaches such as waste disposal, waste recycling, and waste reduction are being employed in managing waste. Under the current domestic sewage system, waste water is discharged into sewer using huge amount of treatment water.

National strategies for GHG emission reduction

Energy sector - Emissions from the energy sector are not significant at present. Energy efficiency, reduced use of non-renewable energy resources, promotion of renewable energy and increased production level of energy are among the imperatives of energy policy laid down by the Ministry of Energy. In Myanmar, energy produced from hydropower and biomass shares about 67 percent of total energy consumption.

Agriculture and livestock sector - Ammonia emission is the primary loss of nitrogen from rice fields, which are fertilized with animal waste slurry. Keeping the flooded water table about 10cm high at the time of ADS application, ammonia volatilization from ADS treated paddy soil will be significantly reduced. It could also be suppressed by adding organic waste and wood vinegar for neutralization.

Use of genetically improved breeds, reduction of livestock numbers, increase in animal productivity, improved higher forage quality, and better nutrient composition are the mitigation options, currently feasible at the farm level in Myanmar. Use of urea molasses mineral blocks (UMMB) was introduced by some projects in cooperation with international organizations.

Land use change and forestry - In forestry sector, the mitigation strategies are usually not aimed at only to reduce carbon emission but also increasing carbon sequestration. Forest mitigation options will include mainstreaming climate change concerns into forest policy and legislations, improved forest management, habitat management for wildlife and wild plants, forest protection, afforestation and reforestation, and reduced firewood cutting. Promoting carbon trading is also a promising mitigation strategy.

Waste sector

Development of industries in Myanmar - In Myanmar, both municipal waste and industrial waste have been increasing rapidly. By 2002, 83 main industries and 61 sub-industries under the 6 branches of the Ministry of Industry No.1 are producing 542 kinds of various goods including textiles, garments, foodstuffs, etc. There are 9 major factories under the Ministry of Industry No.2 in 2002. The factories are also producing various kinds of goods, including tires and tubes, trucks, light vehicles, bicycles, etc. There are also several co-operatives and private-owned industries of various scales. Moreover, the government has established 27 industrial zones in year 2000. The total number of factories established was 60,513 in 2006. Minsitry of industry No. 1 and No. 2 are combined to Ministry of Industry in 2011.

Greenhouse Gas emission reduction - In waste management, waste production, waste distribution and waste consumption are involved. Recycling of plastic wastes, and reuse and recycling of wood and agricultural residues are being promoted in recent years.

Appropriate mitigation strategies for municipal solid waste - Development with zero emission has been a growing concept of global acceptance. Use of "waste to energy" plants is also growing. With regards to the management of MSW, there are 4 options and they are — (i) anaerobic digestion of bio-waste (ii) 'Round-trip Paddling Fermenter (RTF)', (iii) Refuse-Derived Fuel (RDF) system, and (iv) use of waste-to-energy power plant.

Proposed projects - A total of fifteen project proposals are presented in this report. Four are directly related to rice cultivation, six on GHG mitigation potential and energy security, four on forestry-related proposals and one is to investigate the effect of nutrient management on N_2O emission from commercial cabbage cropping.

DEVELOPMENT AND TRANSFER OF ENVIRONMENTALLY SOUND TECHNOLOGIES

Technology Needs Assessment In order to identify ESTs need for mitigation of, and adaptation to climate change, Technology Needs Assessment (TNA) was carried out by the NCEA (MOECAF) under the INC project.

It was observed that large segment of the industrial community in Myanmar are not aware of the industry related environmental problems and many factories are still using old machines, obsolete technologies and old trucks that mostly emit smoke and exhaust gases. Many factories have to keep and use power generators which emit hazardous gases due to lack of constant electric power supply. Waste water treatment and systematic waste disposal systems are lacking in most industrial zones.

The survey revealed that there are many industries that have much interest in securing ESTs. Most of them mentioned that they required 3Rs, incineration and final disposal technologies. Most private and government owned industries do not have separate or special funds for environmental programs.

From the TNA carried out under the present INC and the pilot TNA conducted in cooperation with the New Energy and Industrial Technology Development Organization (NEDO) of Japan in 2005, it was found that most preferred technologies of the Government ministries and departments include renewable energy technologies, energy saving technologies, energy efficient technologies and ~~4~~cleaner technologies.

Based on the concern of the ministries and industries, EST needs have also been identified. From the TNA survey, it is obvious that there is a great need for ESTs in Myanmar for both mitigation and adaptation purposes. Supports from the government as well as from the multilateral and bilateral sources are much needed for the transfer of ESTs to Myanmar.

Establishments of ESTs database, technology information network, and information clearing house - EST database is being developed at the NCEA (MOECAF) using the information and data obtained through TNA. A technology information network and information clearing house on EST are also being initiated by the NCEA (MOECAF). Network members from the ministries, departments concerned and all related organizations have been identified.

RESEARCH AND SYSTEMATIC OBSERVATION

Department of Meteorology and Hydrology (DMH), Myanmar has been taking meteorological, hydrological and seismological observations since the late 19th century.

Climate/Hydrological reviews Currently, DMH has 161 observatory stations across the country. According to the data collected since late 19th century, the long-term average annual rainfalls were 5011 mm in Sittwe, (to be checked in spelling) 912 mm in Mandalay, 2629 mm in Yangon and 4137 mm in Myeik.

For the period 1991-2000, annual mean temperatures in Sagaing, Magwe, Bago and Yangon Regions had decreased by a range of 0.2°C-0.8°C while those of the rest of the States/Regions had increased by a range of 0.1°C-0.6°C. The areas with higher latitudes in northern and central parts experience a trend of change from warming to cooling starting from 1977. Annual mean rainfalls of Shan State, Sagaing and Bago Regions had decreased by 58 mm, 6 mm and 65 mm respectively, and those of the rest of the States/Regions had decreased within the range of 2 to 339 mm.

Research on Climate Change

Region-wise annual mean temperature The lowest annual mean temperature of Myanmar is 15.8°C in Chin State followed by 19.1°C in Eastern Shan State, 27.4°C in Yangon Region and the highest 27.5°C in Magway Region for the WMO normal period 1961-1990. There is the general warming trend of mean annual temperatures in the whole country since the year 1979.

For the longer term of 1951-2007, the highest warming rate per decade was 0.32°C in Kayin State, and cooling trends of -0.23°C and -0.16°C per decade were observed at Magway and Bago Regions respectively.

Region-wise extreme mean temperature During 1951-2000, annual mean frequency of heat wave occurrence in Myanmar was 15. The most extensive heat wave covering up to 60% of the country occurred in 1998, the ENSO year.

Region-wise annual mean rainfalls The lowest mean annual rainfall of 768 mm is observed in Lower Sagaing. It increases eastward to about 1500 mm over Shan State, northward to about 2000 mm over Kachin State, westward to 4700 mm over Rakhine State and southward to 5400 mm over Tanintharyi Region. Up till 2007, increasing rainfall trends were observed in many regions of the country, but decreasing rainfall trends observed in some.

Extreme rainfalls Over the period 1991-2004, high extreme rainfalls with maximum frequencies of 5 years occurred at Nyaung-U station and low extremes occurred at Monywa with maximum frequencies of 5 years. The stations with maximum frequencies of low to lower extremes were observed in the Dry Zone. During 1961-1990, about 94% of 24-hour heaviest rainfalls occurred in the "early to peak monsoon (mid-May to August)".

Cyclones During 1887-2005, there were 1248 tropical cyclones in the Bay of Bengal. Of these, 80 cyclones crossed Myanmar coast, i.e. about one every other year. But, Myanmar coast was hit by cyclones every year after 2002 except for 2005. Low lying areas along the rivers are subject to normal floods during monsoon and multiple floods occur when monsoon is intensified at its peak. Dry Zone also experiences catastrophic floods when heavy rains occur for days.

Southwest monsoon The onset of southwest monsoon into the country is becoming late and its withdrawal is advancing earlier. For 1988-2000, the monsoon duration was shortened by three weeks in

Northern Myanmar and one week in other parts compared to 1951-2000 average. But post-monsoon rains can occur due to the influence of cyclonic disturbances in the South China Sea.

Drought can occur in a number of areas in the country. In the Dry Zone, 1954, 1957, 1961, 1972, 1979 and 1991 are the year most affected by drought.

ENSO, El Nino and La Nina Over the past 40 years, all ENSO years resulted in large deficient rainfall in Myanmar. Recently, the ENSO years in Myanmar were 1982- 83 and 1997- 98. Maximum highest temperature records were set in 1998 ENSO year in almost the whole country except Sagaing Region and Kachin and Chin States.

In general, monsoon onsets are late and the withdrawals are earlier in El Nino years, compared to the normal. There have been records of highest maximum temperatures and lowest annual rainfalls in El Nino years.

The 1950, 1956, 1964, 1970, 1975, 1989 and 1999 were the La Nina years. Despite the widespread occurrence of temperature rise in the last two decades, record low minimum temperatures occurred at many stations in the cool season of 1999, a La Nina year.

Warning systems on natural disasters Cyclones in the Bay of Bengal usually accompanied by strong winds, heavy rainfall, floods and storm surges, can cause loss of lives and destruction of property and infrastructure. DMH has established five Meteorological and Early Warning Centers for the issuance of various hazard warnings as required. Myanmar is able to issue warnings on storms, flood and tsunami in advance of 5-7 days, 2-3 days and a few hours respectively.

Networking Myanmar has been working with a number of organizations such as WMO, IPCC, UNFCCC, UNEP, UNESCAP, UNESCO, JICA, etc. to jointly undertake a wide range of projects and programs. Myanmar has also been studying and investigating important issues on air pollution, oceanography, marine meteorology and climate change in cooperation with ASEAN, BIMSTEC, India, China, Korea Republic, Thailand and US.

National strategies for promoting RSO National strategies for promoting RSO are identified and they are: (i) to strengthen climate change research, (ii) to upgrade facilities and technologies with the increased use of automation system and digitization, and (iii) to enhance capacity building.

Research on climate change Climate research will particularly focus on the areas of climate variability, climate change, tropical storms, droughts and El Nino in Myanmar. Technological and financial support and human resources development are in need of strengthening. The need for information networking at all levels is imminent.

REPORT OF EDUCATION, TRAINING AND PUBLIC AWARENESS ON CLIMATE CHANGE

Myanmar Agenda 21 (1997) has identified activities which are to be implemented to strengthen environmental education and awareness programs. During the period of 2008-2010, a number of activities for Education, Training and Public Awareness on Climate Change (ETPA) were implemented accordingly.

For strengthening education and training, three activities were undertaken:

(i) *Development of information, education and communication (IEC) materials:*
Under this activity, a manual of WHO on climate change was translated into Myanmar version to be used as a reference by students and families in Myanmar; a pre-tested tool kit of climate change communication was developed for field extension agents; a climate change educational video was translated into Myanmar version for trainings purposes; and a calculation sheet for self-examination of ecological footprint was produced.

(ii) Training of government officials on climate change:
A six-day course, participated by 29 officials representing relevant but different government

agencies from various regions across the country was organized.

(iii) Training on environmental journalism and climate change communication:
The training was organized for local media groups, and follow-on information-sharing meetings between the ETPA team and trained journalists had occurred, resulting in increased number of climate-related articles in weekly journals locally published.

For public awareness raising, four activities were undertaken:

(i) *Public awareness survey*:
One page self-administered questionnaire was prepared and circulated to the public and NGOs via local media throughout the country. The survey indicated the need for establishing more of social networks to enhance the effectiveness in public awareness raising.

(ii) *Stakeholder awareness raising workshops*:
Two stakeholder workshops were organized to raise the awareness of private business sector, civil society and NGOs through consultative process. As a result, UNDP formed a tri-partite steering committee for setting up a small grant scheme, under which NGOs and CBOs could initiate grassroots-level climate change adaptation programs.

(iii) *Nation-wide public awareness raising campaigns:*
Public awareness raising campaigns were organized at township, district and state/Region levels across the nation, and the target audiences were local authority, government officials, non-state actors and community leaders at each level. During each campaign, participatory group discussions were made to analyze greenhouse gas emissions and extreme weather events.

(iv*) Climate Information Center:*
Nearly 500 information materials on various aspects of environmental conservation and climate change were collected by the ETPA team and a Climate Information Center (CIC) that was established at the office of Forest Academy and Advisory Group in Yangon. The collected materials were made available to all stakeholders.

INTEGRATION OF CLIMATE CHANGE CONCERNS INTO DEVELOPMENT PLANS AND PROGRAMMES

Integration of climate change concerns (CCCs) into development plans and programs is of vital importance to Myanmar in view of further enhancing its low-carbon economy and reducing its vulnerability to climate change challenge. Myanmar has proved more than being a net carbon sink nation, with a CO_2 net removal of (-) 67,863 Gg CO_2e in 2000.

In order to mitigate the GHG emissions and adapt to the increased warming, policy measures have been identified for integration into the national and sectoral development plans and programs as follows:

Energy sector
The fourth Short-Term Five-Year Plan (2006/2007 to 2010/2011) of the National 30-year Energy Development Plan placed its emphasis on environmental conservation while producing more crude oil and natural gas.

Policies: (i) To enhance energy conservation, efficiency and production and ensure energy security, and (ii) to promote efficiency of national transportation system, regulation of imports of second-hand motor vehicles

Strategies: (i) Perform energy audit, (ii) tap all potential power sources including renewable energy, (iii) improve traffic demand management, and (iv) establish national ambient air quality standards

Actions:
Mitigation measures: Set energy efficiency standards and label efficiency grades on products; Provide advices, inspection, incentives for energy conservation and efficiency; Capture fugitive gaseous emissions; Develop voluntary agreements for increased use of energy efficient products; Invest more on and promote the use of cleaner and zero-emission energies; Construct more hydropower facilities where EIA permits; Upgrade existing power-generation and

transmission systems; Extract coal-bed methane; Promote bio-energy production from available sources without compromising food security and viability of forests and soils; Further promote and expand CNG-used vehicles and CNG pipelines and stations; Improve all transport modes and traffic demand management, including cycling and containerized freight transport; Install more light-emitting diodes for traffic lighting.

Adaptation measures: Adopt environmental standards for energy efficiency; construct buildings with designs to increase cross ventilation, prevent direct sunlight in the afternoon and reduce heat gains with shade covers; increase the use of fuel-efficient motor vehicles; make all public transports more attractive and affordable; raise public awareness on GHG emission reduction and energy conservation; build institutional capacity to monitor ambient air quality.

Industrial processes and product use sector
In the industrial sector, Ministry of Industry 1 and Ministry of Industry 2 are producing various kinds of goods. The sector has some joint ventures with foreign companies. Between 1995-96 and 2005-2006, 18 industrial zones were established and about 9,849 factories and mills are operating in them.

Policies: (i) To adopt energy efficiency standards and labelling system, (ii) to prohibit manufacture and import of GHG inefficient products, and (iii) to promote energy efficiency and emission control technologies.
Strategies: (i) Practice Green Certification System, (ii) introduce clean and green technologies, and (iii) promote cleaner production.

Actions:
Mitigation measures: Set high energy efficiency and environmental standards; conduct at each industry, Efficiency Audit and provide green labels and tax benefits to the industry and product that meet the set standards; further promote the use of CNG, LPG and renewable energies by providing incentives.

Adaptation measures: Encourage the use of more energy-efficient boilers, motors, furnaces and electrical equipment; introduce energy-saving, process-specific technologies; initiate the development of carbon capture and storage for energy-intensive plants; implement energy-saving regulations and improved energy management systems; provide energy efficiency-related information services; conduct advocacy extensively on conservation of energy and utilization of cleaner energy.

Agriculture and livestock sector During 1988 to 2000, 116 irrigation projects were completed. Irrigation coverage increased from 12.5% in 1987-88 to 29.4% of the total rice land in the year 2000. Summer rice cultivation has been introduced since 1992 and rice production increased from 21 million tons in 2000-2001 to over 31 million tons in 2007-2008. In general, cattle and buffaloes constitute a part of Myanmar farming system. However, feed resources are scarce and of poor quality especially during the dry season, resulting in low productivity. Emissions of CH_4 and N_2O are likely to increase due to the expansion of agriculture with more fertilizer inputs and increasing livestock population.

Policies: (i) To follow Code of Good Agricultural Practice (CGAP), (ii) to ensure increased food production in climate friendly and resilient manner, and (iii) to improve livestock management and livestock feed.

Strategies: (i) To improve rice cropping systems and water management, (ii) to promote organic farming, (iii) to do research and development on crop varieties adaptable to climate change, (iv) to breed genetically improved strains of animals and regulate their population, and (v) to improve manure management and animal feed with quality forage and mineral supplements.

Actions:
Mitigation measures Reduce tillage and practice intermittent irrigation, proper selection of rice varieties and crop rotation in rice fields; promote "Conservation Agriculture", "Sloping Land Agricultural Technology" and other climate friendly technologies; improve water, crop and crop residue management; promote organic farming and bio-fertilizer use, and reduce the use of chemical fertilizers; apply slow release fertilizer; improve and expand pastures, grasslands

and forage and its quality; improve the use and management of animal waste to harvest producer gas and to use gasification effluent as bio-fertilizer; supplement poor quality roughage with minerals, urea molasses, legume or other agricultural bi-products.

Adaptation measures Adjust cropping systems, improve farm management including post-harvest technology ; use stress-resistant plant varieties and ensure climate-resilient agriculture; promote water use conservation and efficiency; expand water impoundment systems through clusters of smaller dams, ponds, etc.; promote organic farming and use of bio-fertilizers; popularize dry-land agricultural technologies, improve and expand pasture and grassland; add fermentation-control medicine, fermentation stabilizers and micro-organism repressors to animal diets; access to advanced livestock technologies.

Land use change and forestry sector Annual deforestation rate was estimated at 466,420 ha during 1989-1998. To check or reverse this trend of forest depletion and degradation, protection of remaining natural forests and reforestation have been sped up. Local communities, private companies and individuals have been actively establishing forest plantations. Both GHG inventories conducted in 1990 and 2000 had testified that Myanmar was a net CO_2 sequester.

Policies: (i) To promote carbon sequestration through sustainable forest ecosystem development, (ii) Change of land use to be preceded by EIA in accord with broad National Land Use Plan.

Strategies: (i) To introduce private forestry, (ii) To manage state and non-state forest ecosystems in a sustainable manner, (iii) To intensify reforestation and afforestation programs, (iv) To promote community forestry and urban tree planting, (v) To encourage manufacture of long lasting value added forest products, (vi) To develop national land use plan; (vi) To let EIA precede any major land use change.

Actions:

Mitigation measures: Protect existing forests effectively; expand forest extent, increase forest density and growth; maintain structural diversity of forest and species mixture; restore forests; expand Protected Areas System; avoid clear felling of forest in timber harvest, practice reduced impact logging and restore harvested areas; increase advocacy and educate public on community forestry (CF); apply systems such as agro-forestry or aqua-forestry to establish CFs; continue the annual free distribution of tree seedlings for roadside and urban greening and set up incentives to ensure the survival of the planted trees; develop technologies for manufacturing end-use forest products for extended use; strive for development and implementation of national land use plan to sustain permanent forest estate; conduct EIA and thorough cost-benefit analysis prior to deciding any major land use change.

Adaptation measures: Conserve, enrich and sustain biodiversity; encourage climate-resilient species in reforestation and afforestation program; practice multi-culture and structurally complex forest ecosystems management; intensify mangrove reforestation and afforestation in coastal zones; establish an effective mechanism for fire protection and fire fighting; enhance public awareness and participation in managing the forests; educate public on climate change concerns.

Waste sector

Since the inception of the market-oriented economic system in 1988, urbanization and industrialization have accelerated in the country. Daily waste generation in Yangon increased three folds within 1990 to 2007. Emission from the waste sector will assume an upward trend with the improving economy coupled with increasing industrialization.

Policy: (i) To strengthen "Green and Clean Cities " campaign to make the city green and clean; (ii) to reduce GHG emissions and environmental pollution.

Strategies: (i) To minimize per capita waste generation, (ii) to recycle waste, (iii) to generate heat and electricity from waste, (iv) to advocate self-cleanliness and public hygiene, and (v) to enforce "Polluter Pay System"

Actions:

Mitigation measures: Reduce the volume of waste per capita; categorize waste and dispose it properly at designated landfills; collect fees for waste disposal;

fine heavily those who throw wastes recklessly; eliminate the use of polyethylene bags; expand waste treatment facilities; produce biogas for electricity generation at sewage treatment facilities; encourage waste recycle and waste reuse; promote market opportunities for recycled waste products; enforce regulations and standards for waste management; raise public awareness on waste generation and disposal.

INFORMATION AND NETWORKING

Assessment and enhancement of Information Communication Technologies The existing ICT tools and communication facilities are not adequate in most of the government departments and other relevant organizations. Only a few experts in ICT are available, and more ICT trainings are needed. The promotion of ICT has been undertaken jointly by the private computer associations and the government in recent years. However, many gaps and constraints such as financial and technical difficulties, and poor infrastructure and frequent power failures still remain. Institutional strengthening including human resource development and skills and expertise on ICT are to be further enhanced in almost all the government organizations.

Establishment of information networks The climate change information network has now been officially established at MOECAF with initial 25 members from various government departments and local NGOs. The project has also established its own website www.myanmar-unfccc-nc.net. Training relating to the use of website has been provided for MOECAF by a local company. In effect, Myanmar has laid down firm foundation for promoting climate change information sharing and networking within and outside the country.

CAPACITY BUILDING

Myanmar needs capacity building to be able to address climate change and its impacts and to fulfil its commitments to the Convention.

Capacity building needs assessment - Myanmar undertook capacity-building needs assessment covering the areas of human resources, and technology capacity building. The assessment highlighted the needs of the institutions and organizations for man-power training, technology transfer and dissemination.

Regarding human resources: Many organizations are interested to have trainings on climate change issues, GHG inventory, vulnerability and adaptation assessment, technology needs assessment, environmental management and clean development mechanisim (CDM) and carbon trading.
Regarding technologies: A large number of organizations are interested in ESTs and renewable energy technologies. Cleaner production of cement, efficient and cleaner CH_4 gas reduction from livestock, air quality monitoring, reduction of emission from deforestation and forest degradation (REDD) are of interest to some specific organizations.

Capacity building strategy The strategy involves three steps namely; capacity-building needs assessment, identification and formulation of priority capacity building projects, and mobilization of resources for implementing the projects. Capacity building strategy could be applied on the national scale or on sector-wise basis. But implementation should be made on a continuous basis.

Enhancement of international negotiation skills Capacity building to enhance the negotiation skills is largely needed in developing countries due to limited experience, limited expertise and knowledge and language barrier. In this respect, more seminars and workshops on climate change with the participation of relevant specialists and experts are to be organized.

OTHER INFORMATION CONSIDERED RELEVANT TO THE ACHIEVEMENT OF THE OBJECTIVE OF THE CONVENTION

Apart from the programs and activities that are required by the UNFCCC to be undertaken by a party to the Convention, there are several other environmental protection and conservation activities carried out in Myanmar which could directly or indirectly contribute towards addressing climate change and achieving the objective of the Convention.

United Nations Convention to Combat Desertification (UNCCD) related programs and activities - Myanmar acceded to the United Nations Convention to Combat Desertification (UNCCD) in January 1997. Even before acceding to the UNCCD, the Forest Department had implemented a special greening project for the nine districts in 1994. The project area was extended to 13 districts with the formation of a new Dry Zone Greening Department in 1997. Currently, there are 140 dams constructed in the Dry Zone with water shed areas of 4.5 million hectares. Rehabilitation and reforestation of mangroves is also being carried out in the Ayeyarwady delta region where large areas of mangrove forests had disappeared due to over-exploitation. Myanmar has also formulated a National Action Programme (NAP) to combat desertification with 5 proposed projects particularly in the Dry Zone. The Dry Zone has now started to benefit from the greening activities thereby, achieving the objective of the UNFCCC.

Vienna Convention and Montreal Protocol related programs and activities - Myanmar also acceded to the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol in November 1993. The preparation of a Country Program which was supported by the UNEP and coordinated by the NCEA (MOECAF) was completed during 1998 and 1999. Refrigeration Management Plan (RMP) was formulated in 2002 and was approved by the Multilateral Fund in 2005. A Memorandum of Understanding (MOU) on the Preparation of ozone regulations for the control of ODS, and monitoring implementation of the RMP was signed in 2008. The MOU on Provision of services and data collection for the formulation of the Hydrochlorofluorocarbons (HCFCs) Phase out Management Plan (HPMP) has also been signed.

Today, Myanmar has successfully phased out CFC consumption in all sectors. Awareness promotion activities on protection of the ozone layer, training programs for refrigeration and air conditioning service technicians, and training programs for enforcement officers have also been conducted.

Convention on Biological Diversity (CBD) related programs and activities There is a loss of biological diversity due to social and economic pressures all over the world. Today, climate change is also posing threats to the biological resources. Conservation of biological diversity (CBD) is therefore being carried out by nations around the globe. Myanmar is making efforts for the conservation of biological diversity by, promulgating a Protection of Wildlife and Wild plants and Conservation of Natural Areas Law in 1994, formulating Myanmar Forest Policy in 1995, ratifying CBD in 1994, acceding to the Convention on International Trade on Endangered Species of wild flora and fauna (CITES) in 1997 and ratifying the Cartagena Protocol on bio-safety in 2008. MOECAF is now initiating the development of National Biodiversity Strategy and Action Plan (NBSAP) with technical support from UNEP Regional Office for Asia and the Pacific (UNEP-ROAP). Conservation of biodiversity calls for protection of the habitats mainly forests, so that by implementing the CBD, forests are being protected and conserved. In 2009, about 4.35% of the country area has been notified as protected area. Moreover, 34 protected areas, 3 zoological gardens, 1 botanical garden and a national herbal park have been established.

Organizational improvement In addition to the NCEA which was formed in 1990 to manage and coordinate environmental matters in the country, and to act as the national focal point for environmental relations with other countries and international organizations, the Environmental Conservation Committee (ECC) was formed in 2004 to effectively carry out environmental conservation activities within the country. The National Environmental Conservation Committee (NECC) has been reformed in 2011 as a full flash focal organization for the environment sector throughout the country and the NCEA was abolished. Moreover, to speed up its environmental protection measures the Ministry of Forestry was renamed to Ministry of Environmental Conservation and Forestry (MOECAF) in 2011. In recent years, there has been a substantial development in the formation of the non-governmental environmental organizations such as Forest Resources Environment Development and Conservation Association (FREDA), Biodiversity and Nature Conservation Association (BANCA), Wildlife Conservation Society (WCS- Country program), Ecosystem Conservation and Community Development Initiative (ECCDI), Economically

Progressive Ecosystem Development (ECODEV), Re-newable Energy Association Myanmar (REAM) etc; that are doing environmental promotion matters including climate change mitigation and adaptation related Programs.

International cooperation for addressing climate change After signing the UNFCCC in 1992, Myanmar ratified the convention in 1994. The country regularly participated in the COPs of the UNFCCC and its subsidiary bodies meetings. It was one of the 12 participating countries in the ALGAS project, and ratified the Kyoto Protocol in 2003.

Regarding CDM projects, there has been some cooperation between Myanmar and Japan. The Designated National Authority (DNA) of Myanmar was established in 2006 for approving and providing information on proposed CDM projects. In order to make Myanmar safer and more resilient to natural hazards after the country suffered from a disastrous cyclone Nargis in 2008, the National Disaster Preparedness Central Committee (NDPCC) was formed in the same year. The Committee is chaired by the Prime Minister and has 38 members. Myanmar Action Plan on Disaster Risk Reduction (MAPDRR) 2009-2015 has been prepared. The Plan has identified projects and activities which are necessary to meet the Hyogo Framework for Action (HFA) and ASEAN Agreement on Disaster Management and Emergency Response Commitments.

CONSTRAINTS AND GAPS, AND RELATED FINANCIAL, TECHNICAL AND CAPACITY NEEDS

Development of national greenhouse gases inventory

Present efforts in national greenhouse gases inventory - Very limited activities on climate change have been carried out in Myanmar apart from the preliminary greenhouse gases (GHG) inventory and mitigation options assessment undertaken in the ALGAS-study in 1996. Cooperative efforts of the United Nations, e.g. IPCC, UNEP, international organizations and Non-Government Organizations, are important to address the climate change issues and research activities.

Data availability constraints Limited user-friendly database on ESTs, including endogenous technologies is an example of such constraints. There are no forecasts of El Nino Southern Oscillation (ENSO) events in Myanmar. The methods used for the development of Vulnerability indices & maps need to be elaborated.

Needs for GHG-inventory on a continuous basis
CO_2, CH_4 and N_2O data need to be updated and extended based on the COP-8 Guidelines. Capacity building of Individual researchers in various sectors should be promoted, and GHG-inventory needs to be conducted on a continuous basis.

Constraints and needs

Energy and industrial processes sectors
Greenhouse gas inventory for energy sector include CO_2 and N_2O emissions from fossil fuel combustions, CH_4 emissions from fugitive coal mining activities, fugitive oil and natural gas system, and NMVOC from fuel combustion. A wide variety of industrial activities produces greenhouse gases as a by-product. The total CO_2 emissions from the energy and industrial processes in Myanmar were estimated at 8,326.76 Gg in 2000.

Agriculture sector The injudicious use of chemical fertilizers and pesticides, the production of CH_4 from paddy fields and ruminant animals, and of CO_2 from the burning of , crop residues for land clearing have often adversely affected the environment and created many problems. Promotion of ~~a~~ balanced and efficient plant and animal management systems to intensify agriculture in a sustainable manner is needed.

Waste sector GHG inventory for the waste sector mainly includes CH_4 emissions from MSW and domestic & industrial wastewater. In rural areas and small towns, there is no systematic collection of waste. Due to filling of waste over the years in sub-urban areas, anaerobic conditions develop and hence these dumping sites generate large amount of CH_4.

Land Use, Land Use Change and Forestry sector
Countrywide, the annual deforestation was 0.3%, which is only slightly above the global average. Population growth and its effects on natural habitats

are exacerbated by the lack of comprehensive land use policies and planning. Species-specific and ecological zone-specific data are still lacking. The dry matter (biomass)-based inventories for planted species should be carried out. Inventory activities with new approaches to address deforestation, its causes and land use changes should be conducted. Reliable data on types of fire, actual area burnt annually and greenhouse gases emission are still lacking.

Financial needs

Financial resources for climate change outreach programs and activities are needed in Myanmar at present. Myanmar's contribution to the mitigation of and adaptation to global climate change depends to a great extent on transfer of technologies and capacity building, as well as on funding support. Due to the limited financial resources, only a few activities have been done in Myanmar to raise the public awareness on climate change issues. The UN system has an important role to play in supporting and enabling developing countries to participate in the carbon market and prepare for future funding opportunities to catalyze climate action.

Technical needs

Technology needs for mitigation of climate change

Updated and improved cost-effective mitigation options assessment for CO_2, N_2O, CH_4, and new assessment of mitigation options for CO, NOx, Non-Methane Volatile Compound (NMVC), SO_2, HFCs, PFCs and SF_6 for the year 2000, including appropriate mitigation technologies, are needed. Lack of legal and economic instruments for mitigation measures, lack of a national strategy for GHG mitigation, and lack of technical capacity in quantitative mitigation options analysis, are undoubtedly obvious. Technical capacity to effectively integrate V&A assessment and mitigation options analysis into sustainable development programs, and to develop national adaptation and mitigation programs of action ~~is~~ are still lacking.

Technology needs for adaptation to climate change No previous studies on the vulnerability of Myanmar to climate change have been undertaken, and hence no adaptation strategy or action plan has been developed. Thus, all selected priority areas will require participatory rapid appraisals (PRAs) with the aim of collecting information on vulnerabilities to climate change. Cost-effective technological and policy adaptation measures that are appropriate to Myanmar should be identified. Policies on climate change adaptation are still needed to be addressed. Progress in the field of climate change related assessments is insufficient to obtain up-to-date situation in many aspects.

Systematic observation and research on climate system Inadequate computers and internet access, limited climate change related information to function as a clearing house, and limited practice of sharing information among departmental personnel are most commonly obvious. Lack of training, information and experience on Environmentally Sound Technologies Information System (ESTIS) are also constraints in this regard. The hydro-meteorological data sets provide a long-term baseline against which the impact of change in land use and land management on water quality and quantity can be measured. Such information is useful for other researchers, in particular, for understanding issues regarding global climate change. Traditional water management system needs to be strengthened to meet the future requirements. Adaptation measures for water scarcity and drought include water supply and demand management, improved watershed management, water conservation and increased storage of water.

To enhance the systematic observation and research activities, technical/ financial/ expertise support will certainly be necessary from various international/ regional organizations. Research works of climate change will be particularly focused on El Nino, ENSO, tropical storms and associated hazards and droughts in Myanmar.

Myanmar has signed some 30 international and regional environmental treaties and conventions.

Needs for capacity building

Limited capacities at all levels relating to climate change issues, namely (i) climate change negotiation, (ii) preparation of climate change projects for bilateral and multilateral funding, (iii) assessing the impacts of both technological and policy measures for mitigation and adaptation, and (v) effective implementation of various multilateral environmental agreements, including the UNFCCC, are prominent barriers.

Climate change information network should be strengthened nationally/regionally and internationally. Capacity development in DMH, universities and related institutions is also another area of gap in the country.

Training needs Capacity building for GHG-inventory and V&A assessment are urgently needed. Limited human and institutional capacity in assessing, evaluating and verifying ESTs, and inadequate human and institutional capacity in climate data monitoring are gaps to be bridged.

Initiating programs of school education and public awareness on climate change There are few outreach materials, especially in Myanmar language on climate change issues for different target groups. In school level education, it is preferable to integrate environmental issues into existing subjects in the curricula, rather than attempting to introduce environment as a separate subject. Findings of climate change research in universities and other institutions need to be continually made available in appropriate form for use by schoolteachers. It is desirable for practical activities on climate change and environmental studies to be based on traditional conservation practices, and to involve interaction of schoolchildren with local villagers so that they can understand the issues. Public education, awareness, and training programs need to be conducted on a large scale throughout the country with particular emphasis on pollution, natural resources depletion and global climate change.

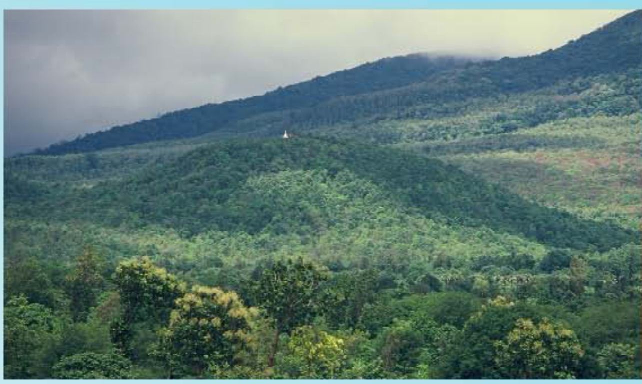
Formulation of the communication network among researchers, institutions and policy-makers Climate change policy, strategy and programs, as well as the integration of this policy and strategy into sustainable development are needed. There is also a need to introduce and strengthen community education on climate change and disaster preparedness.

Policy measures are needed to integrate climate change concerns into national long-term socio-economic and environmental planning. Building up a considerable mass of human resources with required skills, is a basic need for any progress in the institutional framework. The formulated National Environmental Policy calls for harmony and balance between environment and development through the integration of environmental considerations into development process and it forms the basis for developing environmental strategies, programs and plans. Moreover, Myanmar has promulgated environmental conservation in 2012.

Myanmar has undertaken a few activities relating to other Multilateral Environmental Agreements (MEAs). Although Myanmar has prepared its national Agenda 21, the issue on the integration of climate change concerns into sustainable development plans and programs has not yet been addressed.

Activities for overcoming gaps -
Efforts will be made to overcome the data constraints and gap in GHG Inventory. Country specific emission factors should be developed e.g.emission factors from forest fire, and CH_4 emission from rice fields.

As far as capacitybuilding is concerned, it would be appropriate to maximize the synergies for implementing the UNFCCC and other global environmental agreements, such as CBD and UNCCD. The National Capacity Needs Self-Assessment (NCSA) project for Global Environmental management would provide a good basis for such synergies. In addition, a Capacity-Building Strategy that highlights the priorities and options, including the development of South-South capacity building programs, will be developed.




Chapter 1 Introduction

Chapter 1

Introduction

Myanmar lies mainly in the tropic and the climate in the country is greatly influenced by the tropical monsoon through the north-east and south-west monsoon winds. The country enjoys three distinct seasons namely, hot, rainy and cool seasons. However, it is also frequently subjected to cyclones and river flooding. During the last four decades, Myanmar had six major cyclones: Sittway Cyclone in 1968, Pathein Cyclone in 1975, Gwa Cyclone in 1982, Maungdaw Cyclone in 1994, Cyclone Mala in 2006 and Cyclone Nargis in 2008. Flooding is sometimes caused by cyclones, but more often by excessive precipitation in mountainous watersheds. Much of Upper Myanmar lies on a tectonically active zone. Earthquakes are common and occasionally devastating.

The incidence of deforestation, desertification, water shortage, pollution, saltwater intrusion and other adverse environmental conditions have increased in Myanmar due to development activities. Poverty is also prevalent in rural areas and among large segments of the urban population. However, it has great potential for economic development because of its wealth in natural resources.

On the other hand, the socio-economic development and industrialization processes that have been rapidly taking momentum, coupled with the increasing population, have been dwindling the country's natural resources. It is critically urgent, therefore, that the climate change concerns are integrated into all future national and sectoral development plans and programs in order to bring about economic development in social harmony and ecological integrity. *Myanmar Agenda 21 has outlined very comprehensively the process of integration of environment and development in decision-making*. This should be taken as the guideline for integrating climate change concerns into national development plans and programs to ensure economic development in parallel with environmental protection.

In order to form a central body to coordinate environmental affairs with national economic development, the National Commission for Environmental Affairs (NCEA) was established in 1990. It was set up at the Ministry of Foreign Affairs, chaired by Minister for Foreign Affairs. NCEA operates directly under the guidance of the Cabinet and comprises a chairman, a secretary, and a joint-secretary. It has the following four committees:

1. Committee on Pollution Control
2. Committee on Natural Resources Conservation
3. Committee on Training, Research & Education, and
4. Committee on International Relations

NCEA had developed National Environmental Policy which was adopted in December 1994, formulated Myanmar Agenda 21 (MA21) in 1997 and drafted the National Environmental Protection Law (NEPL) in 2000. NCEA was transferred to the Ministry of Forestry to be chaired by the minister for Forestry in 2005 and abolished in 2011. National Environmental Conservation Committee (NECC) was formed in 2004 and reformed in 2011. Moreover, Ministry of Forestry was renamed to Ministry of Environmental Conservation and Forestry (MOECAF). (Here after NCEA was refered to as MOECAF)

A specific aim of MA21 is to facilitate the incorporation of environmental and sustainable development policy considerations into the decision-making and policy formulation processes of the government in the economic and social sectors.

The National Environment Policy underlines the Government's commitment to establish sound policies in the utilization of water, land, forests, minerals, marine and other natural resources in order to conserve the environment and prevent its degradation.

The current process of national development and planning in Myanmar does not provide a systematic means for the integration of environmental dimensions (MA 21). Climate change is one of the hottest environmental issues today and MOECAF is well placed to undertake the task of coordinating line ministries and ensuring the integration of climate change concerns into the national and sectoral development plans and programs.

Myanmar actively participated at the UNCED in Rio de Janeiro and signed the UN Framework Convention on Climate Change in June 1992. It has embarked as one of the 12 participating countries on the Asian Least Cost Greenhouse Gas Abatement Strategy (ALGAS) Regional Project which was implemented by UNDP/GEF and executed by ADB from 1995 to 2000.

Myanmar ratified UNFCCC on 25 November, 1994 as a non-Annex I Party. Article 12.5 of the UNFCCC requires non-Annex I Parties to make their initial national communications. Apart from the preliminary greenhouse gas (GHG) inventory and mitigation options assessment undertaken in the ALGAS-study in 1997, no other project activities relating to UNFCCC have been undertaken in Myanmar.

In 1996, guidelines for the preparation of INC for non-Annex I Parties were adopted by the Second Conference of the Parties (COP). The Global Environment Facility (GEF) provides financial assistance to non-Annex I Parties to prepare their national communications under the guidance of the COP 8. Many countries have already submitted their Initial National Communications reports. Some have submitted their reports as early as in 1997, e.g. Argentina, Jordon, Mexico, Macronesia, Senegal, and Uruguay. A few more countries have submitted their Second National Communication reports whereas Mexico has even submitted their fourth National Communication reports.

Myanmar sought Global Environment Facility (GEF) funding in 2006 to fulfill its commitments and obligations for preparing and reporting its Initial National Communication (INC) according to the recommended guidelines and operational procedures. In this context, MOECAF of Myanmar launched an INC-project in 2008 with the financial assistance from GEF/UNEP. Although this report is the first INC report for Myanmar, it is prepared with components that cover most of the contents of the Second National Communication. The project proposal was formulated in accordance with the guidelines adopted at COP 8 (Decision 17/CP.8) in 2002 and the *GEF Operational Procedures for the Expedited Financing of National Communications from non-Annex I Parties (November 2003).*

In order to facilitate the preparation of this project proposal, an informal stakeholder's consultation meeting was organized by MOECAF on 13 January 2006. A Project Management Team (PMT) and a National Study Team (NST) were established under the auspices of the MOECAF in consultation with other relevant government departments, private sector and NGOs. A National Climate Change Committee (NCCC) to be chaired by the Director-General of MOECAF will also be established to provide guidance to the PMT. The NST is coordinated by a Project Coordinator. The Project Coordinator, together with the leader of each Working Group, formed the PMT.

The NST, which is the backbone of the project comprised working groups that deal with (i) GHG Inventory and Mitigation Option Analysis; (ii) Vulnerability and Adaptation Assessment; (iii) Development and Transfer of Environmentally Sound Technologies; (iv) Research and Systematic Observation; (v) Education, Training and Public Awareness, and (vi) Compilation of the National Communication. Each working group is composed of a number of experts drawn from both the public and the private sectors, including NGOs. Each working group prepared the respective related chapters that constitute this report.

To integrate environment and development, particular emphasis has been placed on key economic sectors for which GHG inventory was undertaken for the preparation of Myanmar's first Initial National Communication. These economic sectors are:

1. Energy,
2. Industrial processes,
3. Agriculture including livestock,
4. Land use change and forestry, and
5. Waste.

Although Myanmar is submitting its INC report only now, the country has long been making efforts for the positive contributions to the mitigation of GHG emission and protecting global climate by making mitigation options assessment and strategies in the key economic sectors of the country. The following mitigation options are being implemented and encouraged:

(i) Hydro power project - Myanmar with many rivers is endowed naturally with abundant hydropower resources. Myanmar has already identified 267 sites with the total capacity of 39,624 MW.

(ii) Solar electric panel to replace diesel generator - Today's electricity supply in Myanmar is generated by fuel generators and hydroelectric power plants. Solar energy is now available all over the country. Photovoltaics (PVs) are the most attractive among renewable energy options that are now being used. It is reliable, clean, and environmentally friendly.

(iii) LED street lighting - LED street lightings are being used in most of the big cities in Myanmar. This is also one of the options to save electric power generation.

(iv)Electric vehicle - An electric car is an automobile that uses an electric motor for propulsion, in place of more common propulsion methods such as the internal combustion engine. In Myanmar, some electric vehicles are now being produced and are being used in the areas, such as hotel zones, zoological gardens, parks, golf clubs, etc.

(v) Waste engine oil recycling -The engine lubricant industry is a big business in Myanmar, with an annual consumption of about 4.5 million gallons (20.24m liters) and turnover ranging from US$ 25 to 40 million. Small amount of lubricant oil is lost during use and the rest are released into the environment. It can also be used as refinery feedstock to become part of crude oil. Used oils are being refined again and again after blending with suitable additives and with no compromise on quality.

(vi) HFCs recycling - Recovery and recycling of HFCs help decrease HFC emissions during equipment service and disposal. The approach involves the use of a refrigerant recovery device that transfers refrigerant into an external storage container prior to servicing of the equipment. Once the recovery process and source operations are complete, the refrigerants contained in the storage container are recharged back into the equipment, cleaned through the use of recycling devices, sent to a reclamation facility to be purified.

(vii) Transport - As transport sector is the largest consumer of fossil fuels, mitigation options in this sector are given due consideration. Recent trends in fuel switching from gasoline to Compressed Natural Gas (CNG) in motor vehicles have already helped to reduce GHG emissions in this sector. The primary mitigation options identified for GHG emission mitigation in the transport sector are:-

a) Road maintenance
b) Modal shift from road to rail (passenger & freight)
c) CNG vehicles and electric vehicles (In terms of CO_2 mitigation potential, the most attractive option in the transport sector is fuel switching to CNG for Myanmar.)

(viii) Recycling of waste - Recycling of waste paper, rubber goods, broken glass wares, steel and various metals, broken plastic and steel pipes, etc. is being done in Myanmar long before 3Rs concept has been introduced globally.

(ix) Forestry - Myanmar has been managing its natural forests under the Myanmar Selection System since 1856. It is a Sustainable Forest Management System. Moreover, Community Forestry and Agroforestry are also being encouraged. These activities will increase the sink and will compensate the emissions from other sectors as well as from other forestry activities.

In addition, reafforestation programs have been intensified and forest and wildlife protection laws and regulations are being increasingly enforced.

The 2000 GHG inventory has very well testified that Myanmar is still a big net carbon sink country.

Chapter 2 National Circumstances

2.1 Natural conditions and resources
2.2 Population and society
2.3 Economic development
2.4 Some of the major sectors which support the national development

Chapter 2

National Circumstances

Figure 2.1: States and Regions of Myanmar

2.1. Natural Conditions and Resources

Location, territory and administrative regions

Myanmar is situated between north latitudes 9º 53'' and 28º 25'' and east longitudes 92°10' and 101°10'. Myanmar shares a border line territory of 2,192 km with China, 224 km with Laos and 2,096 km with Thailand in the east. It shares also 1,331 km border line with India and 256 km with Bangladesh in the west. It has a long sea coast facing the Bay of Bengal in the west, continues south-ward facing the Andaman Sea in the south and southwest. The whole coast line measures 2,832 km in length.

Myanmar has a total land area of 676,577 km^2. The width from east to west is 936 km and the length from north to south is 2,051 km (including 1,200 km long peninsular in the south east). (See location map, Figure 2.1).

Figure 2.2: Hkakaborazi Mountain

Seven States and seven Regions constitute the Union of Myanmar. The seven States are Kachin, Kayah, Kayin, Chin, Mon, Shan and Rakhine, the seven Regions being Magway, Mandalay, Sagaing, Bago, Tanintharyi, Ayeyarwady and Yangon. (Figure 2.1)

Nay Pyi Taw, the recently created new capital city of Myanmar located in the southern part of the Mandalay Region represents a new administrative Region.

Climate change and disaster

Climate of Myanmar

The climate of Myanmar is influenced by tropical monsoon winds, which are the south-west monsoon and the north-east monsoon. Myanmar has three distinct seasons namely, the rainy season, the winter, and the summer. The rainy season starts with the onslaught of the south west monsoon winds in early May and end in October followed by the winter which normally starts from November and ends in February. The summer begins in March and continues to the end of April. During the rainy season the weather is humid, wet and warm, typical of the tropics. During the winter and the summer seasons rain-showers occur occasionally.

During the winter and summer seasons the north-east monsoon winds blow from the north-east. During these seasons northern parts of Myanmar and hilly regions have pronounced cold weather with occasional rainfalls, while other parts are moderately cold.

Rainfall is influenced by the monsoons and also by the locality. The coastal regions have about 5,000 mm of annual rainfall but the central dry zone areas have less than 750 mm.

The highest average rainfall between 1997 and 2006 was recorded in Dawei in Tanintharyi Region as 5,825mm and the lowest for the same period was recorded at Nyaung Oo in Mandalay Region as 641mm. And the highest actual rainfall for 2006 was recorded at Thantwe in Rakhine State as 6,821mm and the lowest for that year was recorded at Nyaung Oo in Mandalay Region as 697mm.

Regarding temperatures, the mean maximum temperature during the period from 1997 to 2006 was recorded at Hpa-an in Kayin State and Monywa in Sagaing Region as 34.3°C and the lowest mean minimum was recorded at Hakha in Chin State as 10.7°C.

The actual mean maximum temperature for 2006 was recorded at Monywa in Sagaing Region as 34.6°C and the lowest was recorded at Hakha in Chin State as 21.8°C, and mean minimum temperature was recorded at the same place as 10.6°C.

The average mean relative humidity for the period from 1997 to 2006 was the highest at Bago in Bago Region being 81% and the lowest at Nyaung Oo in Mandalay Region with 62%.

In Myanmar the temperatures generally vary between 10ºC and 32ºC with the average mean temperature of 21ºC in the northern low lands, sinking sometimes to -1ºC or 0ºC in the high lands and 32ºC in the coastal area. During the hot seasons, temperatures sometimes reach 40ºC and over in central dry zone. (The records of the past few years showed the temperatures ranging between 10.7ºC and 34.3ºC)

Climate change

Climate disasters

During the last four decades, Myanmar had six major cyclones: Sittway Cyclone in 1968, Pathein Cyclone in 1975, Gwa Cyclone in 1982, Maungdaw Cyclone in 1994, Cyclone Mala in 2006 and Cyclone Nargis in 2008. "The Nargis" which severely struck Ayeyarwady delta and eastern part of Yangon in Yangon Region with the wind speed of over 160 mph (approx. 258 km/h) and the resultant associated floods had caused massive physical destructions of mangroves, agricultural fields, houses and utility infrastructures in addition to the deaths of over 100,000 people including trauma for children of the younger age. Furthermore, flooding especially of salt water into the agricultural lands and freshwaters, caused further economic, social and environmental damages extensively.

Other types of disasters also used to occur in the central Myanmar. There are streams which are dry and filled with sand in summer, but, in the rainy season, and occasionally in summer, which happen to be flooded suddenly by heavy showers in the upper watershed regions resulting in the devastating effects such as drowning people and animals and destroying infrastructures.

Figure 2.3: One of the numerous disaster scenes due to the tremendous devastating impact of the Cyclone Nargis

Myanmar environment policy

The wealth of the country is its people, its cultural heritage, its environment and its natural resources. The objectives of Myanmar's Environment policy aim at achieving harmony and balance between these characteristics through integration of environmental considerations into the development process to enhance the quality of life of its citizens (ALGAS, 1998).

Myanmar is still rich in natural resources. Myanmar natural ecosystems are still in good shape, although they have been disrupted by man to some extent.

Physical feature and topography

Myanmar's land surface slopes gradually with undulating mountain ranges, hills and valleys from north to south. The Khakaborazi with its peak elevated to 5,881m is located in Kachin State on the border with Tibetan China. It is the highest mountain not only in Myanmar but also in the whole of South East Asia. The mountain ranges in the northern tip of Myanmar are high, some of them reaching the elevation of over 3,700 m and they are continuations of Himalayan mountain range. From north to south there are the Chin Hills some of which have peaks of 3,400m in height continuing southwards to join the Rakhine Yoma (Rakhine mountain range) in the western part of Myanmar.

The Bago Yoma with some peaks reaching 600 m in height stretches from north to south in the middle of Myanmar to literally end in Yangon.

The Shan Yoma or the Shan Plateau in the east, has peaks as high as 2,800m.

The rivers flow through mostly between the mountain ranges from north to south. Chindwin River which has water source in northern Kachin Hills and Chin Hills is 960 km long. Its so called Chindwin basin lies between Kachin State and the Chin Hills, and on its course to the south Chindwin River joins Ayeyarwady River in the middle of the country. Ayeyarwady River sourced in the northernmost hilly region in the Kachin State has two tributaries namely the Mekha and the Melikha, the confluence of which is above Myitkyina, the capital city of Kachin State.

Ayeyarwady River which is 2,170 km long runs along the western aspects of Bago Yoma southwards to the Ayeyarwady Delta, and into the Gulf of Moattama. It is the most navigable and socio-economically most important river in the country since it passes through many big cities such as Myitkyina, Bhamo, Sagaing, Mandalay, Myingyan, Pyay, Hinthada, Yangon and Pathein in the delta.

Than Lwin River with its source in the Himalayan mountains is 2,800 km long and snow fed. It flows through China, and passing Shan, Kayah and Kayin States in Myanmar entres the Gulf of Moattama. It is navigable only in some places in its lower regions.

Sittaung River, which is 100 km long, is a short river fed by streams mostof which having originated in the Bago Yoma in Yamethin and Pyinmana Districts of Mandalay Region and in Toungoo District of Bago Region. Sittaung valley is a wide valley between Bago Yoma and lower hills of Kayin State.

Mekong River flows along the border with Lao People's Democratic Republic.

In fact, all the big rivers except Sittaung have their sources in Himalayan mountains.

There are also numerous smaller rivers and big streams flowing crisscross throughout Myanmar, which are important to their respective States and Regions for navigation, communication, fishing and water resource. The Tanintharyi peninsular on its western coast has 201 islands of which 112 islands are inhabited.

The geological formation of the Bago Yoma region consists mainly of folded tertiary sedimentary rocks. The main folds run from north to south. It is hilly and characterized by broken ridges. The outcrops have a steep scarp slope on one side and gentle dip slope on the other. The direction of the dip controls the drainage and, along with soils, influences the type of forest.

The Rakhine Yoma range is made up of a belt of ancient rocks including gneiss that occurs in a narrow strip forming the core of the northern part. In the southern part of the eastern foothills of Rakhine Yoma the folds run roughly from north to south, with long narrow outcrops of alternating sandstones, forming hills and clays, forming valleys. From Pakokku District northwards beds of coarse sands are common. The folds run also in the north to south direction. Bands of mottled clays are common with interbedded shales and sandstones. In the north Mu-Chindwin Divide volcanic rocks occur. In the Mu-Ayeyarwady Divide in the further north, the rocks and soils combine to some extent. In the upper Ayeyarwady valley, large stretches of loose sands occur, resulting in swampy areas that are slightly clayey. Considerable areas of crystalline rocks also occur.

In the Rakhine coastal regions the rocks do not vary greatly from those of Bago Yoma, but are more thoroughly lithified.

The whole Shan Plateau, Karen State, Kayah Sate, Mon State and Tanintharyi Region which constitute the eastern part of Myanmar, are formed by the old hard rocks. This area is bound on the west by a relatively narrow belt of old gneiss. In the north, much of the Shan Plateau is formed of alternating bands of gneiss and limestone. In the south, old sedimentary rocks cover most of the country and of these plateau limestone is the most wide spread. In the massifs of the Shan State there are also old filled basins which provide rich alluvial tracts grading into marches in the centre.

There are mud volcanoes and one extinct volcano called Mount Popa which is situated in the central part of Myanmar. From north to south there are faults:

the Chindwin fault, and the Sagaing fault down to Ayeyarwady delta.

Water resources

Myanmar has ample water resources although water availability is not even over the whole country. In the dry zone of central Myanmar, for example, where the land is semi-arid in the rain shadow area of Rakhine Yoma and the Chin Hills water is very scarce: access to fresh water is a big problem facing the local communities. Throughout the length of Myanmar, the valleys and basins of the three big rivers the Chindwin, the Ayeyarwady and the Than-Lwin, there is virtually an ample supply of water. Sittaung River has its own moist and fertile valley as well.

Now, in some places in the dry zone, the farmers are being provided with water for agriculture and household use by pumping the River Ayeyarwady.

The southwest monsoon winds annually bring rain for agricultural lands in many parts of

Myanmar, especially in the Ayeyarwady Delta, Yangon Region, Sagaing Region, and Bago Region. Myanmar now possesses more than 200 dams and reservoirs constructed throughout the country to support the irrigation and the water resources.

The wetlands with big lakes and marshlands also constitute a mechanism to regulate storage and flow of water in the country.

Figure 2.4: Taungtaman lake in Mandalay region

Groundwater pumped up manually and mechanically provides more water to the villages that have ponds with water gathered during rainy season. In the high mountain ranges and forest there used to be many water springs. Mountain springs provide water to villagers way down the hills.

The Inle Lake with its scenic beauty and traditional cultural attraction is shrinking due to soil erosion in the surrounding area because of forest depletion and degradation and environmentally hostile agricultural practices. Similar situations have also been taking place in many other places in Myanmar. Indawgyi Lake in Kachin State is also shrinking. Some of the tributaries of some big rivers are contaminated with chemicals due to all sorts of mining activities in their watersheds.

The percentage of people covered by safe water and sanitation is still very low in the country by the global standard; it is even lower compared to a few neighboring countries.

It is obvious that the traditional water management system can no longer meet the requirements of the market economy. In this context it is urgently needed to reform the present system of water management by establishing a high level national agency for water resource management.

Land resources

The area of Myanmar classified by type of land in the year 2005-2006 is as shown in the following table (Table2.1).

Table 2.1: Area by type of land in 2005-2006

Sr.no.	Type of land	Area (000' ha)	% of total
1	Reserved forest	15,707.05	23.22
2	Other wood land	17,828.41	26.35
3	Current fallows	368.26	0.54
4	Net area sown	10,922.05	16.14
5	Cultivable waste other than fallows	6,279.10	9.28
6	Others	16,552.84	24.47
	Total	**67,657.70**	**100**

Source: Statistical Yearbook, 2006, CSO

The total area of 676,577 km^2 of Myanmar is divided by land types as reserved forest, other woodland, current fallows, net area sown, cultivable waste other than fallows and others.

As seen in the above table forest covered area is about 50%, the net sown area presents about 11 million ha (including fallow land) and the cultivable waste land about 7.9 million ha in the financial year 2005-2006.The land area can be divided into mountainous and plateau, plains and river valleys. The areas occupied by mountain ranges and the plateau are bigger than the plains, river basins, and valleys. The trend of increasing agricultural area against the forest land is obvious (Table 2.2).

Cultivable fallow land and waste land are granted to private individuals, State Economic Enterprises, Joint Ventures and Cooperative societies in order to encourage the development of agriculture, livestock breeding and related activities.

Table 2.2: Changes of land classes in Myanmar (Thousand hectares, percentage)

Classes	1990		2000		% Change (1990-	2005		% Change (2000-2005)	% Change (1990-2005)
	Extent	Share	Extent	Share		Extent	Share		
Closed Forests	28,114.70	41.6	25,841	38.2	-8.1	24,704.20	36.5	-4.4	-12.1
Open Forest	9,755.80	14.4	9,426.90	13.9	-3.4	9,262.40	13.7	-1.7	-5.1
Total Forest	37,870.50	56	35,267.90	52.1	-6.9	33,966.60	50.2	-3.7	-10.3
Other wooded Land	10,405.80	15.4	11,435.30	16.9	9.9	11,950	17.7	4.5	14.8
Other Land (Including water bodies)	19,381.40	28.6	20,954.50	31	8.1	21,741.10	32.1	3.7	12.2
Total Land Area	**67,657.70**	**100**	**67,657.70**	**100**	**0**	**67,657.70**	**100**	**0**	**0**

Source: FAO (2006)

Forest resources

Myanmar is rich in vast varieties of natural resources, both renewable and non-renewable. Among them, forest resource is one of the most critical suppliers not only for the livelihood of the people but for the national economy as well.

It has very diverse ecosystems and accordingly different forest types from high alpine forests to sea level tidal forests have been identified.

The area under different forest types are presented in (Table 2.3).

Table 2.3: Major forest types

No.	Forest Types	Area (ha)	% of total forest area
1.	Tidal Forest	1,382,160	4
2.	Beach and Dune Forest		
3.	Swamp Forest		
4.	Tropical Evergreen Forest	5,528,640	16
5.	Mixed Deciduous Forest	13,476,060	39
6.	Dry Forest	3,455,400	10
7.	Deciduous Indaing (Dipterocarps)	1,727,700	5
8.	Hill and Temperate Evergreen Forest	8,984,040	26
	Total Forest Area	**34,554,000**	**100**

Planning and Statistic Division, Forest Department, Myanmar, 2000

The flora recorded so far in Myanmar includes 273 plant families, 2,371 genera, 11,800 species of which 2,300 species are trees, 97 bamboo species, 26 species of rattan (cane), and 841 species of orchids.

Figure 2.5: Mangrove forest in the delta

Forestry

Forest cover

According to the analysis of 1989 Landsat imageries, closed forests occupied 293,269 km^2 or 43.34%, degraded forests 50,963 km^2 or 7.53% and forests affected by shifting cultivation 154,389 km^2 or 22.8% of the total land area as shown in (Table 2.4)below.

Table 2.4: Forest cover in Myanmar

Sr. No.	Forest cover	Area (km^2)	Percent of country area
1	Closed forest	293,269	43.3
2	Degraded forest	50,963	7.5
3	Forest affected by shifting cultivation	154,389	22.8
	Total	**498,621**	**73.6**

Source: Forestry in Myanmar, June 2000

Change of forest cover

The forest cover of Myanmar had reduced from 65.8% of the total area of the country in 1925 to 52.3% in 1999 (Table 2.5)

Table 2.5: Change of forest covers between 1925 and 1999

Year	% of total land area	Average annual change %
1925	65.8	-
1958	57.2	0.253 (-)
1975	52.7	0.237 (-)
1989	50.8	0.127 (-)
1999	52.3	0.136 (+)
Average annual change from 1925 to 1999		0.180 (-)

Source: National Forest Master Plan (2001-2002 to 2030-2031)

The forest cover of the country had decreased continuously from 1925 (65.8%) to 1989 (50.8%), a decrease of 15% in 65 years. From 1989 it started to increase to reach 52.3% in 1999, indicating an increase of 1.5% during the period. However, the area under closed forests had decreased from 43.3% to 37.4%. The average annual loss of forest cover over the period of 75 years had been approximately 0.18% of the total land area or 0.274% of the forested land.

Permanent forest estate

Reserved forests (RF), protected public forests (PPF) and protected areas system (PAS) constitute permanent forest estate (PFE). The status of PFE as of 31 March 2001 is shown in (Table 2.6).

Table 2.6: Status of permanent forest estate in Myanmar (31 March 2001)

Category	Area (km^2)	Percent of total land area
RF and PPF	129,445	19.13
PAS	15,276	2.26
Total PFE	**144,721**	**21.39**

Source: PSD (Planning & Statistics Division), FD

The total area of the reserved forests and the protected public forests has reached 129,445 km^2 constituting 19.13% of the total area of the country, and that of Protected Areas System 15,276 km^2 or 2.26% of the total land area. Thus, by the end of the financial year 2000-01 the total area of the Permanent Forest Estate has become 144,721 km^2 covering approximately 21.39% of the country.

During 1988-2001 the Myanmar Forest Department had been able to extend the area of reserved forests and the protected public forests by 29,425 km^2 and had to disforest 579 km^2. Thus, on 31 March 2001, the total RF and PPF area stood at about 129,445 km^2 constituting 19.13% of the total area of Myanmar. The annual growth of permanent forest area, excluding PAS, had been 2,220 km^2. Myanmar Forest Policy has envisaged increasing total PFE to 30% of the total land area.

Myanmar has been losing its closed forests at the rate of 0.64% annually. The problem of forest depletion had been even greater with the mangroves in the Ayeyarwady delta; they had depleted at the rate twice the national average. Of a number of causal factors of forest degradation and depletion, agricultural expansion has always been the main cause.

Timber resource

Myanmar flora, so far recorded, consists of 1,347 species of big trees, 741 species of small trees, 1,696 species of shrubs, 96 species of bamboos, 36 species of rattans and 841 species of orchids. Out of 2,088 tree species, 85 have been recognized and accepted as producing multiple-use timber of premium quality.

It has been estimated that closed broad-leaved, mangrove and coniferous forests of the country taken together contain about 2.25 billion cubic meters of standing timber (Table 2.7), while the total annual growth of closed broad-leaved forests is estimated at 31 million cubic meters based on an estimated annual growth of 1.5 m^3/ha of all trees of *dbh* (diameter at breast height) 20 cm and up.

Table 2.7: Estimated volume of standing timber in Myanmar

Type of vegetation	Productive forest		Unproductive forest		Grand total
	Total (mil.m^3)	v/ha (m^3)	Total (mil.m^3)	v/ha (m^3)	(mil.m^3)
Closed broad-leaved	1,859	90	357	30	2,216
Mangrove	12	30.6	4	16	16
Conifers	16	141.6	-	-	16
Total	**1,887**		**361**		**2,248**

Source: Status Paper of the Forestry Sector in Myanmar, September 1996.

Density of Myanmar natural forests is very low having only 90 m^3 per ha in the closed broad-leaved forests and 30.6 m^3 in the mangroves. Coniferous forests with a growing stock of about 142 m^3/ha are best stocked in the country.

Forest management

Myanmar Selection System (MSS) has been the main silvicultural system practiced in the management of practically all the natural forests in the country. Clear felling, simple coppice and coppice with standards systems are applied in local supply forests and fuel wood plantations.

Forest plantations

Establishment of forest plantations started in Myanmar as early as in the late 1850's. Forest resources being abundant in those days, the plantation policy had been only to enrich the existing natural forests. In consequence, the annual planting target had never exceeded 700 ha until 1960. However, the last three to four decades had seen a rapid rate of deforestation and degradation of natural forests as a result of shifting cultivation, excessive fuel wood cutting, and expansion of agricultural lands and development of infrastructure.

In this context, extensive block-wise planting schemes have been called upon since early 1970's in order to rehabilitate the degraded forests, restore the lost forest area, supplement the yield from the natural forests and improve environment. FD and Dry Zone Greening Department (DZGD) have now been planting around 45,000 ha annually.

In addition, a special teak plantation project was started in 1998 with the main objective of increasing teak yield and reducing pressure on the natural forests. Planting 20,000 ha each year, a 40- year rotation has been envisaged in order to be able to harvest a final yield of about 1.8 million cubic meters every year.

At the end of the year 2000, total area of various forest plantations exceeded 675,000 ha (Table 2.8 and 2.9). Commercial plantations constituted 55% of the total planted area, and teak constituted 42% of all the planted species.

Table 2.8: Status of forest plantations at the end of Year 2000 by type of plantation

Sr. No.	Type of plantation	Area (ha)	%
1	Commercial plantation	371,074	55
2	Village supply plantation	188,703	28
3	Industrial plantation	50,356	7
4	Watershed plantation	65,610	10
	Total	**675,743**	**100**

Source: PSD, FD

Table 2.9: Status of forest plantations at the end of Year 2000 by species

Sr.No	Tree species	Area (ha)	%
1	Teak	281,190	42
2	Pyinkado	52,219	8
3	Padauk	15,539	2
4	Pine	15,899	2
5	Eucalypt	74,682	11
6	Others	236,214	35
	Total	**675,743**	**100**

Source: PSD, FD

Private plantations

In 2008, the Government started granting long term leases to private individuals and companies to establish forest plantations. Private establishment of plantations in 2008 was 8,892 ha out of which 2,454 ha were teak and 10,571 ha were other hardwoods.

Mineral resource

Myanmar has extensive mineral resources. The Ministry of Mines is responsible to explore and develop them. One State Enterprise is responsible for the production of metallic minerals and the other for dealing with industrial minerals as well as steel and iron products. The production of precious stones such as rubies, sapphire, jades and diamonds are handled by another State Enterprise. The main mineral products are refined lead, refined silver, zinc concentrates, copper concentrates, refined tin and tin concentrate, tin-wolfram-sheelite concentrate, and gold. Industrial mineral products include coal, gypsum, byrate, limestone, dolomite, bentonite chromite, fireclay, fluoride, granite and other items.

Marine resources

Myanmar has about 2,832 km long coast line and more than 800 islands in Myeik Archipelago. It is very rich in both pelagic fish and demersal fish.

Myanmar coastal region with the total area of swamp of about 0.5 million ha serves as spawning, nursery and breeding ground for aquatic and near shore and brackish water fishes. The continental shelf covers 228,751 square kilometers.

Myanmar marine fishery waters include territorial sea and exclusive economic zone (EEZ). The territorial sea of Myanmar extends 12 nautical miles from the baseline towards the sea and EEZ is the area which covers all areas of the territorial sea and extends 200 nautical miles from the baseline. The total area of Myanmar fishery waters, including EEZ is 486,000 square kilometers.

According to marine Fishery Resource Survey and Exploratory Fishing Project conducted by fishery experts one million metric tons of pelagic fish and 0.85 million metric tons of demersal fish exist in Myanmar marine waters. The Maximum Sustainable Yield (MSY) from Myanmar Waters was estimated at about 1.05 million metric tons. Since the early 1960s, trawl fishing has been introduced in Myanmar waters and later more advanced technologies of fishing such as bottom trawl net, purse seine net, etc are used. Landing data from marine fisheries showed that exploitation rate of marine fish has increased year by year and now it nearly equals the MSY.

Myanmar scientists collaborate with scientists from ASEAN member countries and had conducted researches in the high sea areas which indicated that environmental conditions of Myanmar sea waters are still in good shape and the aquatic resources such as Tuna, Deep Sea Squids, Deep Sea Lobster and other pelagic fishes are more abundant than in the waters of the neighbouring countries.

Biodiversity

Myanmar can claim as possessing a rich biodiversity distributed in different types of forests. Besides, complex arrays of plains along with the major rivers and plateau running parallel to each other with unique ecosystems support numerous live forms interacting between varying climate and geo-physical components in the entire country. Biodiversity is a vital resource for the sustainable development of the nation. Biodiversity in Myanmar can be differentiated as shown below:

(i) Mountain Biodiversity
(ii) Forest Biodiversity
(iii) Dry and Sub-humid land Biodiversity
(iv) Inland Water Biodiversity

(v) Agricultural Biodiversity
(vi) Marine and Coastal Water Biodiversity and
(vii) Small Islands Biodiversity

Status of biodiversity

Various forest types of Myanmar are inhabited by a vast array of plants and wildlife species whereas river systems and tidal forests serve as breeding places for a wide range of aquatic species. Conservation of these biological resources has been incorporated in the broader scope of nature and wildlife conservation which is regarded as one of the national priorities in Myanmar.

Protection of soil, water, wildlife, biodiversity and the entire environment is identified as an important imperative in the 1995 Myanmar Forest Policy.

There are 11,800 plant species under angiosperms and gymnosperms including 841 medicinal plant species, 96 bamboo species and 37 rattan species. Under fauna, there are 251 species of mammal, 1,056 species of birds, 272 species of reptiles, including: 153 snake, 87 lizard and 32 turtle and tortoise species. Under amphibians there are 82 species, including 79 frog species, 2 caecilians, and 1 salamander. There are 310 fresh water fish species, and 465 marine water fish species recorded so far in Myanmar.

Protected Areas System

The protected areas system (PAS) is well established with the set-up of parks and sanctuaries. Myanmar is committed to sustainable development of forests and biological resources through accession to a number of international conventions and agreements. In effect, forestry in Myanmar has been well in place, maintaining a balance between environment, development and social needs.

Diverse forest ecosystems in Myanmar have a diverse fauna and flora. So far, 23 sanctuaries and five parks constituting about 2.26% (15,270 km^2) of the total land area of the country have been established. It is stipulated in the Myanmar Forest Policy that the coverage of the PAS will be increased to 5% in the short term. In the long term it is intended to increase up to 10%.

Threats to biodiversity

Myanmar with its topography featuring high mountain ranges, rivers and lakes and valleys and a long coastal regions making up of different ecosystems, diversed life forms of flora and fauna are found all over Myanmar. Biodiversity of different types are described above. They have also common and different threats. Common threats to the biodiversity come from human interferences whether high on the mountain slopes, or in the forests, along the rivers and in the valleys. Taungya cuttings, illegal felling of trees and plants, poaching and hunting for sale of wildlife products are the major threats in the mountain ecosystem. Forest fires, erosion and landslides are also threats in these areas. In the forest lands, encroachment of land for taungyar, agricultural expansion, road building and urbanization, dam construction and geological extractions of minerals are common all over the country. Illegal felling of trees and over exploitation, cutting of trees for making household products, charcoal burning for sale and household fuel wood utilization are the major threats to forest degradation, deforestation and loss of biodiversity. Forest fragmentations cause habitat loss species loss and loss of genetic resources.

In the dry and sem-humid areas in Myanmar, the development of trades and cottage industry is growing with the increase in population, and demand for forest products and firewood is great threatening surrounding dry forests. The increasing temperature, very low rainfall, soil deterioration and reducing water holding capacity are additional threats. Wetland regions in Myanmar consisting of big rivers, and small rivers streams and small lakes have diversity of fresh water fishes. The threats are deforestation in catchment areas, erosion and siltation, legal and illegal settlements leading to pollution, eutrophication due to residues of fertilizers in catchment areas, panning for gold leading to water poisoning and destructive illegal and over fishing.

2.2. Population and Society

Population

The population of the Union of Myanmar in 2008 was estimated at 57.5 million, an increase of 0.98 million over the year 2005-2006 population of 56.52 million, registering a growth rate of 2.02 percent. The total population was 56,515,000 which included 28,097,000 males and 28,418,000 females. Myanmar is inhabited by over 100 ethnic nationalities. Bamar was the largest group constituting about 69 percent of the total.

About 70 percent of Myanmar's population live in rural and remote areas and about 30% in towns and cities. The most populous cities are Yangon, the former capital, and Mandalay, the ancient capital of Myanmar. According to the statistical data ending year 2000, the most populated Regions are Mandalay, Ayeyarwady and Yangon.

Myanmar supports a diversity of ethnic groups, officially listed as 135 national races classified into eight groups namely Bamar, Chin, Kachin, Kayah, Kayin, Mon, Rakhine and Shan. The ethnic groups like Kachin, Kayin, Kayah, Chin, Rakhine, Shan, and Mon live in Kachin State, Kayin State, Kayah State, Chin State, Rakhine State, Shan State and Mon State respectively. The people living in the Regions are mostly Bamars.

The people of Myanmar are mostly Buddhists, but a rich mix of religions can be found, including Christian, Hindu, Muslim and Animist. The ethnic groups have their own traditions and societal structures.

Employment

In the year 2005, there were 77 labour offices throughout the country. All persons wishing to join government service have to register for work in government labour offices.

The results of the labour force survey conducted in 1990 by the Department of Labour are shown in (Table 2.11) together with the 1973 and 1983 population censuses. The table presents labour force, unemployment rates and visible underemployment rates. "Unemployed" refers to persons who are not employed but are available for or seeking paid work. Visible underemployment is primarily a statistical concept directly measurable by labor force and other surveys reflecting an insufficiency in the volume of employment. It occurs when a person is in employment of less than normal duration and is seeking or would accept additional work. The table presented below has used the time utilization approach as well as the usual status approach to estimate the rate of visible underemployment in Myanmar (Statistical Yearbook, 2006).

Education

Education system in Myanmar is built upon broad streams: General, Professional, Technical and Vocational. Under the general and professional streams are included Basic education, Monastic education, Higher education, two-year College and University of distance education. Under Technical and vocational streams is included Teacher's Training Program (Basic Education and Technical, Agricultural and Vocation Education).

Basic education

The Basic Education comprises primary grade, middle grade and higher grade. It is also classified as preschool (kindergarten), primary school (from grade one to four), middle school (from grade five to seven) and high school (from grade eight to ten) They are also known as Basic Education Primary School (BEPS), Basic Education Middle School (BEMS) and Basic Education High School (BEHS) respectively, after which higher education is offered in Institutes and Universities.

Higher education

After passing the BEHS examination and university entrance examinations, students enter various universities, institutes, degree colleges and technical/ vocational training institutes, according to their merit and choice. There are altogether 102 institutions including universities, technological institutes, and degree and diploma colleges in Myanmar.

The number of schools constructed in States and Regions in 2007 alone amounted to 2,360.

Table 2.10: Distribution of population by State and Region

Sr.	States/ Regions	Land area km^2	Population number	Density per km^2
1	Kachin State	85,783.08	1,511,165	18
2	Kayah State	11,318.63	335,961	30
3	Kayin State	29,313.47	1,739,690	59
4	Chin state	34,750.11	533,047	15
5	Mon State	11,863.87	2,997,543	253
6	Rakhine State	35,483.47	3,183,330	90
7	Shan State	150,317.45	5,464,070	36
8	Sagaing Region	91,294.96	6,274,055	69
9	Tanintharyi Region	41,820.51	1,631,874	39
10	Bago Region	61,953.63	5,792,576	93
11	Magway Region	43,244.85	5,392,446	125
12	Mandalay Region	35,718.36	8,061,708	226
13	Yangon Region	9,812.93	6,724,274	685
14	Ayeyarwady Region	33,901.70	7,862,628	232
	Total	**676,577.00**	**57,504,367**	**85**

Source: Statistical Yearbook, 2006

Monastic education schools

With the aim of providing the needy children and people living in various parts of the country with the basic education in conjuction with Buddhistic teachings 1,313 Monastic Education Schools have been opened in 249 townships. Altogether more than 200,000 boys and girls excluding nuns and novices of the respective monasteries are learning in these schools at present.

Medical care and health

In 1979, the Ministry of Health introduced the Vital Statistics Collection System (VSS) in rural areas of Myanmar. By the year 2006 it covered all rural areas of 291 townships and rural population of 42.49 million representing 100% of the total rural populationof the township that were surveyed.

According to 2005 statistics infant mortality rate was 44.9 per 1,000, and the age specific mortality rate is given in (Figure 2.6).

To provide health assistance in all places of Myanmar, hospitals have been increasingly constructed. In 1988 there were only 361 hospitals in Myanmar but now the number has increased to 846. To enhance capacity

Table 2.11: Labor force, unemployment rates

S.N	Category	1973 Popuation Census	1983 Popuation Census	1990	
				LFS1/	LFS2/
I.	Total Labour Force (in million)	9.37	12.2	11.35	16.52
	1. Employed	9.2	12	10.66	15.83
	2. Unemployed	0.17	0.2	0.69	0.69
II.	Unemployment Rate (%)				
	(a) Both sexes	1.81	1.64	6.08	4.18
	(b) Male	2.08	1.92	4.63	3.69
	(c) Female	0.97	1.14	8.84	4.79

Note: LFS = Labour Force Survey Source: Department of Labour and education in medical sector many more Institutes of Medicine have been opened. In 1988, there were only 3 Institutes of Medicine and one Dental College, but at present there are 4 Institutes of Medicine, 2 Dental Colleges, 2 Nursing Colleges, 2 Pharmaceutical Colleges, 2 Medical Institutes of Technology, and one Institute of Public Health. Previously there were only 7 nurse training schools which have now increased to 23.

To promote and upgrade the standard of medical care in townships and districts, specialists and physicians are assigned to towns and districts all over the country.

With a view to encouraging the practice of traditional medicine, the government has established a University of Traditional Medicine and traditional medicine hospitals and clinics throughout the country.

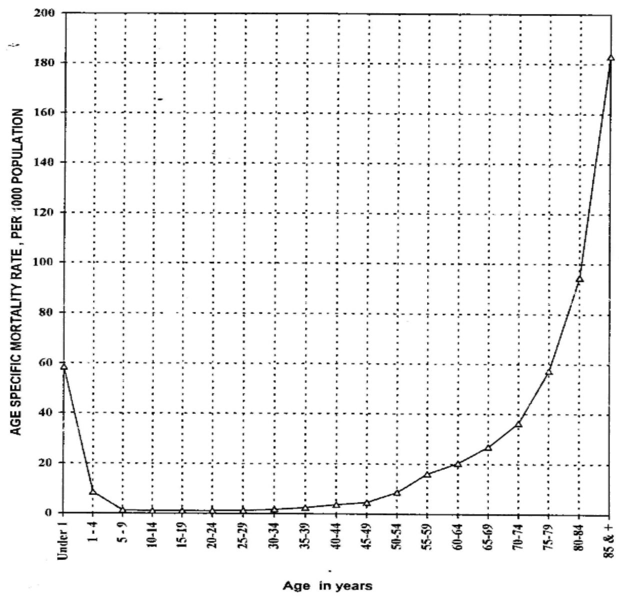


Figure 2.6: Age specific mortality rate (Urban), 2006
(per 1000 population in each age group)

2.3. Economic Development

Level of economic development

From 1988 onwards Myanmar has moved to a more liberalized economic policy based on market oriented system, promoted the role of private sector and open up to foreign investments. To stabilize the economic development and also provide safety nets for the vulnerable groups during the transition, the following laws have been enacted: Foreign Investment Law, New Central Bank of Myanmar Laws, Financial Institution of Myanmar Law and Myanmar Tourism Laws. And the Chambers of Commerce has been transformed and reactivated as the Union of Myanmar Chambers of Commerce and Industry.

The positive GDP growth has been recorded high in certain sectors of the economy. However, neither the rate of social decline and inequity nor the deterioration of natural resources and environmental degradation associated with economic growth has been satisfactorily studied or surveyed and reported. For the continued economic growth, the country will have to face the impending challenges including the macro-economic instability, volatility of foreign exchange earning and unstable exchange rates, low level of savings, large deficits, distortion in the price and insertions system, indiscriminate land uses and ecosystem instability. (Myanmar Agenda 21)

The Planning Department of the Ministry of National Planning and Economic Development is responsible for collection and issuing of statistical data on gross domestic products, consumption, investment and national income, which are calculated both at current prices and constant prices. Since 2006-2007 the total value of net output and services (GDP) are calculated at 2005-2006 constant producer prices.

The Annual Rate of Real Gross Domestic Product increased from 3% in 1988 to about 13% in 2007. Growth rates of Gross Domestic Product, consumption and investments for 2006-2007 show 8.3 percent for forestry, 8.6 percent in agricultural sector and 12.2 percent in livestock and fishery sector. Overall per capita GDP has increased by 10.5 percent (Table 2.12).

Table 2.12: Annual Growth Rates of Gross Domestic Product, consumption and investment

Sr.		Sectors	1985-86	1990-91	1995-96	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
I	GOODS		2.2	2.6	6.7	14	10.6	10.6	13.5	13.1	13.8	12.1
	1	Agriculture	2.2	2	5.5	11.1	8.1	4.7	9.3	10.2	10.7	8.6
	2	Livestock and Fishery	2	-0.6	3	18.9	12.6	14	25.3	15.5	18.8	12.2
	3	Forestry	-0.1	8.3	-4.5	3.3	7.7	6.2	6.4	-5.9	4	8.3
	4	Energy	3.9	-7.6	8.9	30.1	6.9	25	10.3	8.3	19.4	15
	5	Mining		2.9	18.5	27.3	4	32.4	7.9	15.4	37	9.9
	6	Processing and Manufacturing	2.9	0.1	7.6	23	21.8	28.7	22	24.7	21.9	22.1
	7	Electric Power	5.4	5	6.6	15.3	-7.8	22.1	15	7.3	19.2	9.5
	8	Construction	-0.8	35.8	27.2	4	29.4	60.5	19.7	13.5	11	15.2
II	SERVICES		4.1	4.2	9.3	12.6	18.8	25.3	17.4	17.7	15.2	15.7
	1.	Transport	1.5	3.5	6.4	22.5	19.5	25.8	20.9	16.5	16.2	16
	2.	Communications	12	3.9	24.6	29	30.3	89.8	3.5	51.6	18.5	20.7
	3.	Financial Institutions	6.1	16.7	34.8	16.3	24.9	45.5	10.4	27.4	51.7	11.2
	4.	Social and Administrative Services	6.4	4.2	6.2	4.3	13.5	13.5	10.7	14.9	8.4	9
	5.	Rental and Other Services	2.1	3.5	6.3	5.9	18.6	20	14.1	14.4	12	14.3
III	TRADE VALUE		3.7	2.4	5.7	14.1	10.6	10.5	13.3	12.8	12.1	12.7
IV	GROSS DOMESTIC PRODUCT		2.9	2.8	6.9	13.7	11.3	12	13.8	13.6	13.6	12.7
V	PER CAPITA GDP		0.9	0.9	5	11.5	9.1	9.8	11.6	11.3	11.3	10.5
VI	PER CAPITA CONSUMPTION		0.2	-1	4.4	5.5	10.3	9.8	10.3	9.5	8.8	9.3
VII	PER CAPITA INVESTMENT		-0.4	34.8	25.7	8.8	7	4	26.2	19.3	27.1	21.9

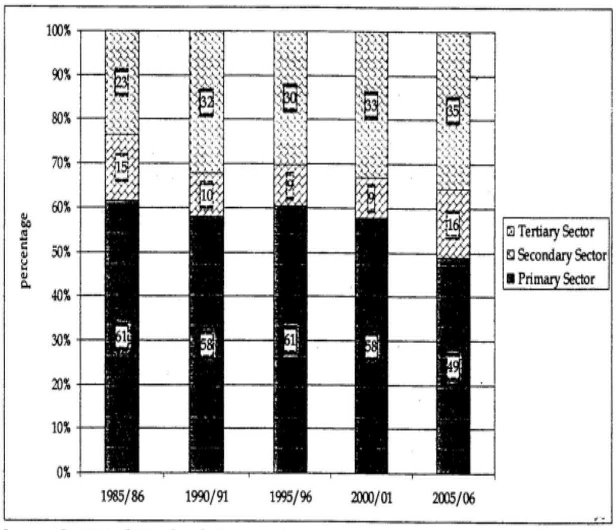
Source: Statistical Year Book, CSO, Myanmar (2008)

As Myanmar is an agrarian country, the agriculture sector comprising agriculture, livestock, fishery, and forestry contributes to more than 50% of the national GDP and about 30% of the export earnings. Although forestry sector's contribution to the national GDP is less than 1 percent, timber export alone contributes about 10 percent of the total export. Like other developing countries, Myanmar's external trade has also to rely on exports of primary products from the natural resources.

There is a prospect for net earnings from forest through carbon initiative proposed by a coalition of developing countries at the UN Climate Talks in Kenya in 2006. Under the proposed carbon finance initiative, Myanmar could earn from $128 million to over $1.8 billion from industrial countries through forest conservation funds if the country mitigated 32-93 megatons of CO_2 which are being emitted due to deforestation of 466,000 hectares per year in Myanmar (Mongaban 2006). The estimation stated that carbon finance could boost per capita GDP in Myanmar from 5 to 20 percent.

Economic structure

Myanmar is in its initial stage of development. Thus, it has to rely on primary sectors such as resource extraction and export. The country is at the transitional period of market-oriented economic system and industrialization. Up to recent days the structure of Myanmar economy has not significantly changed with high domination of primary sectors comprising agriculture, livestock and fishery, and forestry, energy and mining. Secondary sector includes processing and manufacturing, electric power and construction. Tertiary sector consists of transportation, communication, finance, social and administration, rentals and other services plus trade. The proportion of industrial sector in Myanmar slightly increased from 15% in 1985-86 to 16 percent in 2005-2006. The share of agriculture and other primary sectors declined from 61% to 49%, and that of service sector increased from 23 to 35% for the same period. Higher contribution of service sector was due to rapid expansion of international trade with the initiation of the market economy (Figure 2.7).



Source: Statistical Yearbook (various issues).

Figure 2.7: Structure of Myanmar economy

Foreign trade

Export commodities include

1. Agricultural products : rice and rice products, pulses, maize, oilcakes, raw rubber, raw cotton, raw jute and other agricultural products;
2. Animal products;
3. Marine products such as fish, prawns, and other marine products;
4. Timber such as teak and hardwoods;
5. Base metals and ores;
6. Precious and semi-precious materials such as silver, precious stones and pearls;
7. Gas; and
8. Garments.

Export commodities for 2006-07 valued 30,026 million kyats in total. Rice is exported to South-east Asian and a few other Asian countries, Middle East, America, Europe, Africa and Oceania.

Timber is exported mostly to ASEAN and other Asian countries, Middle East, Americas, Europe, Africa and Oceania.

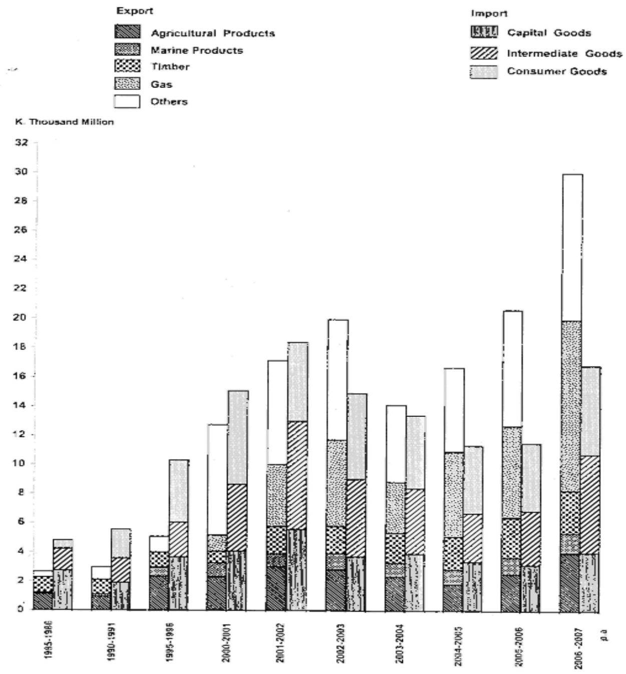


Figure 2.8: Value of foreign trade

Foreign investments

Foreign investors can set up their business in Myanmar either in the form of one hundred percent foreign investment or as a joint venture with any partner (an individual, a private company, a cooperative, a society or a state-owned enterprise). In all joint ventures, the minimum share of the foreign party is 35 percent of the total equity capital.

(Figure 2.8 and 2.9) show foreign investment of Permitted Enterprises from 1990 to 2007, number of Enterprises and Foreign Investments in million US$.

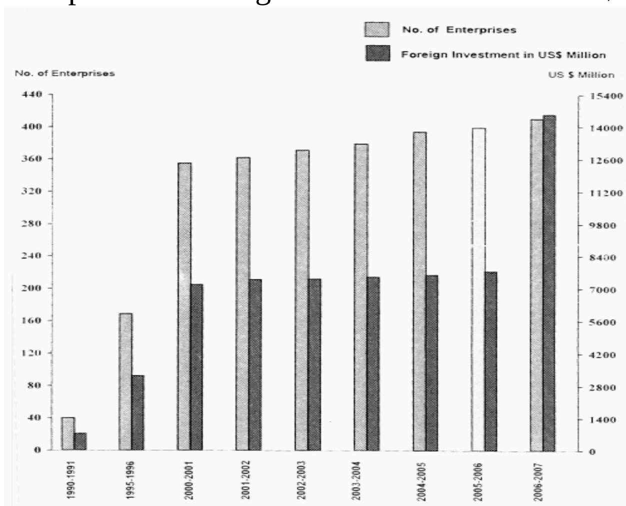


Figure 2.9: Foreign investment of permitted enterprises

2.4. Some of the Major Sectors which Support the National Development

The major sectors are Energy, Electric Power, Transport and Communications, Agriculture and Livestock and Fisheries and Forestry. A brief account of each of these sectors is presented below.

Energy

Myanmar is richly endowed with renewable and non-renewable energy resources that are being exploited by the state sector with the participation of local and foreign investors. The exploitation, development, production and transportation of crude oil and natural gas are the responsibility of Myanmar Oil and Gas Enterprise (MOGE) which operates oil and gas fields both on land and offshore.

Oil producing fields are mostly located in the central part of Myanmar and in Pyay District. Myanaung oil field produces crude oil and natural gas, while in Pyay oil field some new discoveries have been made from the sub thrust zone. MOGE has discovered more gas pools near *Aphyauk*, a small village in Taikkyi Township in Yangon Region. The *Aphyauk* oil field is now providing natural gas for power generation and industrial uses in Yangon and Pyay. Since 1989 MOGE has signed agreements on production sharing contracts with multinational oil companies to explore and produce petroleum in several onshore and offshore areas. Potentials for further exploration and development exist in Hukaung Basin, Chindwin Basin, Shwebo-Monywa Plains, Salin Basin, Central Myanmar Basin, Rakhine Coastal Plain and the Sittaung Basin.

In respect of offshore exploration of oil and gas, several foreign companies have been drilling for oil and gas like Yadana Offshore Oil Company in the Gulf of Moattama offshore area, Shwe Oil Enterprise in Rakhine offshore area, the Yetagun Oil Company in Tanintharyi Offshore area

The development of the energy sector during the period from 1988 to 2009 has been as shown in (Table 2.13 and 2.14).

Table 2.13: Development of energy sector of the whole nation from 1988 to 2009

Sr	State/Region	Unit	1988	2009	Progress
1.	Oil Field Exploration				
	(A) Oil Field (Onshore)	Field	19	31	12
	(B) Oil Field (Offshore)	Field	-	5	5
	Total	Field	19	36	17
2.	Oil and Natural Gas Pipeline Length				
	(A) Onshore	km	403.97	3,169.53	2,765.56
	(B) Offshore				
	(Under Water)	km	-	550.62	550.62
	(C) Offshore				
	(Onland)	km	-	135.24	135.24
	Total	km	403.97	3,855.39	3,451.42
3.	Crude Oil Production				
	(A) Offshore	Bbl	-	3,044,414	3,044,414
	Total	Bbl	6,165,641	6,279,880	1,14,239
4.	Natural Gas Production				
	(A) Offshore	mmscf	-	348,131	348,131

Industries and factories

In 2008, the total number of factories (industries) was 14 including 3 crude oil refineries, 5 chemical fertilizer factories, 1 methanol factory. 1 tar factory and 1 carbon dioxide factory.

Electric power

In 1988 electric power supply for the whole country was 273 million Kwh but it increased to 7,508 million

Table 2.14: Energy exploration of states and regions in Myanmar (Comparison between 1988 and 2009)

Sr	State/Region	Unit	1988	2009
1	Taninthayi Region			
	-Crude Oil Production	bbl	-	3,044,414
	(offshore)			
	-Natural Gas Production	mmscf	-	141,807
	(Offshore	mm^3		
2	Magway Region			
	-Oil Field(Onshore)	field	10	20
3	Yangon Region			
	-Crude Oil Production	bbl	-	2,823
	(Onshore)			
	-Natural Gas Production	mmscf	-	865.96
		mm^3		
4	Ayeyarwady Region			
	-Crude Oil Production	bbl	178,435	220,271
	(Onshore)			
	-Natural Gas Production	mmscf	15,972.23	22,523.20
	(Onshore)	mm^3		
	-Natural Gas Production	mmscf	-	206,342
	(Offshore)	mm^3		

Note: mmscf = million standard cubit feet bbl = barrel

Kwh in 2008. It was due to the construction of 4,115 hydroelectric power stations of various sizes throughout the country. At present, 23 projects are on-going while another 23 stations have been programmed for future construction.

The following (Table 2.15) shows the progress in electric power production from 1985/86 to 2006/2007.

Table 2.15: Production of electric power (1985-86 to 2006-07)

S.N.	Year	Production (Million Kwh) Generation	Unit loss	Departmental Use	Net Production	Cost of Production (000 Kyats)	Unit Cost (Pya)
1	1985-1986	2119.37	630.86	28.98	1459.53	385195	26.39
2	1990-1991	2643.05	934.28	33.57	1675.20	812892	48.53
3	1995-1996	3762.33	1437.21	62.75	2262.37	1771341	78.30
4	2000-2001	5117.64	1747.84	101.86	3267.94	22610627	691.89
5	2001-2002	4688.98	1549.57	98.51	3040.90	16166237	531.63
6	2002-2003	5067.95	1491.67	92.19	3484.09	10261249	294.52
7	2003-2004	5425.88	1498.18 (r)	78.04 (r)	3849.66	11600728 (r)	301.34
8	2004-2005	5608.24	1618.68	80.38	3909.18	9648221	246.81
9	2005-2006	6064.16	1593.29	118.21	4352.66	13336809	306.41
10	2006-2007	6164.15	1726.81	82.35	4354.99	99163940	2277.02

Note : Kyat 1 = 100 Pyas

Sources : 1. Myanma Electric Power Enterprise.
2. Electricity Supply Enterprise.
3. Yangon Electricity Supply Board.
4. Hydropower Generation Enterprise.

Transport and communication

Transport and communication include airways, inland waterways, railways, road transport, sea and coastal shipping, Yangon city transport and post and telecommunication.

Public transport

Public transport is carried out by means of air planes, buses of different categories, railways, ships, boats and motor-cycles. All the vehicles are run either by government, government/private joint ventures, private and private companies. Railway transport is solely run by the State.

Air-ways

The airlines in Myanmar are operated both by the government and the private. The Myanmar Airways International is run by the government. Private airlines include Air Bagan Ltd., Air Mandalay Ltd., and Yangon Airways.

There are altogether 69 Airports in Myanmar. Jet airplanes can land at 37 airports. The international airplanes land at Nay Pyi Taw, Yangon and Mandalay International Airports.

Railways

Railway transport is the most used after road transport in Myanmar. Myanmar Railways started even before the Second World War under the British Colonial Rule. The system was and is still a very efficient transport system. Out of 14 States and Regions, only Chin States doesn't have railway transport. In the year 2008, the total length of railways in the country has reached 5,155 km. The main trunk line is between Yangon and Mandalay. Just in the middle of Yangon Mandalay railway is located the new capital city of Myanmar, the Nay Pyi Taw. Now the railway lines have fanned out from Nay Pyi Taw in all directions. The second trunk line is between Mandalay and Myitkyina which is the capital of Kachin State in the north. The following tables (Tables 2.16, 2.17, and 2.18) show overview of railway sector, railways under construction and upcoming projects.

Table 2.16: Rail transportation sector

Sr.	Particular	1988	2008	Progress
1.	Passenger trains (run)	243	412	169
2.	Cargo train (run)	18	21	3
3.	Engine (unit)	239	319	80
4.	Railroads (km)	3,181	5,321	2,140
5.	Rail track (km)	4,497	7,087	2,590
6.	Railway station (unit)	487	840	353
7.	Rail bridge (unit)	5,650	10,627	4,977
8.	Number of passengers (million per year)	48.8	67	18.2
9.	Tonnage of transported goods (million per year)	1.5	3	1.5

Table 2.17: New railroads under construction

Sr.	Railroad section	Kilometer
1.	Thayet-Kyunchaung	295
2.	Katha-Bhamo	158
3.	Mongnai-Kengyun	364
4.	Pyawbwe-Natmauk-Kanpya-Magway	153
5.	Dawei-Myeik	213
6.	Yechanpyin-An-Minbu	395
7.	Pathein (Begayet)-Nyaungdon-Yangon (Hlinethaya)	140
8.	Pyay (Shwedaga)-Toungoo (Kyetaw) – Nay Pyi Taw	193
9.	Hinthada –Nyaungdon	77
	Total (km)	1,988

Table 2.18: New railroads project to be implemented

Sr.	Road section	Kilometer
1.	Bago-Kayan-Thonegwa-Thanlyin (Okkphosu)	108
2.	Lashio-Muse	233
3.	Kalay-Tamu	136
	Total (km)	**477**

Roads

Road construction works were apparently speed up during the period between 1988 and 2008. According to 2008 statistics, the total length of the roads in Myanmar reached up to 31,076 km.

Bridges

Bridges have been built and roads constructed, crisscrossed all over the country enabling access even to very remote places in the country. Improved accessibility is most evident in the Ayeyarwady Delta which was formerly accessible only by inland water transport. It is now accessible by means of road transport through many bridges across rivers and big streams constructed from 1988 to 2008. As of 2008, total bridges over 55m in length number 233 while bridges under 55m number 2,913.

Table 2.19: The list of bridges built from 1988-2008

Sr.	State/ Region	Under (55m) (number)	Over (55m) (number)
1.	Kachin State	413	18
2.	Kayah State	24	1
3.	Kayin State	187	7
4.	Chin State	17	3
5.	Sagaing Region	408	16
6.	Tanintharyi Region	116	7
7.	Bago Region	171	18
8.	Magway Region	164	19
9.	Mandalay Region	212	11
10.	Mon State	131	4
11.	Rakhine State	259	36
12.	Yangon Region	66	30
13.	Shan State (East)	168	4
14.	Shan State (South)	185	5
15.	Shan State (North)	80	7
16.	Ayeyarwady Region	312	47
	Total	**2,913**	**233**

Inland water transport

The Inland Water Transport (IWT) existed even before the Second World War. The system still functions well. The transport system functions in all the navigable rivers and streams. The Ayeyarwady river system is still an important waterway. Passenger boats, cargo boats, etc. run up and down Ayeyarwady River between Yangon and Mandalay. Ayeyarwady delta river transport system still is very important regardless of bridges and improved road transport. Agricultural produce such as rice, fruits, and vegetables and also fish and fish products are daily transported by water to Yangon and other towns in the country.

In the Rakhine, Delta and Tanintharyi coastal regions the transport is provided by small ships and Ocean liners running up and down along the coasts

Post and telecommunication

Post and Telecommunication Department under the Post and Communication Enterprise render the telecommunication services for the whole country. Currently, the automatic telephone exchange system, the cellular mobile telephone system, the Code Region Multiple Access (CDMA) mobile telephone system and the Global System for Mobile Communication (GSM) system are being applied in the country. Myanmar Post and Telecommunication Enterprise has also been providing internet and email services to the public since March 1998.

Agriculture, livestock and fishery sector

Agriculture

"Development of agriculture as the base and all- round development of other sectors of the economy as well "is one of the main economic objectives of the nation. Thus, the agriculture sector is the main stay of Myanmar economy.

About 60 different crops can be grown ranging from typical tropical species to moderate temperate varieties including cereals such as rice, wheat, maize, millets, beans, pulses and oilseeds, and industrial crops such as cotton, jute, rubber, sugarcane, toddy palms, coconut palms, tobacco and spices and many other edibles and non-edibles.

In 1988 agricultural land area was 9.63 million ha and the fallow land area left was 10.56 m ha. At that time the area under rice cultivation was 4.78 m ha and the descending trend of rice production was estimated at 13.15 million metric tons approximately.

Increase in population growth required increase in cultivation of agricultural crops. In 1992-93 a revolutionary approach was laid down in Agricultural

Sectorarl plans and imperative tasks to develop the sector were launched.

Agricultural research has developed new improved varieties of rice. Starting from year 2008-2009, high grade varieties and hybrid varieties are under cultivation.

Among the extended production of various peas and bean export, varieties such as green gram, mug pea, pigeon pea, cow pea, kidney bean, etc., are included. The area planted with various peas and beans increased to 4,119,444 ha. The area under good yielding varieties has increased to 2,482,558 ha. New varieties of beans such as green gram, pigeon pea and mug pea are grown in place of old poor varieties.

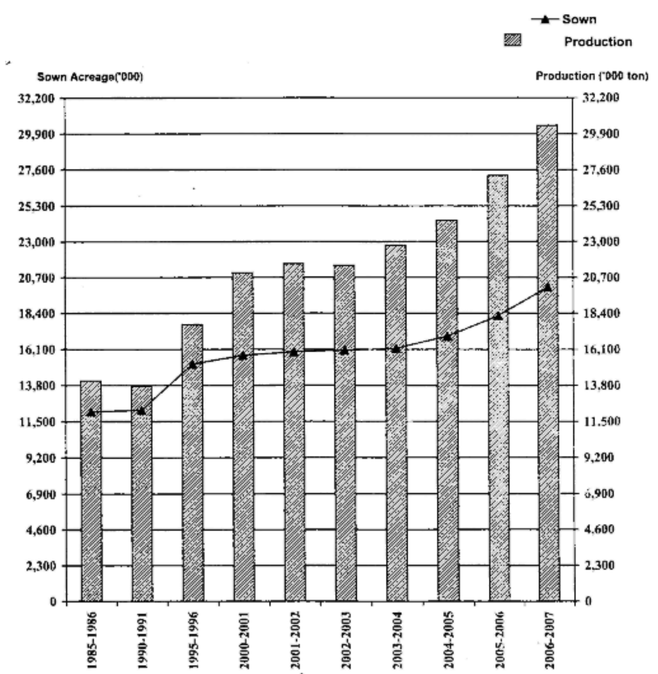
Up to 1988 there were only 138 dams, and irrigated cultivation was only 0.53 million ha. Multiple crop acreage was 1.54 m ha only. During the period of 20 years (from 1988-2008) the number of dams and reservoirs increased by 217. Artisan wells, surface wells and small dams were constructed in places where irrigation channels could not reach.

There are 322 river water pumping stations constructed in order to irrigate the land which can be cultivated. Multiple crop system has increased to 8.05 m ha. Monsoon paddy cultivation has increased to nearly 6.88 million ha and summer paddy to 364,217 ha totaling more than 7.24 million ha making Myanmar a rice bowl of Asia. The production of rice has increased from 1,000 million baskets to 1,230 million baskets in 2008-09. The rice production in Myanmar has increased to the extent that some states and regions have now ample supply of rice. Furthermore, the production and export of industrial crops, oil seeds, peas and beans have increased since 2008-09.

The increase in cultivated area and production of paddy is shown in (Table 2.20 and Figure 2.10).

Table 2.20: Agricultural development in Myanmar

Type	Unit	1988	31-12-2008	Increase/Decrease (-)
Land Resources				
1. Sown Area	Hectare	9,639,943	21,534,006	11,894,063
2. Uncultivated area	Hectare	11,415,638	5,914,914	(-)5,500,724



Source: Statistical Year Book, CSO2006

Figure 2.10: Sown acreage and production of paddy

Livestock and Fishery

Myanmar possesses a huge amount of marine and fresh water resources such as fish, crabs, prawns, etc. Water and land pollution is minimal creating ample breeding grounds and high population growth of the fauna. Ayeyarwady, Chindwin, Than Lwin Rivers and their tributaries make up 8.2 million ha of water surface. Annual water covered area is 6 million ha' and reservoirs and lakes irrigation system covers about 1.8 million ha.

Livestock industry is administered by the Ministry of Livestock and Fisheries, establishing commercial standard of livestock farms in Myanmar. Major livestock in Myanmar include water buffaloes, cattle, sheep, goats, pigs, chicken, ducks, turkeys, Muscovy ducks and quails. There is a marked increase in the number of livestock from 1988 to 2008.

The production of fish and prawns also increased during 1998 to 2008.

The livestock and fishery sector is one of the most productive sectors and it holds vast potential for further expansion and exports of the products.

Livestock breeding of pedigree stock of cattle, buffalo, pig, sheep, goat, poultry, etc forms an integral part of the rural economy. Ownership of the livestock is characterized by small individual herds and flocks. Cattle and buffaloes are reared primarily for use in cultivation of agricultural crops while pigs and poultry are raised for household consumption.

Fishery sector is divided into fresh water fisheries and marine fisheries. Fresh water fisheries make use of natural water, while flood fisheries are made possible through vast river systems and heavy rainfall. There are also leasable fisheries which cover vast areas. Fish culture operations are presently being undertaken extensively in ponds, lakes and reservoirs.

Myanmar's continental shelf covers 228,781 km^2 while the exclusive economic zone is 486,000 km^2 wide. Its maximum sustainable yield (MSY) in marine fisheries is estimated at 1.05 million tons per year, and is still underexploited.

Forest industry

Timber harvesting, milling and marketing

The hardwood industry was nationalized on 1 October 1963. At present, MTE (Myanma Timber Enterprise) is solely responsible for the extraction of both teak and other hardwoods. MTE extensively uses elephants (about 3,000) and buffaloes (about 1,200) for stumping and skidding of logs. Mechanized logging is minimal because of difficult terrain and low per unit area yield under the selection system.

Wood and wood products

Myanmar produces a wide range of wood and wood products, ranging from firewood to high class furniture. Export of teak and hardwood is increasing, but that of value-added products still needs to be promoted. Supply and demand situation of wood and wood products is shown in (Table 2.21).

Table 2.21: Supply and demand of wood and wood products

Particulars	Woodfuel ('000 metric tons)	Industrial ('000 metric tons)	Sawnwood ('000 metric tons)	Pulp for paper ('000 metric tons)	Paper and paperboard ('000 metric tons)	Wood-based panels ('000 cubic meter)
Production	37,560	4,196	1,056	15	43	118
Consumption	37,560	2,720	781	16	82	68
Export	0	1,476	275	0	0	54
(Import)	0	0	0	-1	-39	-4

Myanmar initiated a market-oriented economic system following 1988 and private wood-based industries consequently started to grow after 1990. However, timber harvesting and export of logs by the private sector was banned in 1993, but it was allowed to work in partnership with MTE and to export value-added wood products only. With the aim to develop wood-based industries, Myanmar Forest Products and Timber Merchants' Association (MFPTMA) was formed on 11 May 1993. The Association encourages timber merchants to produce value-added wood products by providing them with technical know-how and market information. Under the motivation of MFPTMA, 1,207 entrepreneurs from production, manufacturing and marketing enterprises have been registered as of 2007. More than 100 wood-based industries have already been established in Yangon and Mandalay industrial zones.

Wood-based industries produce and export mostly furniture and parts, parquet, doors and door frames, and four sides plains (S4S). As ordered by foreign customers, curving chair, garden furniture and indoor furniture are also made. Among the value-added wood-based products, finger joint panel is a product which saves wastes. Although Myanmar entrepreneurs' efforts are to be highly regarded, improvement seems unsatisfactory as yet. According to MFPTMA, Myanmar produces 1.4 million tons of teak and hardwood annually, exports about 0.8 million tons and earns US$ 400 million. A breakdown of types of industry in Myanmar is shown in (Table 2.22).

Table 2.22: Types of wood-based industries in Myanmar

No.	Type of Factory	Number of Factory		
		Private	MTE	Total
1.	Plywood	1	5	6
2.	Finger Joint	1	-	1
3.	Particle Board	-	1	1
4.	Molding	-	3	3
5.	Furniture	1,588 *	5	1,593
6.	Pencil	1	-	1
7.	Match	-	-	-
8.	Saw Mill	228	91	319
	Grand Total	**1,819**	**105**	**1,924**

Source: MFPTMA
Notes: * small-scale home industries

Up to now, round logs, especially teak logs, are the main export item among wood and wood products although Myanmar Industrial Development Plan has envisaged to gradually reduce round log exports and increase supply to domestic wood-based industries.

More than 95 percent of Myanmar timber is exported to Asian countries which include about 80 percent exported to five major trading partners namely India, Thailand, China, Singapore and Malaysia. Except Singapore, which mostly re-exports to other countries, other countries use Myanmar timber domestically.

Figure 2.11: Transit of round logs to foreign countries.


Chapter 3 National Greenhouse Gas Inventory

3.1 Introduction
3.2 Energy Sector
3.3 Industrial Processes and product Use Sector
3.4 Agriculture Sector
3.5 Land Use Change and Forestry Sector
3.6 Waste Sector
3.7 GHG inventory in Myanmar for the year 2000

Chapter 3

National Greenhouse Gas Inventory

3.1. Introduction

The National Commission for Environmental Affairs (NCEA) of Myanmar launched an INC-project in 2008 with the financial assistance from GEF/UNEP. Greenhouse Gas (GHG) inventory and mitigation option analysis team (GHG study team), established in January 2008 is one of the six expert groups who are working for INC preparation under this project. GHG study team successfully accomplished national GHG inventories for 2000 in energy, industrial processes and product use, agriculture, forestry and other land use, and waste sectors. The team made a particular initiative in the context of improving and updating the reliable data on GHG emission/absorption in Myanmar.

The inventory chapter highlights only the main features of Myanmar's GHG inventory, which identifies the potential GHG sources and sinks and provides estimates of major GHGs in Myanmar for year 2000. The GHG inventories on emissions by sources and removals by sinks covers carbon dioxide (CO_2), methane (CH_4) and Nitrous Oxide (N_2O), and Non-Methane Volatile Organic Carbon (NMVOC).

GHG study team conducted the national inventory on GHGs by setting the year 2000 as the base year, and prepared the database for each sector and predicted the GHG emission/reduction in inventoried sectors. In estimating GHG emissions for the year 2000, the experts used the published information on GHG sources and sinks to a great extent. However, research and studies concerning the climate change issues are limited and the country specific emission factors/default values are not available in Myanmar. Therefore, the GHG inventory in this study mostly used the emission factors and default values as described in IPCC 2006 Guidelines.

3.2. Energy Sector

The national GHG inventory in energy sector covers three major GHGs: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The main sources of GHG emissions examined are fossil fuel combustion, traditional biomass fuel combustion, fugitive emissions from coal mining activities, and oil and natural gas system.

Methodology for GHG inventory

The methodologies provided by the IPCC 2006 Guidelines for national GHG Inventories were applied in this inventory. Based on the actual conditions in Myanmar, analysis was made for the applicability of the IPCC methods to Myanmar and the appropriate approaches were selected. In the calculating CO2 equivalent, Global Warming Potentials(GWPs) used were CO=1,CH4=21,N20=310 and NOx=5.

Since there are no country specific emission factors in Myanmar for emission assessment, default values suggested by IPCC 2006 guidelines were used whether in net calorific value estimation or in CO_2 emission studies or in fractions of carbon oxidization. Emissions from the use of fossil fuels from international bunkers are excluded in the current national GHG estimations. Therefore, CO_2 emissions from international aviation fuel burning are not accounted for in the national inventory.

For estimating GHG emissions, the IPCC 2006 Guidelines, Tier 1 and Tier 2 were used depending on the quality and availability of activity data and emission coefficients as required by each approach. The inventory simultaneously adopted the reference approach and sectoral approach based on detailed information on technologies as recommended by the IPCC Guidelines. The sectoral approach was used as the basis for the current inventory. The classification of sectors and fuel types are basically the same as the classification in the IPCC Guidelines in which the transport sector is defined as the transport of the whole society.

In the case of natural gas consumption in energy industries sector, Tier 1 approach was applied. In

Another major sector contributing to GHG emissions was transportation. The transport sector was segregated into road, rail, aviation and navigation. CO_2 emission for all these sectors was estimated by using Tier 1 method and as for CH_4 and N_2O emission for road and air sub sector, Tier 2 method was employed.

In the light of Myanmar's specific circumstances and data availability, the IPCC Tier 1 was adopted to estimate methane emissions from coal mining such as surface and underground mining activities and also the fugitive methane emissions from oil and gas systems in Myanmar.

GHG Emissions from fuel combustion

The current inventory of GHG emissions from energy consumption took into account all emissions from fossil fuel combustion.

Fossil fuel combustion

Fuel combustion, one of the largest contributors to GHG emissions in Myanmar, can be broadly categorized into four groups for emission assessment, i.e. energy industries, manufacturing industries and construction, transport and other sectors having emissions from energy consumption.

Myanmar's commercial energy resources depended almost fully on hydropower and fossil fuels. The emission sources in the sector of electric power and heat supply were defined to be the power generation and heat supply of Myanmar's thermal power utilities while the emissions from auxiliary power plants and other sources of heat supply were reported in the relevant sectors. Machineries and equipments for fossil fuel combustion composed of gas turbines and combined cycle power plants, power generating boilers, industrial boilers, industrial kilns, household cooking ovens, farm implements, power-generation internal-combustion engines, different kinds of aviation vehicles, road transport vehicles, railway transport vehicles, shipping transport vehicles, etc.GHG emission by fossil fuel combustion in Myanmar for the year 2000 was estimated to be 7,755.11 Gg CO_2e (Table 3.1) in which energy industry and transport sectors shared the largest contributions.

Table 3.1: GHG emissions from fossil fuel combustion in Myanmar in 2000 (Gg)

Categories	CO_2	CH_4	N_2O	Total CO_2 e
Energy Industry	2,323.02	-	-	2,323.02
Industry & Construction	784.83	-	0.08	809.63
Transport	2,129.98	0.46	0.1	2,170.64
Commercial & Institutional	888.55	-	-	888.55
Residential	42.87	-	-	42.87
Agriculture/Forestry/Fishery	596.9	-	0.1	627.9
Others	892.5	-	-	892.5
Total emissions from fossil fuel combustion	7,658.65	0.46	0.28	7,755.11

Traditional biomass fuel combustion

It mainly consists of fuel-wood consumed for domestic home cooking. About 95 percent of the rural households uses fuel-wood for their home cooking. Some urban households use saw mill residues (wood waste) and charcoal.

The total volume of fuel-wood, wood waste and charcoal used in the year 2000 amounted to 26,010,600 m^3, 418,517 m^3 and 254,800 m^3 respectively. Total volume of each of the fuels was converted to total biomass by multiplying it by its basic density. The average basic densities of woods and timbers and charcoal were taken as 0.595 ton m^{-3} and 0.425 ton m^{-3} respectively.

GHG emissions from the above mentioned fuels were calculated by the Net Calorific Values (NCV) and default emission factors for stationary combustion in the energy industries given in IPCC 2006 Guidelines. Total CO_2 emission, total CH_4 emission and total N_2O emission for fuel-wood and wood-waste were estimated to be 27,475.3 Gg, 7.3595 Gg and 0.9813 Gg, respectively.

Similarly, total emissions of CO_2, CH_4 and N_2O for charcoal amounted to 357.79 Gg, 0.0958 Gg and 0.0128 Gg respectively.

Finally, total CO_2 equivalent emissions from traditional biomass burned for energy was calculated and it was found to be 28,297.82 Gg CO_2e.

According to IPCC 2006 Guidelines, the total GHG emissions from traditional biomass burned for energy were included neither in the energy sector nor in the national totals.

Fugitive emissions from oil and natural gas systems

Only methane emissions were calculated from oil and natural gas systems. Methane emissions from oil and natural gas systems were estimated to be 4.63 Gg (97.23 Gg CO_2e).

Fugitive emissions from coal mining activities

Only methane emissions were calculated from coal mining activities of Myanmar. Methane emissions from underground mining and surface mining were estimated at 0.53 Gg (11.13 Gg CO_2e) (Table 3.2).

Table 3.2: Estimated CH_4 emissions from coal mining in 2000

Type of mining	Exploited coal (ton)	Emission coefficient	Conversion coefficient	Methane emission (Gg)
Underground mining	36,650	18	0.67	0.44
Surface mining	109,900	1.2	0.67	0.09
Total				**0.53**

Total GHG emissions from energy sector for the year 2000

Total GHG emissions from energy sector of Myanmar were estimated to be 7,863.47 Gg CO_2e most of which came from fossil fuel combustion. CO_2 emissions accounted for 97 % of total emissions while CH_4 and N_2O emissions shared only 2% and 1% respectively (Table 3.3). GHG emissions by different sub-sectors are presented in Figure 3.1.

Table 3.3 : Total GHG emissions from energy sector in 2000 (Gg)

No.	Emission sources	CO_2	CH_4	N_2O	Total CO_2 e
1	**Fuel Combustion**				
	- Fossil fuel combustion	**7,658.65**	**0.46**	**0.28**	**7755.11**
	- Traditional biomass fuel combustion*	**27,475.3***	**7.36***	**0.98***	**28297.82***
2	**Fugitive emissions from coal mining**	-	**0.53**	-	**11.13**
3	**Fugitive emissions from oil and gas systems**	-	**4.63**	-	**97.23**
	Total	**7,658.65**	**5.62**	**0.28**	**7,863.47**

*Not included in national GHG inventory calculations.

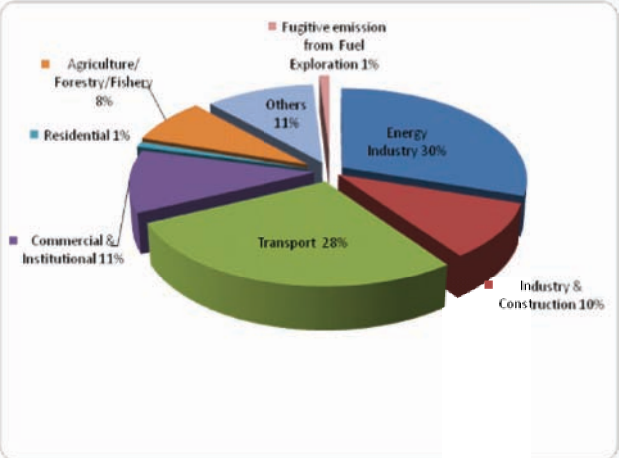


Figure 3.1: Proportions of GHG emission (CO_2- equivalent) from various sources in energy sector

Database for energy sector

Database for fuel production, import, export and fuel consumption by the whole energy sector and fuel consumption by sub-sectors, and database for traditional biomass fuel burned are presented in Appendix I .

Database for GHG emissions in energy sector during 2001-2005 indicated that GHG emission in each sub-sector depended on the annual target of the concerned sub-sector. CO_2 emissions in energy and transformation industries and industry sectors have shown an increasing trend while those of small combustions were seen as a decreasing trend (Table 3.4).

Trend of GHG emissions in energy sector

CO_2 emissions depend on the type and amount of energy consumed, and energy consumption is closely linked to the socio-economic development of a country. Hence, projection of CO_2 emissions from the energy sector is based mainly on projections of the population and economic growth of a country over a specific period in the future. Besides, other GHGs are also emitted from a number of activities that use energy such as residential and commercial cooking, space heating, industrial processes, transportation and so on. Energy use in Myanmar is increasing faster in the transportation sector than in any other sector. Increase in transportation energy use is a clear

Table 3.4: Emissions from Energy Sector (Gg)

	2000	2001	2002	2003	2004	2005
Energy and transformation industries						
CO_2	2,323.02	2,118.25	2,430.94	2,756.17	3,734.13	3,050.16
Industry						
CO_2	784.83	865.39	889.92	866.07	961.44	695.03
N_2O	0.08	0.06	0.07	0.07	0.06	0.06
Transport						
CO_2	2,129.98	1,980.12	2,486.63	2,608.35	2,504.92	2,432.82
CH_4	0.46	0.42	0.48	0.54	0.55	0.67
N_2O	0.1	0.09	0.12	0.12	0.12	0.11
Small combustion						
CO_2	1,528.30	1,428.30	1,417.08	1,406.97	1,177.10	1,333.94
N_2O	0.1	0.08	0.08	0.07	0.07	0.07
Traditional biomass burned for energy* (not included in calculations)						
CO_2	27,833.09	28,545.25	29,177.07	30,125.50	30,204.63	30,801.48
CH_4	7.46	7.65	7.82	8.07	8.09	8.25
N_2O	0.99	1.02	1.04	1.08	1.08	1.1
Fugitive emissions from fuels						
CH_4	0.53	0.35	0.42	0.61	0.83	0.73
Oil and natural gas						
CH_4	4.63	4.8	5.12	5.41	6.59	6.76
Others						
CO_2	892.52	363.82	331.1	425.92	248.53	454.3
Total CO_2 e	**7,863.47**	**6,944.15**	**7,765.79**	**8,281.84**	**8,870.99**	**8,212.01**

indication of a large amount of carbon emissions because virtually all energy requirements of this sector are in the form of petroleum products. The growing population, increased urbanization and industrialization are accelarating the growth in the ownership of motor vehicles, refrigeration and air conditioning and various energy intensive products. These are some of the main factors underlying the rapidly increasing greenhouse gases.

The relatively low per capita CO_2 emissions from the energy sector is due to the fact that Myanmar relies predominantly on hydropower generators for industrial, residential and commercial uses. Electricity generation by hydroelectric power plants was 1,248.45 million KWh. This was approximately 47 percent of the total generation in 1990. In year 2005 electricity generation by hydroelectric power plants increased to 2,407.75 GWh. With this rate of hydropower development, the emissions from the energy and transformation industries subsectors will not increase significantly. Fluctuations in the trend are largely driven by emission from energy industry. This category can show year to year fluctulations because of the use of thermal stations to supplement the hydroelectric generation. CO_2 emissions are found to increase significantly with the diversification of the country's energy base, thermal power plants that have become absolutely necessary with the decline in the output of hydropower generation as a result of decreasing precipitations in the catchment areas.

3.3. Industrial Processes and Product Use Sector

GHG emissions from various types of industrial processes are not energy-use related emissions. These emissions are related to physical and chemical transformations of materials, in which GHGs such as CO_2, CH_4, N_2O and other gases are released. The preparation of the industrial processes inventories was basically based on the IPCC methodology.

Industrial production processes produce various types of GHGs apart from energy combustion in industries. These processes involve the chemical or physical transformation of raw materials into intermediate or final products. GHG emissions were worked out for industries namely, cement, lime, iron and steel, glass, urea, calcium carbide used in acetylene, food and beverages.

Cement production

CO_2 emission during the production of cement is one of the most important GHG emission sources from the industrial sector in Myanmar. All the cement factories in Myanmar use its own clinker to produce cement. There are no imports or exports of clinker. Two types of cement are produced in Myanmar. The majority of the cement produced is Portland cement of which the production is over 99 percent. The raw mixture is initially finely ground and fed into a kiln in order to obtain thermal stations to supplement the hydroelectric generation.

The clinker is there after ground with gypsum in order to obtain finished cement. High temperatures in cement kiln chemically change raw material lime into cement clinker and thereby emit carbon dioxide. CO_2 emission from cement production is obtained by using an emission factor expressed in tons of CO_2 released per ton of cement produced.

Lime production

For lime production, the inventory was conducted using the activity data of mineral production. Limestones are exploited by mining activities rather than production industry in Myanmar. Therefore, fugitive emissions could have occurred, but no proper data are available.

The amount of lime produced is generally governed by the demand. Therefore, the total amount of lime consumed per year could be approximated to the total annual production. The amount of lime produced could be estimated to be 0.57 t lime/t of dolomite used and an emission factor of 0.77 tCO_2 of lime produced. The usage of dolomite for the production of lime stood at 39.93 kt in 2000. For lime production, the inventory used the activity data of industrial raw mineral production.

Glass production

Industries which manufacture glass emit CO_2. The total production of glass in Myanmar in 2000 was 15,031 tons. The emission factor for the glass industry was 0.21 t CO_2/t of glass produced.

Metal production

Metal production includes the production of metals such as iron and steel. The quantity of iron and steel produced in 2000 was 2.7 and 7.6 kt respectively. Emission factors were the default values recommended by the IPCC 2006. For iron production, default CO_2 emission factor from pig iron production was used and as for steel production, CO_2 emission was calculated by electric arc furnace steel making method.

Food and drink

NMVOC are emitted in preparing some foods in the sector. GHG emissions were worked out for food industries, namely, alcoholic beverages, sugar, shrimp and biscuit. Emission of NMVOC in 2000 was estimated to be 4.57 Gg.

Consumption of Halocarbons and Sulphur hexafluoride

Introduction of HFCs to replace ozone-depleting substances (ODS) to Myanmar commenced in 1997, but there are no records of import of these chemicals for the year 2000. ODS such as CFCs and HCFCs have been used by refrigeration and air conditioning service during the phase down period of ODS. Mobile air conditioners, both locally manufactured and imported, use HFCs as refrigerants. ODS substitutes are also used in refrigerators, air conditioning and cold storages. Emissions of ODS substitutes were estimated using the default method recommended by the IPCC.

Electrical equipments using SF_6 have been imported to Myanmar since 1984. Emissions of SF_6 per year have been estimated using the default method recommended by the IPCC.

Lubricant use

Lubricants are mostly used in industries and transportation. The use of lubricants in internal combustion engines is primary for their lubricating properties and associated emissions are, therefore, considered as non-combustion emissions. A small proportion of lubricants are oxidized during use. Therefore, in calculating CO_2 emissions, the total amount of lubricant lost during their use was assumed to be fully oxidized as CO_2 emission. Specific quantities of lubricant used as motor oil / industrial oil and ODU factor for lubricants were based on local knowledge.

Total GHG emissions from Industrial processes and product use sector in 2000

A total of 463.3 Gg of CO_2-equivalent and 4.57 Gg of NMVOC is estimated to have been emitted during the year 2000 from the industrial processes and product use (Table 3.5).

Table 3.5: GHG emissions from Industrial Processes and Product Use in the year 2000

Sources of Category	CO_2	NMVOC	ODS	SF_6	Total CO_2e	%
Industrial processes						
Cement	203.23				203.23	44
Lime	30.74				30.74	7
Glass	1.74				1.74	0
Urea	0.8				0.8	0
Iron & Steel	4.34				4.34	1
Food & Drink		4.57				
Product Use						
Carbide for Acetylene Production	0.35				0.35	0
Refrigeration & Air Conditioning	-		0.11		143	31
Electrical Equipment	-			0.003	71.7	15
Lubricant Use	7.39				7.39	2
TOTAL	**248.6**	**4.57**	**0.11**	**0.003**	**463.3**	**100**

Database and trend of GHG emissions for industrial processes and product use sector

Database for production in different industrial processes of Myanmar is presented in Appendix II.

The emissions from industrial processes and product use sector for the years 2000-2005 showed a rising trend in general (Table 3.6).

Table 3.6: Emissions from Industrial Processes and Product Use sector (Gg)

	2000	2001	2002	2003	2004	2005
Industrial Processes						
CO_2	241.2	225.9	227.17	336.02	302.77	292.01
NMVOC*	4.57	4.84	4.29	3.52	3.66	3.17
HCFCs/CFCs	0.11	0.08	0.09	0.12	0.18	0.11
SF_6	0.003	0.003	0.003	0.003	0.003	0.003
Solvent Used						
CO_2	7.39	6.26	6.98	7.13	6.52	6.33
Total CO_2 equivalent	**463.3**	**407.9**	**422.9**	**570.9**	**615**	**513**

3.4. Agriculture Sector

Agriculture

Since Myanmar is an agro-based country, its economy mainly depends on agricultural production. Agriculture sector contributed 34 % of GDP, 23 % of total export earnings, and employed 63 % of labor force in 2000. Seventy percent of the population reside in rural areas and are mainly engaged in agriculture, livestock and fishery sectors for their livelihoods. The net sown area was 10.12 million ha which is only one-fourth of the total land area of Myanmar. Most farmers traditionally grow rice in monsoon season as a single cropping system under the rain-fed condition. Since 1988, the Government has been constructing dams and reservoirs across the country to irrigate the paddy fields. The irrigation projects completed during 1988 to 2000 totaled 116. Irrigated area increased from 12.5 % of the sown area in 1987-88 to 18 % in 1998-99. Summer paddy program was introduced in 1992. In the year 2000, together with the use of high yielding, short duration varieties in summer (pre-monsoon) season, the total rice sown area reached 6,302,306 ha of which the irrigated rice land was 1,852,691 ha (29.4 % of the total rice land in Myanmar) (DAP, 2001).

Rice is a staple food and it grows well in all agro-ecological regions of Myanmar. Flooded rice fields act as a major emitter of CH_4, which is one of the potent greenhouse gases for global warming. The production of methane from paddy fields, ruminant animals, fertilizer application, land clearing and organic matter decomposition have been linked to global warming as GHG.

Estimation of CH_4 emission from rice fields

According to the specific conditions in water availability and soil condition for cultivation, rice ecosystems are generally classified into five categories: 1) Irrigated rice land, 2) Regular/favorable rain-fed lowland, 3) Drought-prone rain-fed lowland, 4) Deep water rice and 5) Upland rice which respectively covered about 30%, 38 %, 12%, 17% and 3% of total rice area in the year 2000 (Myanmar Agriculture Service Annual Report, 2004). Tier 1 method in 2006-IPCC guideline was adopted with the use of default emission and scaling factors. Applying the equations and worksheets described in the 2006-IPCC Guidelines, CH_4 emission from rice cultivation in 2000 was estimated to be 507.23 Gg CH_4 yr^{1}, which irrigated rice contributed to the largest share with 220.46 Gg (43.46%) (Table 3.7).

Table 3.7: CH_4 emissions from flooded rice fields of different rice ecosystems in 2000

No.	Rice ecosystems	Harvested area (ha)	CH_4 (Gg yr-1)	% of total emission
1	Irrigated Rice	1,852,691	220.46	**43.46**
2	Regular Rain-fed Rice	2,432,690	134.62	**26.54**
3	Drought-prone Rain-fed Rice	756,276	34.75	**6.85**
4	Deep water Rice	1,071,392	117.4	**23.15**
	Total	**6,302,306**	**507.23**	**100**

Estimation of N_2O from agricultural soils

N_2O is an important GHG produced in agricultural soil by microbial processes of nitrification and denitrification. Increased N inputs to agricultural soils have greatly increased N_2O emission. It was recognized that upland fields that favor both nitrification and denitrification processes promote N_2O formation. Therefore, the significant contribution to global N_2O production from upland agriculture was well recognized in the past few decades.

The total N_2O emission from agricultural soils in the year 2000 was estimated to be 8.2 Gg N_2O yr^{-1} of which direct N_2O emissions and indirect N_2O emissions were 7.45 Gg N_2O yr^{-1} and 0.75 Gg N_2O yr^{-1}, respectively (Table 3.8).

Crop residue burning

Use of crop residues for animal feed and fuel wood are common for the smallholder farmers across Myanmar. Farmers usually burn down the residues of previous crops and weeds at the land clearing time (e.g paddy, wheat, corn and sugarcane) However, the practice of burning and the amount of burning materials vary from region to region, and even plot to plot. In the dry zone of central Myanmar where the animal feed and fuel are scarce, the residues of paddy, pulses, peanut and corn are used for cattle feeding and those of sesame, pigeon pea, cotton are for household fuel and jaggery industry.

For the estimation of GHG emissions from burning of field residues, sugarcane, rice, wheat and corn were included, and others were assumed to be insignificant for field burning. With the adoption of Tier 1, IPCC 2006 Guidelines, the emissions of CH_4, CO, N_2O and NO_x in 2000 were estimated to be 0.024, 0.81, 0.0006 and 0.022 Gg yr^{-1} respectively.GHG emissions from the agricultural sector for the year 2000 are summarized in Table 3.8.

Database and trend of GHG emission for the agricultural sector in Myanmar

The basic information on the harvested area and production of four major crops, the total harvested area, variety of rice in terms of growing period and irrigation types for the years 1990, 1995, 2000, and 2001-2005 is presented in Appendix III. Database for the use of fertilizers and the annual burning of crop residues in agriculture sector is also presented.
The trend of GHG emissions from agriculture sector for the years 1990, 1995, 2000, and 2001-2005 is presented in Table 3.9. CH_4 and N_2O emissions in agriculture sector during 1990-2005 tended to rise because of increased agricultural land and area increased fertilizer input.

Livestock sector

Livestock is used for draft power, means of transportation, capital, credit, meat, milk, social value, hides and sources of organic fertilizer for seasonal cropping. Livestock-crop holding have been in the hands of resource-poor farmers for many decades and will remain so for many years to come. In general, farming systems in Myanmar include traditional rice cultivation, field crop production, and livestock rearing (especially buffalo or cattle or both). Livestock in Myanmar mostly consume the agricultural crop resisues and farm by- products.

Feed resources are scarce and quality is poor especially during dry season, which results in low productivity.

Myanmar relies heavily on draft cattle population to promote agricultural expansion. Land cultivation is mostly done with the use of draught cattle and buffaloes. Draft cattle are also very useful as means of transport in the rural areas. Dairy cattle are bred to produce dairy products for domestic consumption.

Chicken, pigs, ducks, sheep and goats are raised for domestic consumption. Data for horses, mules and asses population in Myanmar were obtained from LBVD. Livestock population as per Statistical Yearbook 2007 is shown in Table 3.10.

Table 3.8: Total GHG emissions from agriculture in 2000

Source	CH_4 (Gg)	CO (Gg)	N_2O (Gg)	NO_x (Gg)	Total GHG emissions* CO_2 eq. (Gg)
1. Rice cultivation	507.23	-	-	-	10651.8
2. Emission from agricultural soils	-	-	8.2	-	2542
(a) N_2O Direct emissions	-	-	*7.45*	-	*2309.5*
(b) N_2O Indirect emissions	-	-	*0.75*	-	*232.5*
3. Field burning of crop residues	0.024	0.81	0.0006	0.022	1.61
TOTAL	507.254	-	8.2006	0.022	13195.41

Enteric fermentation

Emission sources of methane by animals were in conformity with the emission sources defined by the IPCC. Methane emissions mainly came from the enteric fermentation of ruminants, including dairy cattle, non-dairy cattle, buffalo, goat, sheep, horse, donkey and mule/ass. At the same time, methane emission from swine was also taken into consideration. IPCC 2006 Tier 1 method was adopted to estimate CH_4 and N_2O emissions from enteric fermentation and manure management in the livestock sector.

Considering its key source category status, an attempt was made to estimate the CH_4 emission coefficient for cattle and buffalo. For this purpose, the cattle and buffalo populations have been divided into dairy and non-dairy categories, with different age groups (LBVD 2000).

To estimate CH_4 emission from the livestock sector, coefficients for cattle and buffalo from India's initial national communication 2004 were used, because Myanmar's cattle and buffalo breeding and feeding system as well as breed characterization are very similar to India.

Table 3.9: Estmation of GHG emissions from agriculture sector

Years	1990	1995	2000	2001	2002	2003	2004	2005
Emissions from Rice Cultivation (Gg)								
CH_4	349.33	485.18	507.23	514.06	511.32	523.69	540.09	589.81
Emissions from Agricultural Soils (Gg)								
N_2O	5.53	7.07	8.2	8.53	8.67	9.05	9.49	10.19
Emissions from Field Burning of Agricultural Residues (Gg)								
CH_4	0.0174	0.0214	0.024	0.0249	0.0247	0.0255	0.0264	0.0282
N_2O	0.0004	0.0006	0.0006	0.0006	0.0006	0.0007	0.0007	0.0007
NO_x	0.0161	0.0198	0.022	0.0231	0.0229	0.0236	0.0245	0.0262
CO	0.5913	0.729	0.81	0.8488	0.843	0.8696	0.9003	0.9623
Total ($Gg\ CO_2\ e$)	**9,051.39**	**12,381.94**	**13,195.41**	**13,441.23**	**13,427.08**	**13,804.73**	**14,285.58**	**15,546.81**

Table 3.10: Animal population census (number in millions)

No.	Kind of Animal	2000-01
1	Cattle	10.98
2	Buffalo	2.44
3	Sheep & Goat	1.8
4	Pigs	3.97
5	Poultry	55.21

Manure management

The inventories of CH_4 and N_2O emissions from animal manure management systems involved 11 main domestic animals and poultry (swine, non-dairy cattle, dairy cattle, buffalo, goat, sheep, camel, donkey, mule/ass, horse and chicken). Among them, emissions from manure management systems for swine, non-dairy cattle, goat, sheep and chicken were the key sources. Based on the data availability and the importance of the emission sources, methods were determined for calculating CH_4 and N_2O emissions from animal manure management systems. Since there have been no actual measurements for emissions factors, Tier 1 method with default emission factors of the IPCC 2006 guidelines was applied (Table 3.11).

Table 3.11: Emission coefficients for CH_4 emission in livestock sector

Animal type	Enteric fermentation, kg/head-year	Manure management, kg/head-year
Dairy cattle	43	31
Non-dairy cattle		
0-1 yr	9	1
1-3 yr	23	1
Adult	32	1
Dairy buffalo	50	31
Non-dairy buffalo		
0-1 yr	8	2
1-3 yr	22	2
Adult	44	2
Sheep	5	0.2
Goat	5	0.22
Horses	18	2.19
Mules and Asses	10	1.2
Swine	1	7
Poultry	-	0.02

Total GHG emission from livestock in 2000

CH_4 emissions from the livestock sector from the year 1998 to 2002 increased by 1.25%. annually. The inventory was conducted mostly using 2000 as the base year. CH_4 emissions from enteric fermentation and manure management were 404.43 Gg and 52.07 Gg, respectively, resulting the total methane emission value of 456.50 Gg . The greatest amount of methane (27.82 Gg), was released from manure management of swine followed by non-dairy cattle (Table 3.12).

Table 3.12: Total GHG emission from livestock in 2000

No	Kind of Animal	CH4 Emissions	
		Enteric fermentation (Gg)	Manure management (Gg)
1	Cattle	305.43	17.1
2	Buffalo	83.78	5.39
3	Sheep	1.95	0.08
4	Goats	7.08	0.31
5	Horses	2.11	0.26
6	Mules and asses	0.1	0.01
7	Swine	3.97	27.82
8	Poultry	-	1.1
	Sub-total	404.43	52.07

Database and trend of GHG emissions for livestock sector of Myanmar

Database for total livestock population, and milk production in livestock sector of Myanmar during 1990-2005 is presented in Appendix IV. Methane and N_2O emissions in livestock sector during 1990-2015 are presented in (Table 3.13).

CH_4 and N_2O emissions in livestock sector during 2000-2005 tended to rise because of increased number of livestock.

Table 3.13: Estimation of GHG emission from livestock sector

GHG	1990	1995	2000	2001	2002	2003	2004	2005
CH_4 (Gg)	378.38	404.83	456.5	469.29	484.11	495.49	506.49	519.23
N_2O (Gg)	0.14	0.17	0.2	0.21	0.22	0.23	0.24	0.25
Total (Gg CO_2e)	7990.79	8554.35	9648.31	9919.57	10233.98	10476.59	10709.42	10980.15

3.5 Land Use Change and Forestry Sector

The forest resource assessment (FRA 2005) conducted by the Food and Agriculture Organization (FAO) in cooperation with the Forest Department(FD) of Myanmar has indicated that Myanmar is still endowed with a forest-covered area of 52% of the country's total land area of 676,577 km^2. This is one of the highest forest cover in the Asia-Pacific Region. Closed forests (i.e. good forests) account for 37.4%, while open forests constitute 14.9%. The forest types and areas, along with the respective IPCC-classifications, are shown in (Table 3.14).

Table 3.14: Forest types and areas in Myanmar in 2000

Forest type (Myanmar)	Forest Type (IPCC)	Area (ha)	% of total forest area
Tropical ever green forest	Tropical rain forest	5,528,640	16
Mixed deciduous forest	Tropical moist deciduous forest	13,476,060	39
Dry forest	Tropical dry forest	3,455,400	10
Dipterocarps forest	Tropical dry forest	1,727,700	5
Hill and temperate evergreen forest	Subtropical mountain system	8,984,040	26
Beach and dune forest	Tropical rain forest	1,382,160	4
TOTAL		34,554,000	100

The annual increases in biomass carbon stocks in the land use change and forestry sector were calculated for the following categories:

1. Natural forests
2. Forest plantations
3. Home garden trees
4. Roadside trees

Annual increase in biomass carbon stocks by natural forests

Annual increase in biomass carbon stocks by natural forests of Myanmar for the year 2000 was calculated by using Equation 2.9 of IPCC 2006 Guidelines. Increase of carbon stocks (including aboveground and belowground biomass) in the forest land remaining as forest land in Myanmar for the year 2000 was estimated to be 35,410.53 Gg of Carbon (129 838.59 Gg of CO_2) (Table 3.15).

Annual increase in biomass carbon stocks by forest plantations

Forest plantations established by departmental taungya system accounted for 658 595 ha during the period 1963 to 2000. The planted species included Teak (*Tectona grandis*), Pyinkado (*Xyia xylocarpa*), Padauk (*Pterocarpus macrocarpus*), Tinyu (*Pinus spp*), Eucalypt (*Eucalyptus spp*) and others.
Based on these values, increases in carbon stocks of forest plantations with different species were calculated. Since the documented data for the present status on the total area of the forest plantations are not available, it is assumed that all the forest plantations established during the period 1963 to 2000 are still maintained.

Increase of carbon stocks (including above- and below-ground biomass) of the forest plantations in Myanmar for the year 2000 was estimated to be 3,204.56 Gg of Carbon(11,750.04 Gg of CO_2 (Table 3.15).

Annual increase in biomass carbon stocks by home garden trees

Home gardens are common in Myanmar and they play an important role in fulfilling household requirements. Based on the available data from different studies, average number of trees in each home garden, planted species, number of households (rural and urban), and average growth rate were collected and annual biomass growths in home gardens calculated.

Annual increase in biomass carbon stocks by home garden trees in Myanmar for the year 2000 was estimated to be 128. 55 Gg of Carbon (470.07 Gg of CO_2). (Table 3.15)

Annual increase in biomass carbon stocks by roadside trees

Total length of roads in the Union of Myanmar in 2000-2001 was estimated to be about 28,600 km. The number of roadside trees were calculated based on the total length of the roads, the spacing between the planted trees and the rows, and later converted to plantation areas (Woodlots are not included). The aboveground biomass growth was again estimated by using Equation 2.9 and 2.10 in IPCC 2006. Species composition, growth rates of the common species planted and age of the roadside trees were taken into account in determining the default values. Annual increase in biomass carbon stocks by roadside trees of Myanmar in 2000 was estimated to be 44.32 Gg of Carbon (162.49 Gg of CO_2) (Table 3.15).

(a) Total annual CO_2 removal by different activities for the year 2000

Total annual increase in biomass carbon stocks by different activities in the land use change and forestry sector for the year 2000 was estimated to be 38,787.96 Gg of carbon (142,221.19 Gg of CO_2). The summary for the annual increase in biomass carbon stocks by different activities in Myanmar for the year 2000 is shown in (Table 3.15).

Annual decrease in biomass Carbon Stocks

Annual decreases in biomass carbon stocks due to biomass losses for the year 2000 were calculated for the following activities:

1. Loss of carbon by wood removal
2. Loss of carbon by harvested wood products (HWP)
3. Loss of carbon by fuelwood removal
4. Biomass burning following land clearing
   (i) Site preparation for forest plantations
   (ii) Shifting cultivation
   (iii) Deforestation

Loss of carbon by wood removal

Total amount of industrial roundwood harvested in the year 2000 was 2,161,980 m^3 (CSO, 2007). Annual carbon loss in biomass by wood removal (ie. industrial roundwood) for the year 2000 was estimated to be 2,177 Gg of carbon.

Table 3.15: Annual increase in carbon stocks and annual CO_2 removals in 2000

Activity	Annual increase in carbon stocks (Carbon, Gg)	Annual carbon dioxide removal (Carbon dioxide, Gg)	Percentage to total CO_2 removal (%)
Natural forests	35, 410.53	129, 838.59	91.3
Forest Plantations	3,204.56	11,750.04	8.26
Home Garden Trees	128.55	470.07	0.33
Roadside Trees	44.32	162.49	0.11
TOTAL	**38,787.96**	**142,221.19**	**100**

Loss of carbon by harvested wood products

Harvested Wood Product (HWP) is defined as wood-based material harvested from forests, they are used for products such as furniture, panel board and paper and paper-like products or for energy. HWPs exclude, however, logging residues that are left at harvested sites.

Since the technical details and complexity of HWP accounting and its role in climate change mitigation have made the topic incomprehensible, the HWP contribution for the year 2000 was assumed to be zero for this study.

Loss of carbon by fuelwood removal

Annual carbon loss in biomass by fuelwood removal was calculated by using Equation 2.13 of IPCC 2006. The default values for calculations were taken from (Table 4.3), (Table 4.4) and (Table 4.5) of IPCC 2006.

Total amount of fuelwood production in Myanmar for the year 2000 was 33,442,200 m^3 (CSO, 2007). Fuelwood removal volumes were converted to aboveground and belowground biomass. Finally, annual carbon loss in biomass of fuelwood removal for the year 2000 was calculated.
Annual carbon loss in biomass by fuelwood removal in Myanmar for the year 2000 was estimated to be 26,936.418 Gg of carbon (CO_2 emissions from fuelwood and charcoal combustion were calculated and described in the energy sector) (Table 3.16).

Biomass burning following land clearing

GHG emissions from burning following forest clearing were estimated by using Equation 2.27 of IPCC 2006.

Since Taungya system and shifting agriculture are commonly distributed in various ecological zones of Myanmar and reliable data on biomass stock for burnt areas were not available, the default value for the amount of fuel actually burnt was assumed to be 42.2 tons dry matter ha^{-1-} (Table 2.4 of IPCC-2006).

Site preparation for forest plantations

The total forest plantation area established in 2000 was 30731 ha. Forest plantations in Myanmar are established for different purposes viz. commercial, local supply (fuel-wood), industrial, watershed conservation, etc. During land preparation, not all the selected areas are burnt (eg. watershed conservation plantations). The actual burnt area for site preparation in the year 2000 was 23,277 ha.

GHG emissions from biomass burning for site preparation of the forest plantations for the year 2000 were estimated to be 1,863.207 Gg CO_2 equivalent (Table 3.17).

Shifting cultivation

In this study, typical shifting cultivated areas (forest areas that were slashed and burnt for growing cash crop but left for natural regeneration after some years,

Table 3.16: Annual decrease in carbon stocks and GHG emissions by different activities in 2000

Activity	Loss of carbon	GHG emission	Remark
Wood removal	2,176.888 GgC	Not accounted	Not all the wood products are burnt
Harvested wood products	Not estimated	Not accounted	Not needed to calculate in Tier 1 level
Fuelwood removal	26,936.418 GgC	Accounted	GHG emissions are further estimated in Energy sector but not included in the National Totals
Site preparation for forest plantations	-	1,863.207 GgCO_2e	
Shifting cultivation	-	1,200.674 GgCO_2e	
Deforestation	-	37,340.974 GgCO_2e	

Table 3.17: GHG emissions by different activities in 2000

Activity	Emissions					Total (CO_2 equivalent)
	CO_2 (Gg)	CO (Gg)	CH_4 (Gg)	N_2O (Gg)	NO_x (Gg)	(Gg)
Forest plantations	1, 552.017	102.158	6.68	0.196	1.572	1,863.21
Shifting cultivation	1 ,000.140	65.832	4.304	0.127	1.013	1,200.67
Deforestation	31,104.35	2,047.38	133.867	3.937	31.498	37,340.97
TOTAL	**33,656.51**	**2 ,215.365**	**144.851**	**4.26**	**34.083**	**40,404.86**

and that do not change permanently to other land use) where the natural vegetation could lead to a new forest were accounted for the estimation. The average annual area burnt for shifting cultivation for the year 2000 (forest land remaining as forest land) was 15,000 ha yr^{1-} (FD, 2000).

GHG emissions from biomass burning by shifting cultivation for the year 2000 were estimated to be 1,200. 674 Gg CO_2 equivalent (Table 3.17).

Deforestation

GHG emissions from deforestation share the largest portion of the GHG emissions in land use change and forestry sector of Myanmar. Deforestation in the year 2000 was 466,500 ha (FRA 2005). All the deforested areas were not burnt. However the reliable data on the land use change pattern (from forest land to grassland, cropland, settlement, water body, etc) was not available. Therefore, all the deforested lands were assumed to be burnt in this study for conservative estimation.

GHG emissions from biomass burning by deforestation for the year 2000 were estimated to be 37,340.974 Gg CO_2 equivalent (Table 3.17).

(b) Total GHG emissioins by different activities for the year 2000

The activities responsible for annual decrease in biomass carbon stocks in land use change and forestry sector could be divided into two groups. One is the activity which caused the annual decrease in carbon stocks but could not be accounted for direct GHG emission (eg. wood removal); another was the activity which could be accounted for direct GHG emission (eg. biomass burning). GHG emissions by selected activities in this study are shown in Table 3.16.

In this study, the greenhouse gas emissions in the land use change and forestry sector for the year 2000 were be estimated to be 40 404.855 Gg CO_2e. The activities and their GHG emissions are shown in (Table 3.17).

(c) Net CO_2 emissions/ removals in 2000

Total annual increase in biomass carbon stocks in the forestry sector by natural forest, forest plantations, home garden trees and roadside trees accounted for 38, 787.61 Gg of carbon, which means the land use change and forestry sector of Myanmar had removed 142,221.19 Gg of CO_2 from the atmosphere in year 2000.

On the other hand, total carbon loss by wood removal, fuelwood removal and HWP accounted for 29,113.31 Gg of Carbon. The total GHG emission by biomass burning following land clearing was estimated to be 40,404.855 Gg of CO_2e.

Therefore, the net annual CO_2 removals of the land use change and forestry sector of Myanmar for the year 2000 were estimated to be 101 816.38 Gg of CO_2e. The summary for the net CO_2 emissions/ removals for the year 2000 is shown in Table 3.18 .

Database and trend of GHG emission / removals for the land use change and forestry sector

Following the same approach as in calculating GHG emissions and removals for the Year 2000, those for the years 1990, 1995 and 2001 to 2005 were calculated. The database for each source/sink category in land use change and forestry sector is presented in Appendix V. Net CO_2 emissions/ removals during 1990-2005 in the forestry sector are summarized in Table 3.19.

Table 3.18: GHG emissions / removals from land use change and forestry sector in 2000

Activity	CO_2 emissions (Gg)	CO_2 removals (Gg)	Net CO_2 emissions/ removals (Gg)
Natural forests	-	129,838.59	(-) 129,838.59
Forest plantations	1,863.21	11,750.04	(-) 9,886.833
Home garden trees	-	470.07	(-) 470.07
Roadside trees	-	162.49	(-) 162.49
Wood removal	-	-	-
Fuelwood removal	(Energy sector)	-	-
Harvested wood products (HWP)	-	-	-
Shifting cultivation	1,200.67	-	(+) 1,200.674
Deforestation	37,340.97	-	(+) 37,340.974
TOTAL	**40,404.86**	**142,221.19**	**(-) 101,816.38**

Table 3.19: Summary for net CO_2 emissions / removals

Year	Total annual CO_2 emissions (Gg)	Total annual CO_2 removals (Gg)	Total net annual CO_2 emissions/removals (Gg)
1990	40 ,855.26	154 ,034.90	(-) 113 ,179.64
1995	40 ,784.58	147 ,906.36	(-) 107 ,121.78
2000	40 ,404.85	142 ,221.23	(-) 101 ,816.38
2001	40 ,445.35	141 ,015.22	(-) 100,569.87
2002	40 ,425.18	139 ,825.50	(-) 99 ,400.32
2003	40 ,384.44	138 ,674.57	(-) 98 ,290.13
2004	40 ,447.27	137 ,473.85	(-) 97 ,026.58
2005	40 ,484.01	136 ,258.74	(-) 95 ,774.73

Net GHG removal in land use change and forestry sector shows a major carbon sink. CO_2 removal by land use change and forestry sector can compensate the total emission by different sectors. However, the trend of net GHG removal during 1990-2005 has pointed out the constant decline because of decrease in natural forest area.

3.6. Waste Sector

GHG emissions from solid waste, domestic and commercial wastewater were estimated for the waste sector in Myanmar following the IPCC 2006 Guidelines. Like in most developing countries, only very limited information was availabled on waste quantities and waste management practices. Therefore, the methane emissions from the waste sector were estimated mainly from population data in urban areas.

For the activity data, Municipal Solid Waste obtained from Yangon City Development Committee (YCDC) and the Statistical Year Book of Myanmar were applied in the calculations.

Methane emissions from waste sector was estimated from two different categories, namely (1) disposal of solid waste and (2) treatment of domestic and commercial wastewater.

Solid Waste

Waste includes agricultural waste (mainly crop residues), livestock waste (farming manure), industrial waste and domestic/municipal waste.

Urban infrastructural services and the wastes generated in the urban areas produce GHGs due to decomposition of organic materials. However, in the cities and large towns, solid waste is decomposed by land filling, especially in low-lying areas located in sub-urban areas. Due to the piling of waste over years, anaerobic conditions develop and hence these dumping sites generate large quantities of biogas containing a fairly large amount of methane.

In rural areas and small towns, there is no systematic waste management system. It can be assumed that no CH_4 is generated as anaerobic conditions do not develop in these areas.

As the waste generated in the rural part is typically scattered in the agricultural fields rather than in solid waste disposal sites, they tend to decay aerobically generating extremely low CH_4 emissions. Hence, only the urban population was taken into account for the estimation of solid waste in this chapter.

Total population in Myanmar in 2000 was 50.125 millions of which the population in urban area was 15.03 million. In general, amount of solid waste was about 0.278 kg per capita according to the calculation of YCDC. It was also assumed that total generated wastes were 1,514.12 Gg and 80 %(1,211.9 Gg) were taken to the Solid Waste Disposal Site (SWDS) in the year 2000.

Waste incineration is the combustion of solid and liquid waste in controlled incineration facilities. It was assumed that about 8 percent of waste collected was incinerated and open-burned in sub-urban townships and quarters. Information on basic data such as amount of waste, waste sorting, and waste treatment practice were not available. Therefore emissions from incineration and open burning were not included in this study.

Biological treatments of solid wastes, that are composting and anaerobic digestions of organic waste, such as food waste, waste from gardens and parks and sludge, are common both in developed and developing countries.The advantages of biological treatments include reduced volume in the waste material, stabilization of the waste, destruction of pathogens in the waste material, and production of biogas for energy use. However, they are not yet practiced in Myanmar. The dumping of these solid wastes released 133.31 Gg of CH_4, equivalent to 2,799.51Gg of CO_2 emitting into the atmosphere.

Wastewater

Emissions from domestic and commercial wastewater treatments were estimated according to the IPCC 2006 Guidelines, in which the urban population and default values were applied. It was assumed that 30% of total population (15.3 million) lived in urban areas in the year 2000.

CH_4 emission from domestic and commercial wastewater was estimated to be 0.083 Gg in 2000. Degradable Organic Component (DOC) for 1000 persons per year and the fraction of DOC removed as sludge were 14,600 kg and 0.09 respectively in the calculation. Total methane emission from domestic and commercial wastewater and sludge was estimated to be 1.257 Gg and 1.198 Gg respectively.

Methane emission from waste sector in 2000

For the year 2000, the total methane emissions from waste sector were estimated to be 134.57 Gg. of which the disposal of solid waste contributed 133.31 Gg (99 %), and domestic and commercial wastewater treatment contributed 1.198 Gg (1%) of CH_4 emission.

Database and trend of GHG emission for waste sector

Data for total CH_4 emissions from the disposal of solid waste contributed and domestic and commercial wastewater were described in Table 3.20.

The trends of estimated methane emissions from waste sector of Myanmar were increasing due to the increase of total population especially in urban area.

Table 3.20 Estimation of CH_4 emission for waste sector

Year	From SWDs	From Domestic & Commerical waste-water	From Sludge	Total Emissions
2000	133.31 Gg	1.198 Gg	0.059 Gg	134.57 Gg
2001	136.05 Gg	1.222 Gg	0.060 Gg	137.206 Gg
2002	138.01 Gg	1.240 Gg	0.061 Gg	139.311 Gg
2003	141.59 Gg	1.272 Gg	0.063 Gg	142.925 Gg
2004	144.396 Gg	1.297 Gg	0.064 Gg	145.757 Gg
2005	147.32 Gg	1.320 Gg	0.065 Gg	148.70 Gg
2010	157.32 Gg	1.420 Gg	0.070 Gg	159.44 Gg
2015	172.690 Gg	1.550 Gg	0.076 Gg	174.30 Gg
2020	188.650 Gg	1.700 Gg	0.083 Gg	190.40 Gg

3.7. GHG inventory in Myanmar for the year 2000

GHG emissions in Myanmar for the year 2000

Summary of GHG emissions in Myanmar for the year 2000 is presented in Table 3.21 with a total net emission amounting to – 67,820.5 Gg CO_2e. Total CO_2 emission in Myanmar for the year 2000 was estimated to be 41,563.75 Gg.

Emissions from energy sector have been estimated at 7,863.47 Gg CO_2e. Emissions from traditional biomass burned for energy accounted for 28,297.82 Gg CO_2e. However, these emissions are not included in the calculation of national totals since they are far less than the total net emissions and within the range of sustainability. It was reported only for information in this study.

CH_4 was emitted from agriculture and livestock sector emitted 963.73 Gg of CH_4; forestry sector produced the largest amount of GHG emissions of 40,404.73 Gg CO_2e.

GHG removals in Myanmar for the year 2000

Due to the biomass growth in natural forests, forest plantations, road side trees and home garden trees, land use change and forestry was the only sector which absorbed CO_2 in the country amouting to142,221.19 Gg. The country's net emissions turned out to be -67,820.50 Gg CO_2e (67.8 million tons of CO_2). Therefore, Myanmar can be said to be a green city owing to its vast extent of natural forests.

Table 3.21.Summary Table: GHG emissions and removals in Myanmar in 2000

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 Emissions (Gg)	CO_2 Removals (Gg)	CH_4 (Gg)	N_2O (Gg)	CO (Gg)	NO_x (Gg)	NMVOCs (Gg)	SO_x (Gg)	SF_6 (Gg)	ODS (Gg)
Total national emissions and removals	41563.75	142221.2	1248.79	12.94	2216.18	34.1	4.57	-	0.003	0.11
1. Energy	7658.65	-	5.62	0.28	-	-	-	-	-	-
A. Fuel conversion (sectoral approach)										
1. Energy Industries	2323.02	-	-	-	-	-	-	-	-	-
2. Manufacturing industries and construction	784.83	-	-	0.08	-	-	-	-	-	-
3. Transport	2129.98	-	0.46	0.1	-	-	-	-	-	-
4. Other sectors										
(Commercial institution)	888.55	-	-	-	-	-	-	-	-	-
(Residential)	42.87	-	-	-	-	-	-	-	-	-
(Agriculture/Forestry/Fishery)	596.9	-	-	0.1	-	-	-	-	-	-
5.Other (please specify)	892.5	-	-	-	-	-	-	-	-	-
B. Fugitive emissions from fuels										
1. Solid fuels (Coal mining)	-	-	0.53	-	-	-	-	-	-	-
2. Oil and natural gas	-	-	4.63	-	-	-	-	-	-	-
2. Industrial processes	241.2	-	-	-	-	-	4.57	-	0.003	0.11
A. Mineral products	32.48	-	-	-	-	-	-	-	-	-
B. Chemical industry	0.8	-	-	-	-	-	4.57	-	-	-
C. Metal production	4.34	-	-	-	-	-	-	-	-	-
D. Cement production	203.23	-	-	-	-	-	-	-	-	-
E. Production of halocarbons and sulphur hexafluoride										
F. Consumption of halocarbons and sulphur hexafluoride										
G. Other (please specify)										
(Carbide for acetylene production)	0.35	-	-	-	-	-	-	-	-	-
(Refrigeration & air conditioning)	-	-	-	-	-	-	-	-	-	0.11
(Electrical Equipment)	-	-	-	-	-	-	-	-	0.003	-
3. Solvent and other product use	7.39	-	-	-	-	-	-	-	-	-
4. Agriculture	-	-	963.75	8.4	0.81	-	-	-	-	-
A. Enteric fermentation	-	-	404.43	0.1743	-	-	-	-	-	-
B. Manure management	-	-	52.07	0.0257	-	-	-	-	-	-
C. Rice cultivation	-	-	507.23	-	-	-	-	-	-	-
D. Agricultural soils	-	-	-	8.2	-	-	-	-	-	-
E. Prescribed burning of savannahs										
F. Field burning of agricultural residues	-	-	0.024	0.0006	0.81	-	-	-	-	-
G. Other (please specify)	-	-	-	-	-	-	-	-	-	-
5. Land-use change and forestry	33656.51	142221.19	144.85	4.26	2215.37	34.08	-	-	-	-
A. Changes in forest and other woody biomass	2552.157	11750.04	10.983	0.323	167.99	2.582	-	-	-	-

B. Forest and grassland conversion	31104.35	-	133.867	3.937	2047.38	31.498	-	-	-	-
C. Abandonment of managed lands	-	129838.59	-	-	-	-	-	-	-	-
D. CO_2 emissions and removals from soils	NE	NE								
E. Other (please specify)										
(Home gardens)	-	470.07	-	-	-	-	-	-	-	-
(Road side trees)	-	162.49	-	-	-	-	-	-	-	-
6. Waste	-	-	134.57	-	-	-	-	-	-	-
A. Solid waste disposal on land	-	-	133.31	-	-	-	-	-	-	-
B. Waste water handling	-	-	1.257	-	-	-	-	-	-	-
C. Waste incineration	-	-	-	-	-	-	-	-	-	-
D. Other (please specify)	-		-	-	-	-	-	-	-	-
7. Other (please specify)										
Memo items										
International bunkers										
Aviation										
Marine										
CO_2 emissions from biomass	27475.3	-	7.36	0.98	-	-	-	-	-	-

* Traditional biomass fuel combustion: Not included in national GHG inventory calculations.

Notes: Shaded cells do not require entries.

[a] The following standard indicators should be used, as appropriate, for emissions by sources and removals by sinks of GHgs: **NO** (not occurring) for activities or processes that do not occur for a particular gas or source/sink category within a country, **NE** (not estimated) for existing emissions and removals which have not been estimated, **NA** (not applicable) for activities in a given source/sink category which do not result in emissions or removals of a specific gas, **IE** (Included elsewhere) for emissions and removals estimated but included in elsewhere in the inventory (Parties should indicate where the emissions or removals have been included), **C** (confidential) for emissions and removals which lead to the disclosure of confidential information.

[b] Do not provide an estimate of both CO_2 emissions and CO_2 removals. “Net” emissions (emissions – removals) of CO_2 should be estimated and a single number placed in either the CO_2 emissions or CO_2 removals column, as appropriate. Note that for the purpose of reporting, the signs for removals are always (-) and for emissions (+).

The Trend of GHG emissions in Myanmar

The trend analysis in Energy Sector, including industrial processes and product use, for the short term (2000-2005) indicated many fluctuations in estimating GHG emission. The main GHG sources in the sector include energy industries and transportation which are responsible for most CO_2 emissions. Thus, the industrial and economic development will largely influence the GHG emissions from energy sector. NMVOC, ODS, SF_6 emissions also show substantial amount. However, those GHGs are covered by Montreal Protocol and have to be deducted from industrial sector. Thus, the trend for NMVOC, ODS, SF_6 emissions are expected to be decrease.

The trends for GHG emissions in agriculture and livestock sectors clearly highlighted a sharp increase in short-term (2000-2005) periods. Due to the increase in the net sown area and more inputs in agricultural systems and the increased domestic animals in livestock sector, the CH_4 and N_2O emissions are likely to increase.

Waste sector also shows increase in CH_4 emissions due to the population growth and increased urban population. The CH_4 emission is likely to drastically increase for both short- and long- terms.
Land use change and forestry sector was the major GHG emitter in the country. The major emissions came from deforestation, shifting cultivation and land clearing for forest plantations.

The total annual CO_2 removals by natural forests are declining steadily due to deforestation and degradation. Since forests constitute both a source and a sink of CO_2, vitally important that they are protected, conserved and manged in a sustainable manner.

Appendix I: Energy Sector Database

Table 3A1.1: Energy Sector Database: Fuel production, import and export

	2000	2001	2002	2003	2004	2005
Production						
Crude oil (gal)	144,693,019	168,687,423	223,357,902	250,602,772	261,735,659	278,850,523
Sub-bituminous coal (Ton)	146,583	97,239	115,175	169,728	230,384	201,830
Natural gas (dry mmcf)	299,388	310,502	331,419	349,965	426,171	437,729
Import						
Crude oil (gal)	106,581,618	218,934,181	101,034,966	8,637,051		
Gasoline (gal)	12,236,000					
Diesel (gal)	117,333,000					
Export						
Petroleum Coke (Ton)	32,951	33,457	34,510	25,160	21,686	19,515
Natural Gas (mmcf)	246,425	242,787	295,598	304,600	353,408	368,913

Table 3A1.2: Energy Sector Database: Fuel consumption (TJ)

	2000	2001	2002	2003	2004	2005
Gasoline	15,327.48	13,867.23	14,593.62	16,899.61	16,899.60	16,908.56
Jet Kerosene	1,293.09	1,293.09	1,293.09	1,293.09	1,293.09	1,293.09
Residual fuel oil	5,861.48	4,992.53	6,110.50	5,386.09	4,633.81	3,893.72
LPG	712.25	730.51	721.19	596.37	558.35	463.38
Diesel oil	48,741.16	39,259.07	45,049.61	44,349.38	38,603.01	41,113.34
Sub-bituminous Coal	1,296.97	3,423.92	2,623.09	3,106.32	4,854.53	4,894.06
Natural gas (dry)	41,698.39	37,477.68	43,095.36	48,831.25	66,466.94	52,397.01
Solid Biomass	248,509.71	254,868.29	260,509.87	268,977.70	297,684.23	275,013.21

Appendix I: Energy Sector Database

Table 3A1.3: Energy Sector Database: Fuel consumption by sub-sectors (TJ)

	2000	2001	2002	2003	2004	2005
Energy and Transformation Industries						
Natural Gas (dry)	41,616.62	37,997.02	43,019.12	48,749.48	66,301.21	50,805.92
Industry and Construction						
Gasoline	171.75	141.02	134.52	117.73	132.99	128.23
Residual fuel oil	5,861.48	4,992.53	6,110.50	5,386.09	4,633.81	3,893.72
LPG	25.59	25.26	26.15	25.89	25.56	25.01
Diesel oil	2,818.63	2,313.28	2,410.85	2,387.12	2,253.50	2,025.35
Sub-bituminous Coal	1,269.10	3,310.40	2,566.84	2,945.33	4,717.79	2,607.09
Transport						
Gasoline	12,178.85	11,019.19	12,083.21	14,300.72	14,371.26	14,235.68
Jet Kerosene	1,293.09	1,293.09	1,293.09	1,293.09	1,293.09	1,293.09
Diesel oil	16,277.95	15,219.07	21,208.23	19,295.85	19,148.88	17,379.87
Sub-bituminous Coal	27.86	113.52	56.24	160.99	136.74	0.06
Natural gas (dry)	81.76	80.66	76.24	81.76	165.74	1,591.09
Small Combustion						
Gasoline	2,976.88	2,707.03	2,375.89	2,481.15	2,395.35	2,544.64
LPG	686.65	705.24	695.04	570.48	532.78	438.37
Diesel oil	29,644.58	21307.15	21026.33	22189.13	16747.49	21,633.24
Biomass						
Solid biomass	248,509.71	254,868.29	260,509.87	268,977.70	297,684.23	275,013.21

Table 3A1.4: Energy Sector Database: Traditional biomass burned

	2000	2001	2002	2003	2004	2005
Population Characteristics						
Total population	50,125,000	51,138,000	52,171,000	53,224,000	54,299,000	553,936,000
Fuelwood						
Total annual fuelwood consumption (kt dm)	15,725.33	16,086.80	16,406.79	16,781.97	17,034.29	17,366.89
Per capita fuelwood consumption (ton)	0.31	0.32	0.33	0.33	0.34	0.35
Charcoal						
Charcoal consumption (kt dm)	108.29	132.69	154.7	243.36	133	138.64

Appendix II: Industrial Processes and Product Use Sector Database

Table 3A2.1: Industrial Processes and Product Use Sector Database: Production in Industrial Processes of Myanmar

Production	2000	2001	2002	2003	2004	2005
Cement (kt)	407.67	383.12	475.36	587.38	534.56	542.1
Limestone (kt)	39.93	28.41	43.32	46.93	38.33	20.09
Iron (kt)	2.76	2.76	2.76	2.76	2.76	2.76
Steel (kt)	7.59	7.59	7.59	7.59	7.59	7.59
Glass (kt)	15.03	13.91	15.95	14.19	13.7	9.71
Urea (kt)	160	39	61	142	95	100
Alcohol (hl)	242,393	246,757	235,801	197,887	208,343	185,750
Beer (hl)	55,007	87,465	85,964	84,374	113,332	94,830
Sugar (kt)	92.94	113.79	74.33	54.06	52.92	38.12
Shrimp (kt)	1.02	1.18	0.95	1.05	1.03	1.03
Biscuit (kt)	1.54	1.66	2.24	2.1	2.43	2.19
Calcium Carbide Use (kt)	0.25	0.25	0.25	0.25	0.25	0.25

Appendix III: Agricultural Sector Database

Table 3A3.1: Agricultural Sector Database: The harvested area and production of four major crops in Myanmar for the years 1990, 1995, 2000, and 2001-2005

Crop Production	1990	1995	2000	2001	2002	2003	2004	2005
Rice :								
Harvested Area (,000 ha)		6,033	6,302	6,412	6,377	6,528	6,808	7,384
Crop Production (,000 MT)	4,760	18,580	21,324	21,916	21,805	23,136	24,752	27,683
	13,748							
Wheat :								
Harvested Area (,000 ha)		91	80	79	83	95	108	112
Crop Production (,000 MT)	136	78	94	96	107	124	152	159
	121							
Maize :								
Harvested Area (,000 ha)	125	162	211	251	268	284	293	320
Crop Production (,000 MT)	184	275	365	532	603	704	784	918
Sugarcane :								
Harvested Area (,000 ha)	44	64	133	161	142	149	140	129
Crop Production (,000 MT)	1,930	3,251	5,894	7,211	6,429	7,030	7,311	7,187

Appendix III: Agricultural Sector Database

Table 3A3.2: Agricultural Sector Database: Total harvested area, variety of rice in terms of growing time and irrigation types in Myanmar for the years 1990, 1995, 2000, and 2001-2005.

	1990	1995	2000	2001	2002	2003	2004	2005
Total harvested area (,000 ha)	4,617	5,852	6,302	6,220	6,185	6,332	6,603	7,163
Area cultivated with short-term variety (,000 ha)	869	1,767	1,853	1,853	1,845	1,892	1,879	2,100
Season length of short-term variety (days)	110	110	110	110	110	110	110	110
Area cultivated with medium-term variety (,000 ha)	2,939	3,059	3,189	3,277	3,256	3,330	3,567	3,808
Season length of medium-term variety (days)	135	135	135	135	135	135	135	135
Area cultivated with long-term variety (,000 ha)	809	1,026	1,071	1,090	1,084	1,110	1,157	1,255
Season length of long-term variety (days)	170	170	170	170	170	170	170	170
Irrigated rice %	18.3	29.3	29.4	28.9	28.9	29	27.6	28.4
Rain-fed : Favorable Flood Prone	49.7	38.7	38.6	39.1	39.1	39	40.4	39.6
Drought Prone	12	12	12	12	12	12	12	12
Deep water rice	**17**	**17**	**17**	**17**	**17**	**17**	**17**	17

Table 3A3.3: Agricultural Sector Database: Use of fertilizers in agriculture sector

Types of inputs (,000 kg N)	1990	1995	2000	2001	2002	2003	2004	2005
Nitrogen Fertilizer Application	184,179	230,976	259,236	264,968	267,626	277,118	289,396	308,359
Animal manure application	32,691	42,358	49,349	50,793	51,501	53,402	55,819	59,246
Plant residues application	**249,630**	**324,929**	**362,408**	**373,300**	**372,166**	**391,177**	**416,710**	**473,399**

Table 3A3.4: Agricultural Sector Database: Annual burning of crop residues in agriculture sector

Annual burning of Crop Residues	1990	1995	2000	2001	2002	2003	2004	2005
Rice :								
Annual burning area (20% of Total harvested area)	952	1,207	1,260	1,282	1,275	1,306	1,362	1,477
Mass of fuel available for combustion (ton / ha)	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
Annual burning of Crop Residues (MT)	5,236	6,639	6,930	7,051	7,013	7,183	7,491	8,124
Wheat :								
Annual burning area (85 % of Total harvested area)	116	77	68	67	71	81	92	95
Mass of fuel available for combustion (ton / ha)	4	4	4	4	4	4	4	4
Annual burning of Crop Residues (MT)	464	308	272	268	284	324	368	380
Maize :								
Annual burning area (35 % of Total harvested area)	44	57	74	88	94	100	102	112
Mass of fuel available for combustion (ton / ha)	10	10	10	10	10	10	10	10
Annual burning of Crop Residues (MT)	440	570	740	880	940	1,000	1,020	1,120
Sugarcane :								
Annual burning area (100% of Total harvested area)	45	64	133	158	142	146	140	129
Mass of fuel available for combustion (ton / ha)	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
Annual burning of Crop Residues (MT)	293	416	865	1,027	923	949	910	839

Table 3A4.1: Livestock Sector Database: Total livestock population (million head) and milk production

	1990	1995	2000	2001	2002	2003	2004	2005
Cattle	9.3	9.86	10.98	11.24	11.57	11.75	11.94	12.15
Dairy cows	0.17	0.18	0.2	0.21	0.21	0.22	0.22	0.23
Cattle other than dairy cows	9.13	9.68	10.78	11.03	11.36	11.53	11.72	11.92
Buffalo	2.1	2.2	2.4	2.5	2.6	2.6	2.7	2.7
Sheep	0.29	0.32	0.39	0.4	0.4	0.46	0.49	0.52
Goat	1.06	1.18	1.41	1.48	1.48	1.67	1.76	1.91
Horses, mule and asses	0.12	0.12	0.13	0.13	0.13	0.13	0.13	0.13
Swine	2.28	2.97	3.97	4.26	4.62	4.98	5.36	5.78
Poultry	27.28	34.32	55.21	63.03	70.56	81.59	86.97	95.54
Milk production (kg/head/year)	1,198	1,271	1,825	1,849	1,929	1,985	2,196	2,480

Appendix V: Land Use Change and Forestry Sector Database

Table 3A5.1: Land Use Change and Forestry Sector Database - Annual increase of carbon stocks (in terms of above- and belowground biomass) in natural forests of Myanmar

Year	Annual increase of carbon stocks	
	Carbon (Gg)	Carbon dioxide (Gg)
1990	40,191. 161	147,367. 589
1995	37,800. 843	138,603. 089
2000	35,410. 525	129,838. 590
2001	34,930. 924	128,080. 054
2002	34,453. 917	126,331. 028
2003	33,994. 860	124,647. 819
2004	33,516. 575	122,894. 108
2005	33,038. 892	121,142. 605

Table 3A5.2: Land Use Change and Forestry Sector Database - Annual increase of carbon stocks (in terms of above- and belowground biomass) in forest plantations of Myanmar

Year	Cumulative plantation area (ha)	Annual increase of carbon stocks	
		Carbon (Gg)	Carbon dioxide (Gg)
1990	347,735	1,676.97	6,148.88
1995	496, 355	2,379.92	8,726.36
2000	658,595	3,204.56	11,750.04
2001	689,364	3,352.35	12,291.94
2002	720,773	3,501.96	12,840.51
2003	750,485	3,643.63	13,359.96
2004	780,840	3,791.18	13,900.99
2005	811,337	3,933.28	14,422.02

Table 3A5.3: Land Use Change and Forestry Sector Database - Annual carbon Removal and CO_2 removal from home-garden trees

Year	Rural Population	C removal from Rural Home-garden trees (Gg C)	Urban Population	C removal from Urban Home-garden trees (Gg C)	Annual C removal from Home-garden trees (Gg C)	Annual CO_2 removal from Home-garden trees (Gg CO_2)
1990	30,671,072	97.197	10.114,928	7.133	104.33	382.543
1995	33,647,489	106.636	11,096,512	7.825	114.461	419.69
2000	37,694,000	119.46	12,431,000	8.766	128.226	470.162
2001	38,455,776	121.874	12,682,224	8.944	130.818	479.666
2002	39,232,592	124.336	12,938,408	9.124	133.46	489.352
2003	40,024,448	126.845	13,199,552	9.308	136.153	499.228
2004	40,832,848	129.407	13,466,152	9.496	138.903	509.311
2005	41,657,792	132.022	13,738,208	9.688	141.71	519.603

Appendix V: Land Use Change and Forestry Sector Database

Table 3A5.4: Land Use Change and Forestry Sector Database : Annual carbon removal and CO_2 removal by roadside trees

Year	Length of Roads (mile)	Length of Roads (km)	C removal by roadside trees (Gg C)	CO_2 removal by roadside trees (Gg CO_2)
1990	14,951	24,056.16	37.059	135.884
1995	17,299	27,834.09	42.879	157.224
2000	17,874	28,754.44	44.297	162.442
2001	17,996	28,955.56	44.607	163.558
2002	18,112	29,142.21	44.894	164.613
2003	18,936	29,663,524	45.698	167.558
2004	18,640	29,991.76	46.203	169.441
2005	19,201	30,894,409	47.594	174.51

Table 3A5.5: Land Use Change and Forestry Sector Database : Annual loss of carbon due to wood removals

Year	annual volume of fuelwood	Annual loss of carbon due to fuelwood removals	
	(m^3)	(ton C)	(Gg C)
1990	25,078,200	26,336,915	26,336.92
1995	24,876,600	25,133,234	25,133.23
2000	26,10,600	26,278,933	26,278.93
2001	26,560,800	26,834,810	26,834.81
2002	27,137,600	29,200,149	29,200.15
2003	27,763,400	29,852,287	29,852.29
2004	28,229,600	30,375,125	30,375.13
2005	28,761,600	30,947,854	30,947.85

Table 3A5.6: Land Use Change and Forestry Sector Database : Annual loss of carbon from fuelwood removal

Year	annual volume of fuelwood	Annual loss of carbon due to fuelwood removals	
	(m^3)	(ton C)	(Gg C)
1990	25,078,200	26,336,915	26,336.92
1995	24,876,600	25,133,234	25,133.23
2000	26,10,600	26,278,933	26,278.93
2001	26,560,800	26,834,810	26,834.81
2002	27,137,600	29,200,149	29,200.15
2003	27,763,400	29,852,287	29,852.29
2004	28,229,600	30,375,125	30,375.13
2005	**28,761,600**	**30,947,854**	**30,947.85**

Appendix V: Land Use Change and Forestry Sector Database

Table 3A5.7: Land Use Change and Forestry Sector Database : GHG emissions from site preparation for forest plantations

Reporting year	Plantation Area	Emissions					Total (CO_2 equivalent)
	(ha)	CO_2 (Gg)	CO (Gg)	CH_4 (Gg)	N_2O (Gg)	NO_x (Gg)	(Gg)
1990	28 904	1,927.20	126.854	8.294	0.244	1.952	2,313.62
1995	28 021	1,868.33	122.979	8.041	0.236	1.892	2,242.94
2000	23 277	1,552.02	102.158	6.68	0.196	1.572	1,863.21
2001	23 826	1,588.62	104.568	6.837	0.201	1.609	1,907.15
2002	23 574	1,571.82	103.462	6.765	0.199	1.592	1,886.98
2003	23 065	1,537.88	101.228	6.619	0.195	1.557	1,846.24
2004	23 850	1,590.22	104.673	6.844	0.201	1.61	1,909.07
2005	24 309	1,620.83	106.687	6.976	0.205	1.641	1,945.81

Table 3A5.8: Land Use Change and Forestry Sector Database : GHG emissions from shifting cultivated areas for 1990, 1995, and 2000- 2005

Source of Emission	Area (ha)	Emissions					Total (CO_2 equivalent) (Gg)
		CO_2 (Gg)	CO (Gg)	CH_4 (Gg)	N_2O (Gg)	NO_x (Gg)	
Shifting cultivation	15 000	1,000.14	65.832	4.304	0.127	1.013	**1,200.67**

Table 3A5.9: Land Use Change and Forestry Sector Database : GHG emissions from deforestation

Reporting year	Deforested Area (ha)	Emissions					Total (CO_2 equivalent) (Gg)
		CO_2 (Gg)	CO (Gg)	CH_4 (Gg)	N_2O (Gg)	NO_x (Gg)	
1990	466 500	31,104.35	2,047.38	133.867	3.937	31.498	37,340.97
1995	466 500	31,104.35	2,047.38	133.867	3.937	31.498	37,340.97
2000	466 500	31,104.35	2,047.38	133.867	3.937	31.498	37,340.97
2001	466 457	31,101.49	2,047.19	133.855	3.937	31.495	37,337.53
2002	466 457	31,101.49	2,047.19	133.855	3.937	31.495	37,337.53
2003	466 457	31,101.49	2,047.19	133.855	3.937	31.495	37,337.53
2004	466 457	31,101.49	2,047.19	133.855	3.937	31.495	37,337.53
2005	466 457	31,101.49	2,047.19	133.855	3.937	31.495	37,337.53

Chapter 4 Vulnerability and Adaptation Assessment

4.1 Introduction
4.2 Climate change scenarios for Myanmar
4.3 Vulnerability and adaptation assessment
4.4 Vulnerability indices and maps for key socio-economic sectors
4.5 Targeted researches
4.6 Policy options for adequate adaptation and Response strategies
4.7 Conclusion

chapter 4

Vulnerability and Adaptation Assessment

4.1. Introduction

As Myanmar is located in the centre of the southwest monsoon, heavy rain induced floods occur in many parts of the country. The coastal area, with its shore line covering more than 50% of the entire eastern side of the Bay of Bengal and the Andaman Sea, is particularly prone to cyclones and associated strong wind, heavy rain and storm surge. Drought is no less frequent event particularly in the central Myanmar.

Since 70% of the population resides in rural areas and depends on agriculture, livestock and fishery and forest resources, their livelihood is largely influenced by climate conditions. In other words, Myanmar economy is sensitive and vulnerable to climate change, climate variability and natural disasters.

In 2000-2001, net sown area covers 10.41 million hectares where 6.39 million hectares were occupied by paddy fields (Ministry of Information 2002). Agricultural works are centered on the production of paddy not only for domestic consumption but also for foreign currency earning. Summer cultivation of rice was initiated in 1992-93 and has been extended since then. Rice cultivation is currently targeted to reach up to 8.09 million hectares. During the period of 1988 to 2002, Myanmar implemented 129 irrigation projects including Thaphanseik dam which is the largest in Southeast Asia.

Regarding the health care system of Myanmar, there was one doctor for every 2100 persons and the nurse to population ratio was one to 2185 in 2009. Access to health care services has also been improved by the provision of rural health centers and sub-centers in villages. It enables some measures such as immunization and vaccination are among the priority measures taken under the health care system.
Myanmar has abundant water resources that benefit agriculture and power generation. Of the four major rivers systems, the Ayeyarwady is economically the most important one. Some low lying areas along the river course are subject to inundation due to normal floods in the rainy season. When monsoon intensified and widespread heavy rains last long, multiple floods occur along the rivers posing danger to the lower reaches, particularly the Ayeyarwady Delta. Melting of snow and glacier in the Himalayan mountain complex in the far north is somehow important to maintain river flows during dry season.

In the Indo-Myanmar bio-geographical realm, Myanmar is one of the few countries where about half of the total country land area is covered with forests. Forests of Myanmar are valuable in terms of supply of forest products and services, revenue generation, export earnings and environmental conservation. Forest protection and sustainable management of natural forests, plantation forests and community forests are among the priorities.

Biodiversity and forests are tightly coupled together. Myanmar has a long and rich tradition of biodiversity conservation and its forest management system promotes conservation of the environment, forest ecosystem and flora and fauna. The Government has long been strongly committed to biodiversity conservation.

The fishery sector plays an important role in Myanmar's economy. The ecosystems of coastal areas, islands and marine are all interdependently related in the fishery sector. Sustainable management of these ecosystems is vital for fishery.

Although Myanmar Sea is still clean and pollution free, increasing temperature affects marine and fresh water ecosystems. Increasing population and development activities can cause considerable stress on the coastal and marine environment.

4.2 Climate Change Scenarios for Myanmar

Background

"Model for the Assessment of Greenhouse gas Induced Climate Change SCENario GENerator (MAGICC/ SCENG-EN) version 5.3" is used to construct climate scenarios for Myanmar to undergo the vulnerability and adaptation study. User Manual (Wigley, 2008) suggested that the user can select Policy scenario WRE450 and Reference scenario A1TMES.

WRE450 scenario followed the IS92a "Business as usual" pathway for the initial period of 10-30 years (longer for higher stabilization levels), before curving away to reach the stabilization target. Emissions for A1TMES are defined only to 2100 which are the same as the default setting for MAGICC, to run to 2100. In order to characterize the present-day or recent climate in the regions of Myanmar, climatological data from seven selected stations obtained from the DMH are utilized for a baseline period 1971-2000.

In the scenarios background, the forcing controls of carbon cycle model are middle, carbon cycle climate feedback is on, aerosol forcing is middle, sensitivity is 3.0 °C, thermohaline circulation is variable, vertical diffusion is 2.3 sq. cm/s, and ice melt is middle. The brief descriptions of the models used in this study are shown in (Table 4.1).

Table 4.1: Brief description of the models applied

Model	Country	Horizontal resolution	Modeling centre and Reference
CSIRO-30	Australia	3.2° × 5.6°	Commonwealth Scientific and Industrial Research Organization (CSIRO), Gordon and O'Farrell, 1997
GFDLCM20	USA	2.2° × 3.8°	Geophysical Fluid Dynamics Laboratory Wetherald and Manabe, (1986)
UKHadCM3	UK	2.5°× 3.75°	Hadley Centre for Climate Prediction and Research, Gordon *et al* . (2000)
UKHadGEM1	UK	2.5°× 3.75°	Hadley Centre for Climate Prediction and Research Mitchell and Johns,1997

The geographical area of Myanmar is divided into seven regions which are assumed presentable by the selected stations and locations as shown in (Table 4.2) and (Figure 4.1) respectively.

Table 4.2: Stations used for each grid region of Myanmar

Station	Location				Above Mean Sea Level	Representation of the country	Remark
	Lat		long				
	Deg	Min	Deg	Min	(m)		
Myitkyina	25	22	97	24	145	Northern	Hilly region
Mandalay	21	59	96	6	93	Central	Plain dry zone
Kengtung	21	18	99	37	827	Eastern	Hilly region
Sittway	20	8	92	53	5	Western	Coastal
Mingladon (Yangon)	16	59	96	11	28	Lower Myanmar	Delta
Pathein	16	46	94	42	4	Ayeyawady Delta	Plain coastal
Dawei	14	6	98	13	16	Southern	Coastal

Figure 4.1: Location of selected stations for climate change scenarios for Myanmar

With reference scenario A1TMES

A1TMES is one of the six illustrative scenarios from the IPCC Special Report on Emission Scenarios (SRES). In reference scenario A1TMES , A1T stands for the emission storyline in which the scenario family describes a future world of very rapid economic growth and non-fossil energy sources and MES stands for the Model for Energy Supply Strategy Alternatives and their General Environmental impact (MESSAGE).

Comparison of mean temperature and precipitation observed versus model outputs (1971-2000)

In general the temperature outputs of the models (CSIRO, GFDL, UKHadCM3 and UKHadGEM1) are agreeable with the observed values and seasonal variation for all parts of Myanmar (except for northern mountainous region and the southern narrow coastal strip where it needs additional considerations). It suggests that ensemble model output for the interested scenarios period is appropriate at the present moment for temperature field. See (Figure 4.2 to 4.8).

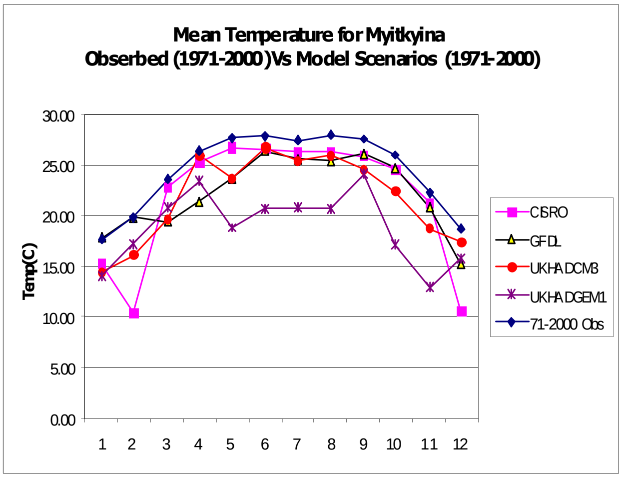


Figure 4.2

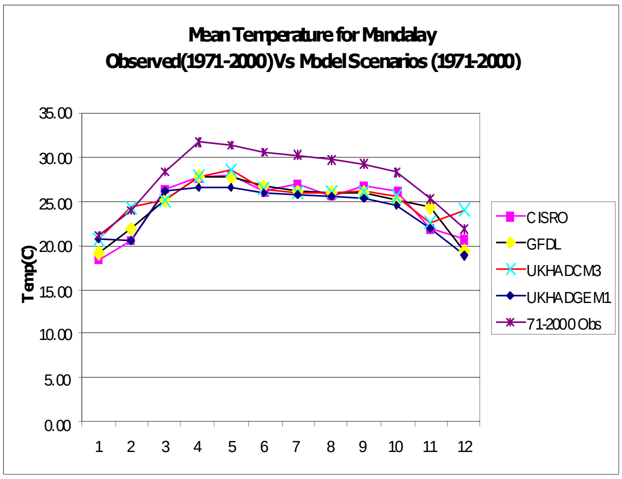


Figure 4.3

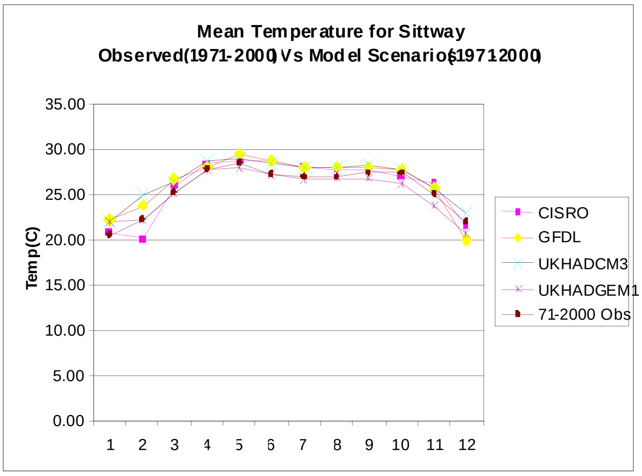


Figure 4.4

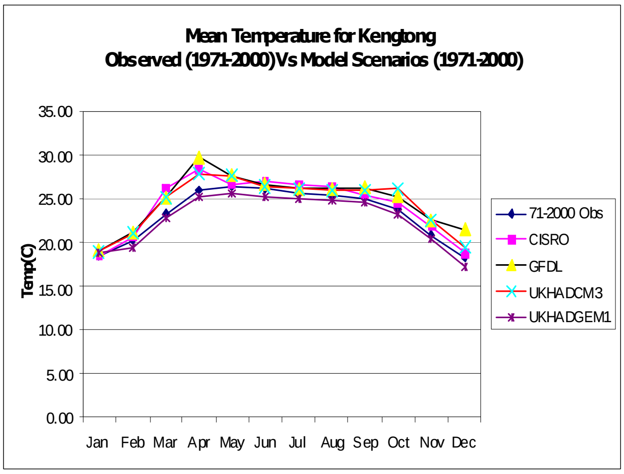


Figure 4.5

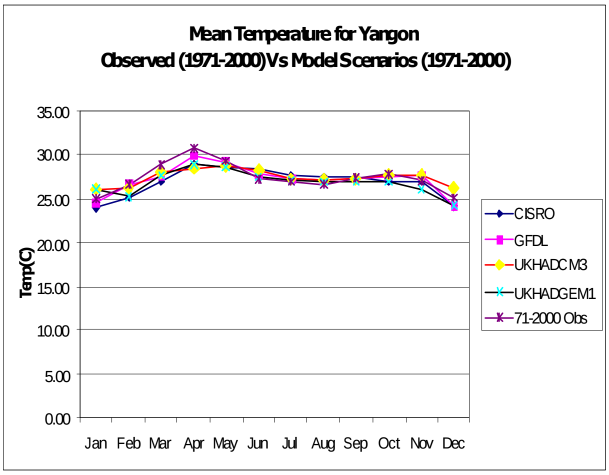


Figure 4.6

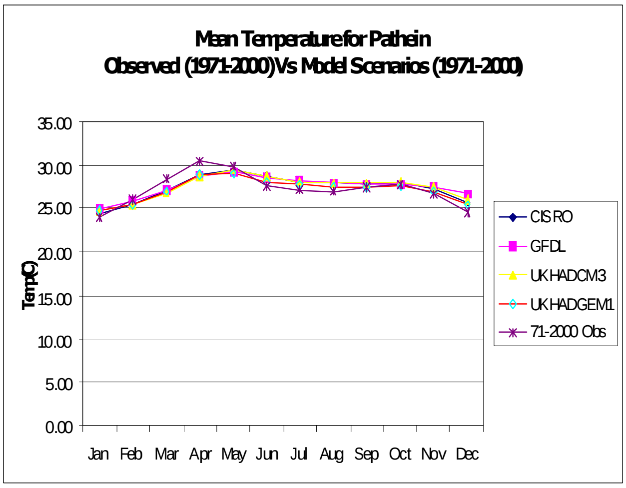


Figure 4.7

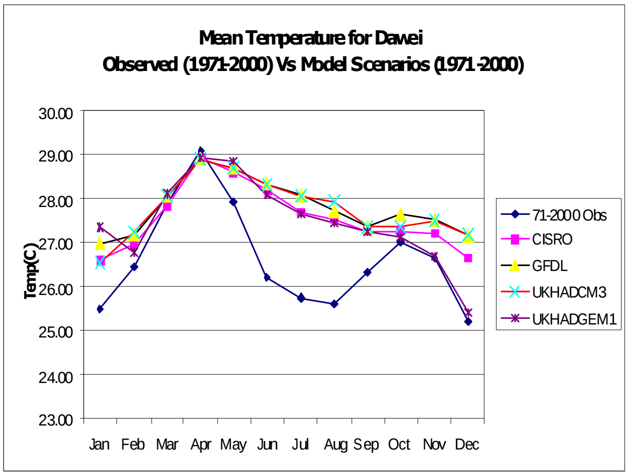


Figure 4.8

The precipitation model outputs are closely correlated to one another even though they are not close to the real precipitation of the regions. The models do show the seasonal variation satisfactorily despite of the complexity of the geographical nature of the regions which calls for extended studies. It also suggests that ensemble model output for the precipitation field will be advantageous for the interested climate change scenarios. See (Figure 4.9 to 4.15).

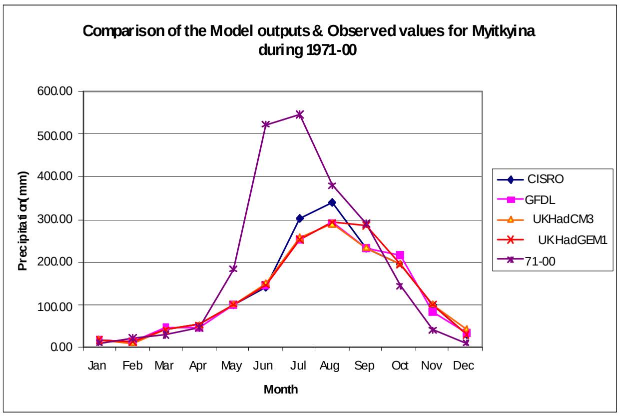
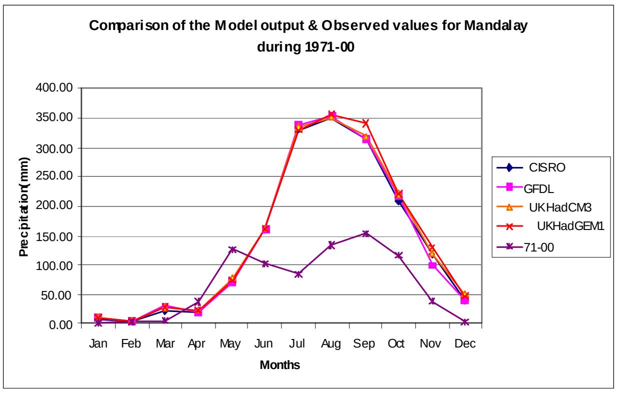


Figure 4.9



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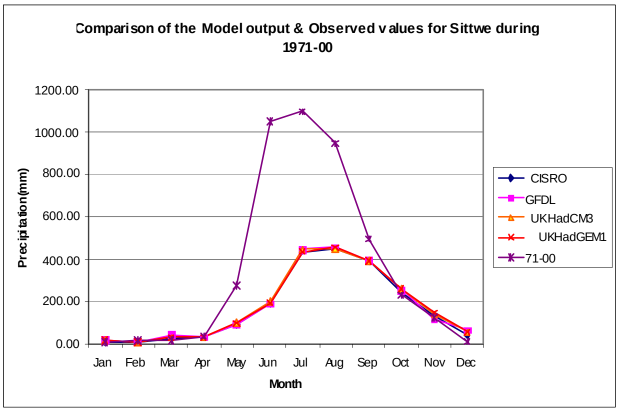

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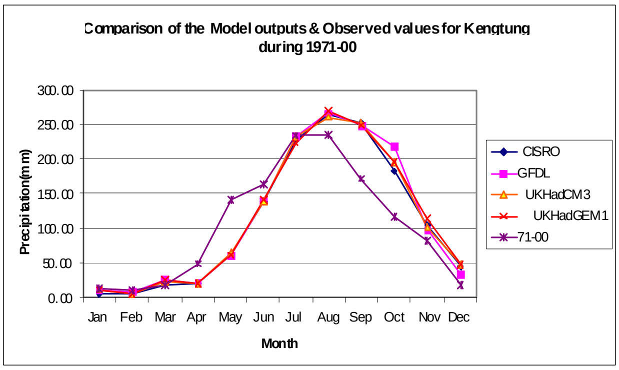

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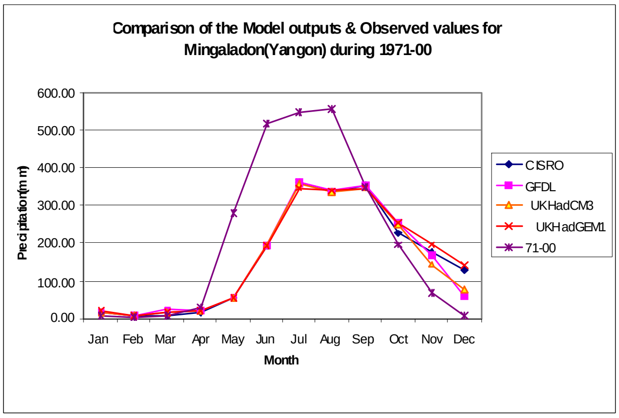

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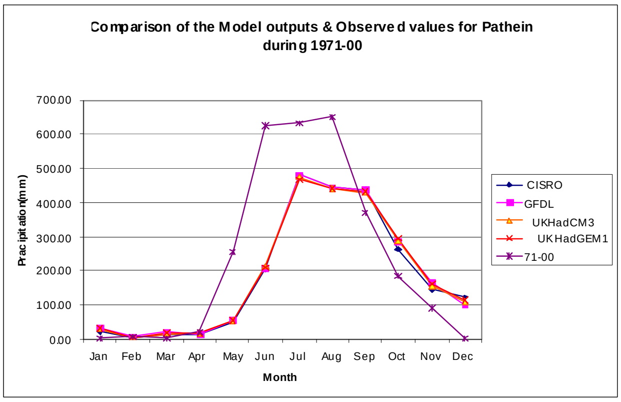

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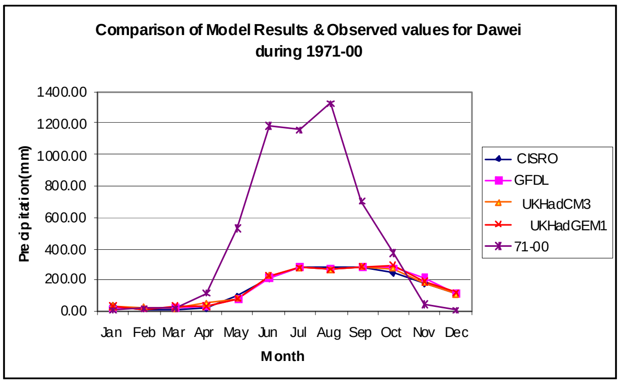


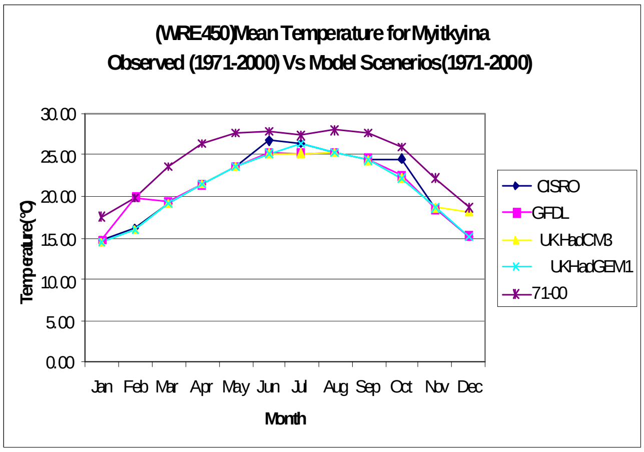
Figure 4.15

With policy scenario WRE450

WRE450 uses CO_2 emission that leads to CO_2 concentration stabilization at 450 ppm along the WRE pathway with compatible non-CO_2 gas emissions that follow the extended MiniCAM Level 2 (the Mini Climate Assessment Model) stability scenario where CO_2 stabilization is set at 450 ppm. According to the "IPCC Climate Change 1995, the science of climate change", the CO_2 concentration was about 340 ppm in the year 2000.

Comparison of mean temperature and precipitation observed versus model outputs (1971-2000)

In general the temperature outputs of the models (CSIRO, GFDL, UKHadCM3 and UKHadGEM1) are agreeable with the observed values and seasonal variation for all parts of Myanmar except for the southern narrow coastal strip where it needs additional considerations. It indicates that ensemble model output for the interested scenarios period is appropriate at present for temperature field. See (Figure 4.16 to 4.22).



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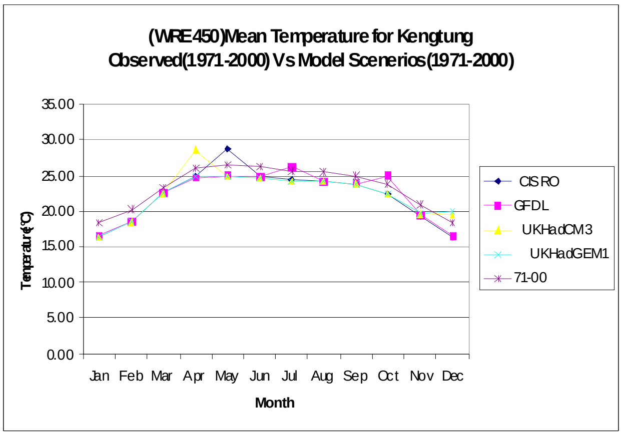

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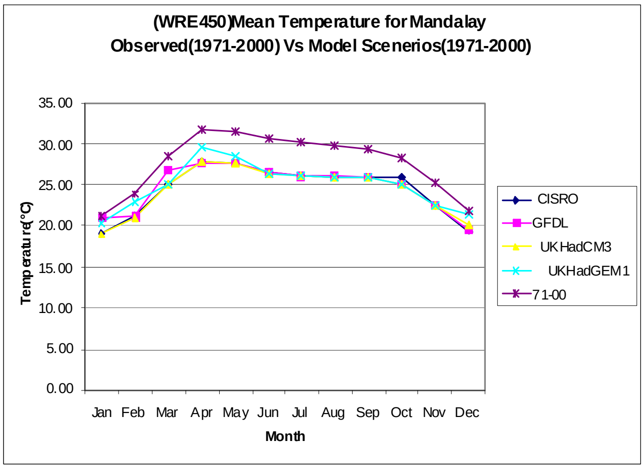

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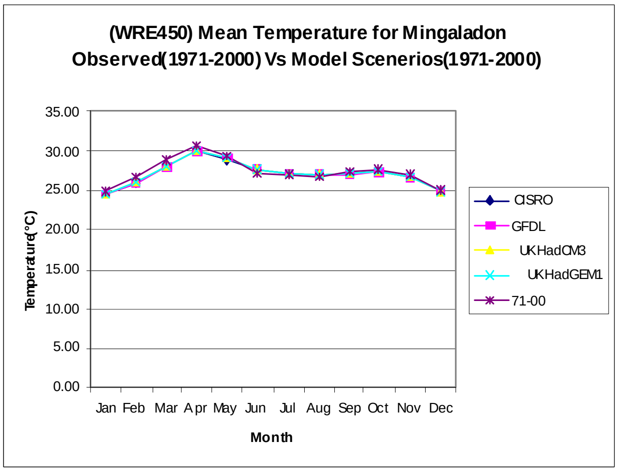

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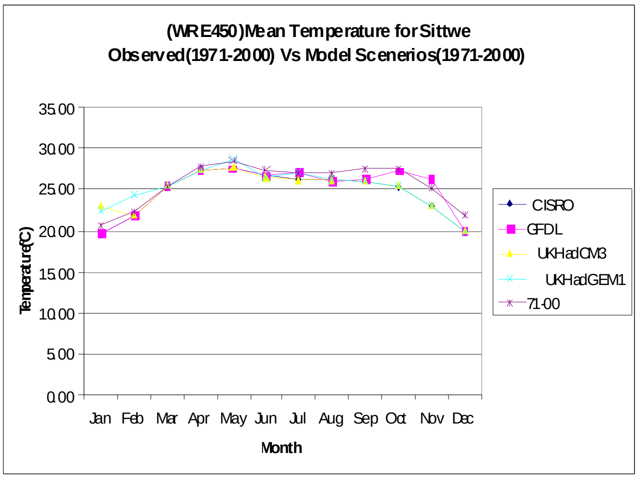

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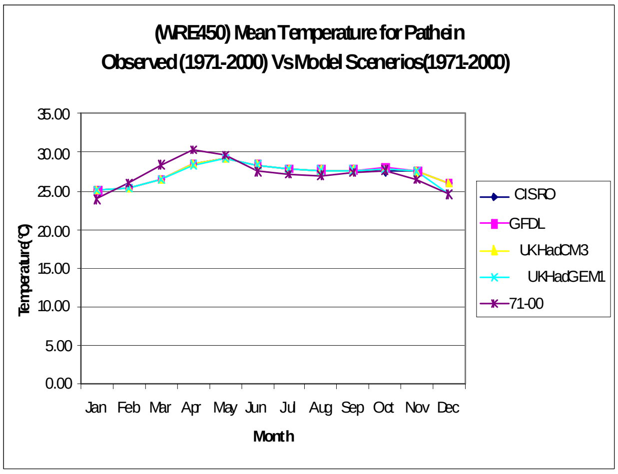

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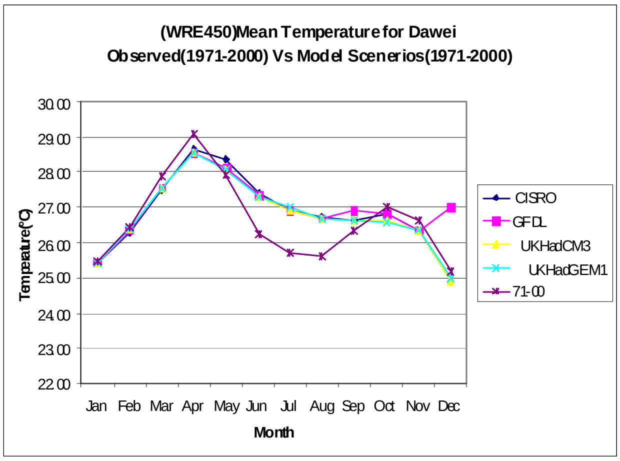

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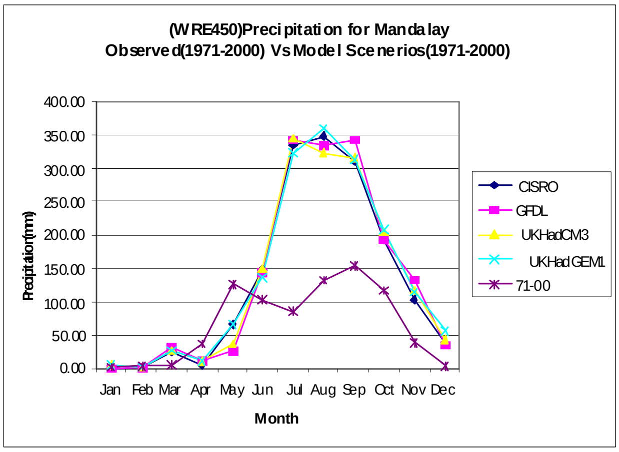
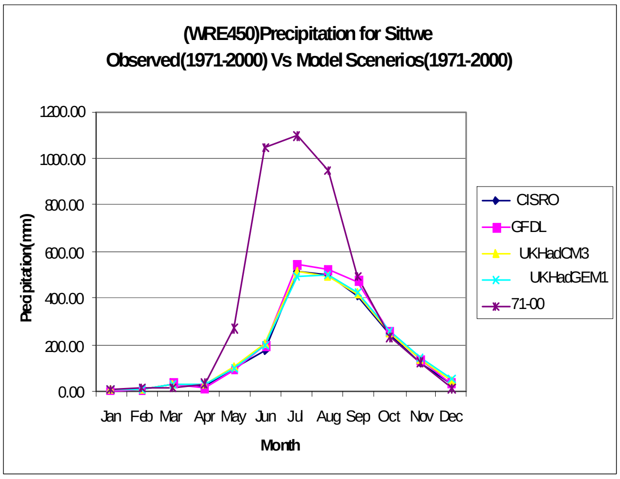


Figure 4.24

The model precipitation outputs are closely correlated to each other even though they have differences from the observed precipitations of the regions. The models do show the seasonal variation satisfactorily despite of the complexity of the geographical nature of the regions which calls for extended studies. It also suggests that ensemble model output for the precipitation field will be advantageous for the interested climate change scenarios in Myanmar for the time being. See (Figure 4.23 to 4.29).



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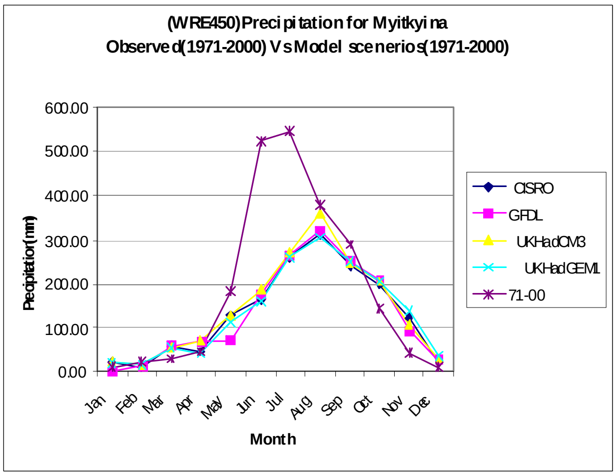

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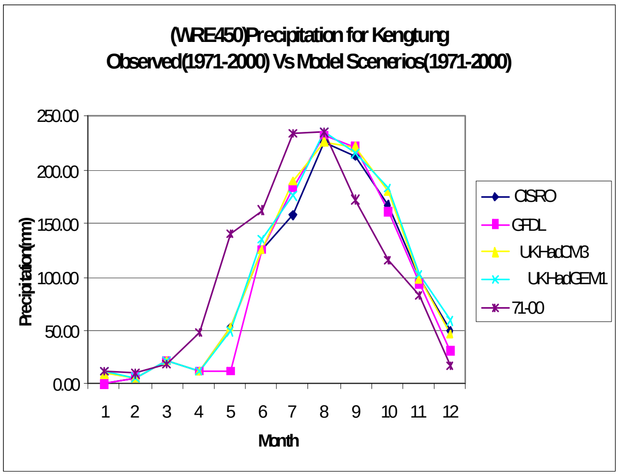

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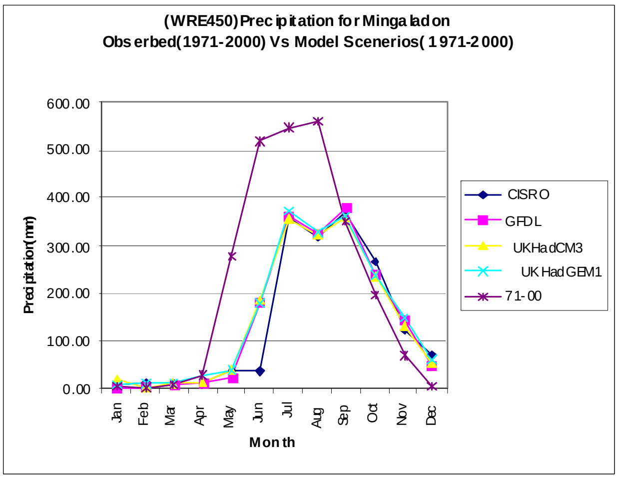

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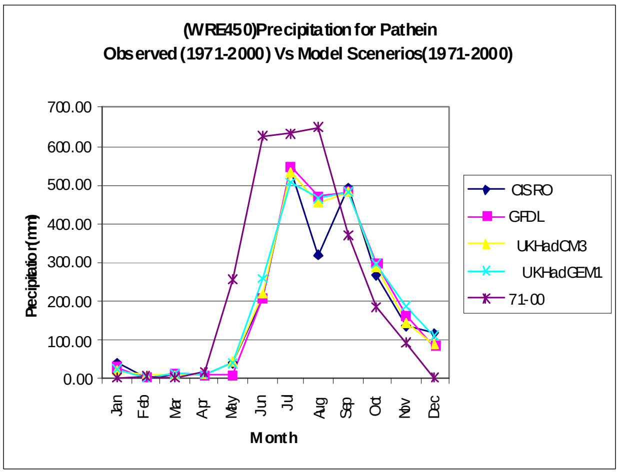

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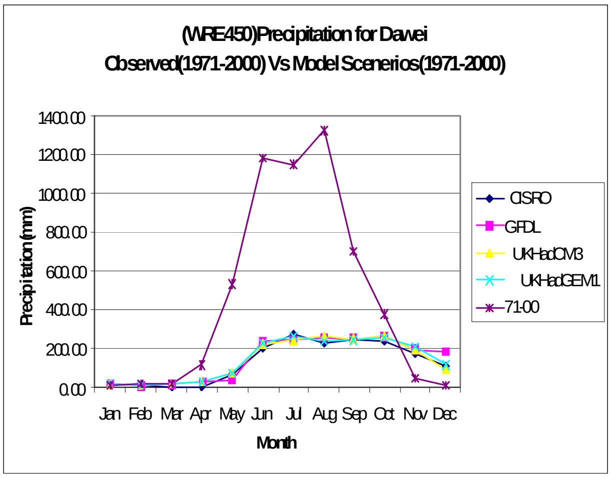


Figure 4.29

Climate scenarios

The ensemble models of CSIRO, GFDL, UKHadCM3, and UKHadGEM1 have been employed to carry out extensive study using Myanmar data so as to be familiar with the software and also to be applicable with high confidence in the production of climate scenarios of various climatic elements under the reference scenario A1TMES. The ensemble model results of seasonal change in temperature and precipitation plausible for Myanmar climate scenarios for 2001-2020, 2021-2050, 2051-2100 are separately discussed. Temperature and precipitation changes are with reference to the base line period of 1971-2000, unless otherwise mentioned. Scenario changes are also based on the model results of the base line period.

Climate scenario for 2001-2020

The temperature scenario of 2001-2020 shows 0.5-0.7°C increase during the whole year in lower Myanmar areas and for the remaining area, 0.6°C during June-November and it increases to 1.0-1.2°C in the other months as shown in (Figure 4.30).

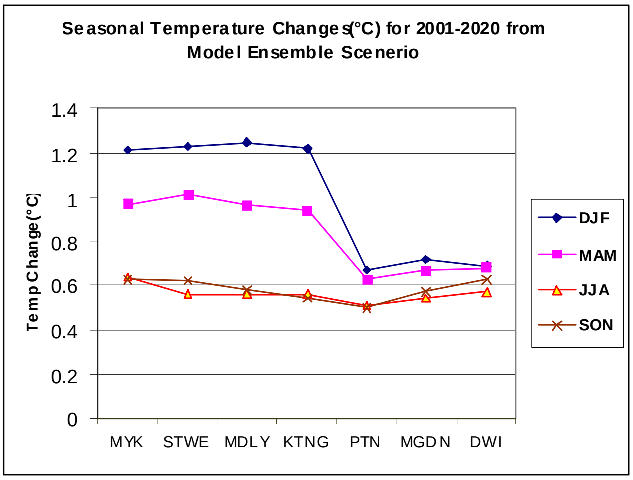


Figure 4.30

In the precipitation scenario, there is an increase of about 4% during March- November in the whole country. Record high maximum temperature may be expected. In the cool season of December- February, there is 30-45% rainfall deficit in the north, west, central and eastern regions and it is less than 12% in the remaining areas as shown in (Figure 4.31).

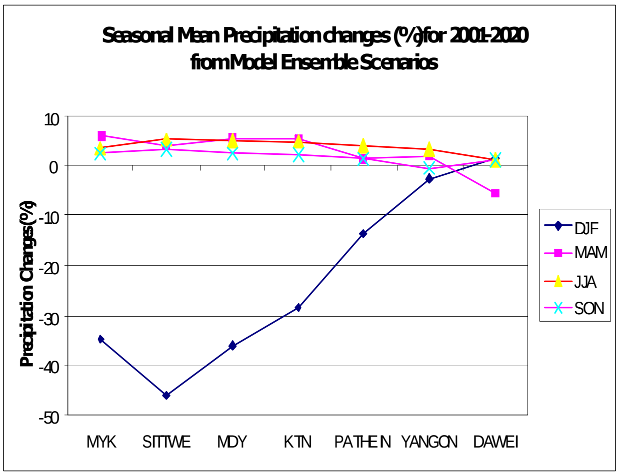


Figure 4.31

It indicates that, there will be less cloudy skies in the country, late onset and early withdrawal of the monsoon into the country shortening the southwest monsoon duration, decreasing strong monsoon days more but intensive rain events followed by more flash floods and erosion, more windy days and increasing drought event. There will be intense heat, high rate of evapotranspiration, and water stress especially in the normally water scarce areas. The warming over the country, more or less reflects the relative warming of sea surface temperature in the Bay of Bengal earlier than normal date so that earlier cyclogenesis is very likely. Since the upper tropospheric level is still dominated by the westerlies, there is a high tendency that the cyclonic disturbances take early recurvature and move to the east towards Myanmar coast, particularly in the pre-monsoon months of April and May. The intensive rains will cause flash floods, severe floods and soil erosions during the rainy season. In the cool season, high deficit rainfall indicates water demand for some winter cultivation particularly in the north, west, central and eastern parts of the country.

Climate scenario for 2021-2050

The temperature scenario shows 1.4-1.7˚C increase in June – November in the whole country. The north, west, central and eastern parts of the regions are 2.3 – 2.8 ˚C warmer during December- May, as shown in (Figure 4.32).

In the case of precipitation, 45 to 80% below normal conditions are projected during the cool season from December to February in the whole country except the lower Myanmar regions and the southern part. In the remaining months there is an indication of about 10 % increase of precipitation in the whole country, as shown in Figure (4.33). It means that Myanmar is going to be warmer with more rain than in 2001-2020.

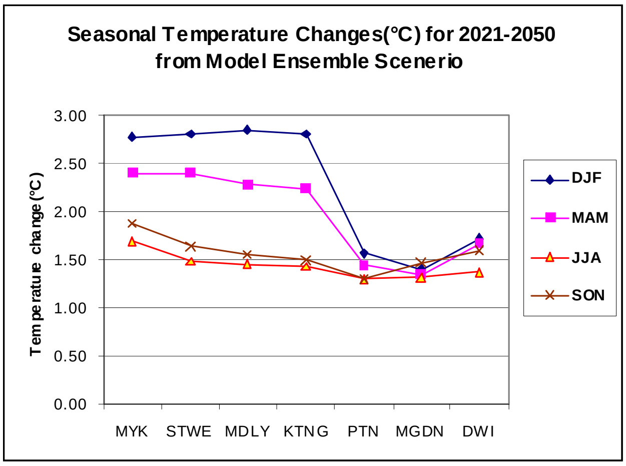


Figure 4.32

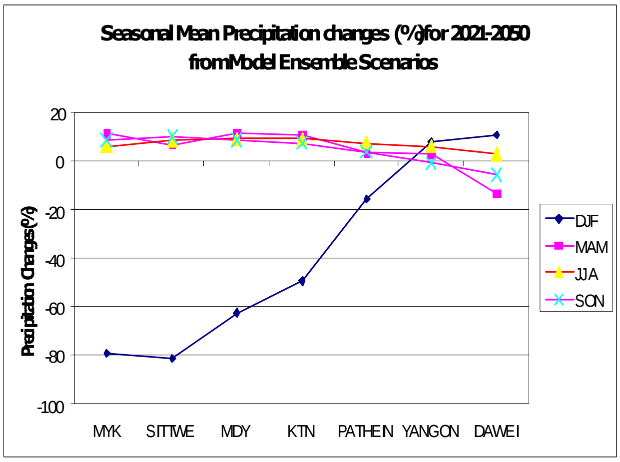


Figure 4.33

Climate scenario for 2051-2100

Temperature scenario shows an increase of 1.25-1.6˚C increase in June to November, increases to about 2.0˚C in March to May and 2.5˚C increases during December to February in the north, west, central and eastern part of the country. It generally is warmer in cool season in the country as shown in Figure 4.34. The range of warming is about the same as in 2021-2050. As for the precipitation, the whole country will generally receive about 10% increase during March to November and deficient rain of up to 80% is likely during the cool months from December to February as shown in (Figure 4.35). The range of change of precipitation is practically the same as in 2021-2050.

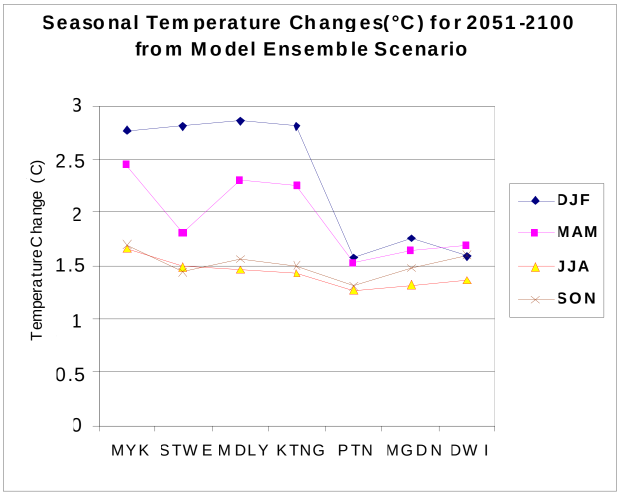


Figure 4.34

With PRECIS A2 emission scenarios

Regional Climate Impact Studies (PRECIS Model) with 20 km x 20 km resolution, operated by South East Asia SysTem Analysis Research and Training Regional Center (SEA START RC) applies A2 emission scenario. Its storyline were was that "World" was differentiated, "Economy" was regionally oriented; "Per Capita Growth" was at the lowest, "Population" was continuously increasing, "Governance" was self-reliance with preservation of local identities and "Technology" was slowest and most fragment development.

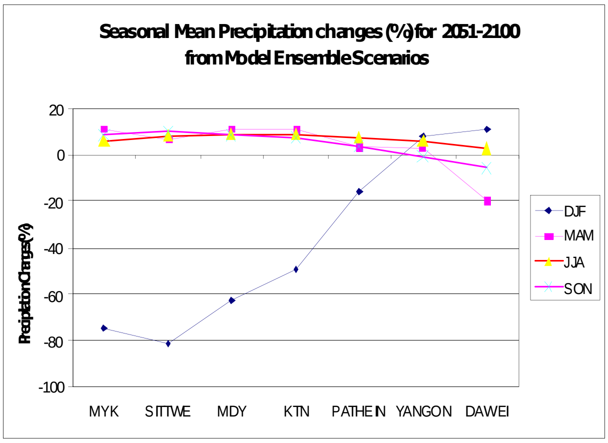


Figure 4.35

Comparison of mean temperature and precipitation observed versus model output for the period (1971-2000)

Comparison between output and observed values of temperature for the period 1971-2000 show that regarding temperature, model output is 1.7°C cooler at Sittway and 1.0°C warmer at Dawei.
It is closed to observed values at other localities. Model output standard deviation values are mostly in agreement between observed and model except Sittway where model output is about one half of the observed value 0.86°C as shown in (Table 4.3).

Regarding annual rainfall mean values model output is 30% higher at Myitkyina and 30% less at Dawei. There is not much difference in other locations. The standard deviations are reasonably in agreement for all locations except for Myitkyina (26% less), Mandalay (16% less) and for Sittway (35% more).

Table 4.3: Comparison between observed and model output

Station	1971-2000 Mean Temp(°C)				1971-2000 Rainfall(mm)			
	Observed		A2 Output		Observed		A2 Output	
	MEAN	STDEV	MEAN	STDEV	MEAN	STDEV	MEAN	STDEV
Myitkyina	24.4	0.37	24.3	0.45	1668	268	2203	197
Mandalay	27.6	0.57	27.7	0.66	812	195	931	164
Sittway	25.7	0.86	24	0.39	4593	660	4117	891
Kengtung	23.2	0.46	23.3	0.44	1250	185	1314	198
Mingladon (	27.5	0.38	27.4	0.45	2661	353	2661	344
Pathein	27.1	0.64	27.2	0.41	2843	400	2960	497
Dawei	26.6	0.36	27.6	0.34	5376	737	3547	850

Climate scenario for 2001-2020

The temperature has become 0.4 to 0.7°C warmer in the whole country. The standard deviation of the mean temperature is large with 0.69°C at Mandalay and 0.58°C at Myitkyina. It is generally less than 0.5°C elsewhere as shown in (Table 4.4). It means that Upper and Central Myanmar can experience more clear sky days which may lead to drought situation.

Annual rainfall will be increasing by 228 mm at Myitkyina, 106 mm at Mandalay, 45 mm at Pathein and 26 mm at Kengtung. It will be decreasing by 58 mm at Dawei, 57 mm at Yangon and 44 mm at Sittway. Annual rainfall will deviate by more than 18% at Mandalay, Sittway, Pathein and Dawei, and the deviation will be more than 14% at Myitkyina, Kengtung and Yangon. The large deviation is the indication of the likelihood of floods or droughts in the region concerned.

Table 4.4: Climate scenario for 2001 to 2020

Station	2001-2020(A2 output)			
	Annual Mean Temperature(°C)		Annual Rainfall(mm)	
	MEAN	STDEV	MEAN	STDEV
Myitkyina	24.9	0.58	2431	346
Mandalay	28.1	0.69	1037	202
Sittway	24.6	0.33	4073	790
Kengtung	23.7	0.47	1340	218
Mingladon (Yangon)	28.1	0.28	2604	437
Pathein	27.8	0.23	3005	556
Dawei	28.1	0.17	3489	692

Climate scenarios in 2021-2050

Temperature is increasing by 1.4°C at Yangon, 1.2°C at Pathein, 1.1°C at Myitkyina, Sittway and Dawei, 1.0°C at Kengtung, and 0.8°C at Mandalay. The standard deviation of temperature is 0.4 to 0.6°C in the whole country.

Rainfall will increase by 661 mm at Sittway, 292 mm at Pathein, 197 mm at Myitkyina, 154 mm each at Mandalay and Dawei, 144 mm at Yangon, and 36 mm at Kengtung. A large standard deviation of 1,130 mm was noted at Sttway as shown in (Table 4.5). It shows that there is larger rainfall variability in the region. There may be periods of heavier rains and long dry spells.

Table 4.5: Climate scenario for 2021 to 2050

Station	2021-2050 (A2 output)			
	Annual Mean Temperature(°C)		Annual Rainfall (mm)	
	MEAN	STDEV	MEAN	STDEV
Myitkyina	25.4	0.52	2400	331
Mandalay	28.5	0.58	1085	158
Sittway	25.1	0.35	4778	1130
Kengtung	24.3	0.46	1350	166
Mingladon (Yangon)	28.8	0.51	2805	367
Pathein	28.4	0.42	3252	499
Dawei	28.7	0.38	3701	876

Climate scenario for 2051-2100

The scenario indicates the increases of 3.5°C at Myitkyina and Yangon, 3.3°C at Pathein, 3.2°C at Sittway, 3.1°C at Kengtung, 3.0°C at Mandalay and 2.8°C at Dawei from 1971-2000 baseline data due to decreasing cloudiness coverage which supports the weak monsoon climate scenario for 2051-2100. Maximum standard deviation is 1.0°C at Myitkyina and the lowest is 0.7°C at Dawei. Periods of drought are likely at Myitkyina, Mandalay, Sittway, Pathein and Yangon where the standard deviation of mean temperature is generally about 0.9°C as shown in (Table 4.6).

Regarding the annual precipitation, there is an increase of 1582 mm at Sittway, 674 mm at Dawei, 667 mm at Myitkyina, 633 mm at Pathein, 414 mm at Yangon, 271 mm at Mandalay and 209 mm at Kengtung. Maximum standard deviation is 1358 mm at Sittway, followed by 902 mm at Dawei and 485 mm at Pathein.

Table 4.6: Climate scenario for 2051 to 2100

Station	2051-2099* (A2 output)			
	Annual Mean Temperature(°C)		Annual Rainfall (mm)	
	MEAN	STDEV	MEAN	STDEV
Myitkyina	27.8	1.012	2870	400
Mandalay	30.7	0.948	1202	301
Sittway	27.2	0.888	5699	1358
Kengtung	26.4	0.794	1523	266
Mingladon (Yangon)	30.9	0.904	3075	401
Pathein	30.5	0.857	3593	485
Dawei	30.4	0.727	4221	902

* (PRECIS computes only up to 2099)

4.3. Vulnerability and Adaptation Assessment

Potential hazard levels

The climate change impacts, which are likely in the tropical coastal regions due to global warming are projected in IPCC Reports. The increasing frequency of cyclones and accompanying strong winds, storm surge, floods or inundation, intense rains, extreme temperatures, droughts and sea level rise are climate change-related impacts to which Myanmar has to pay serious attention.

❖ *Cyclone and strong winds*

The potential hazard level for cyclone and strong winds in Myanmar may be classified as "**High**" for the coastal regions where there is a history of cyclone landfalls; "**Medium**" for the regions having common border or next to the high potential regions and regions with the history of frequent strong wind; and "**Low**" for the regions which have strong winds damages due to squalls. There are evidences of cyclone strong winds devastating a number of regions along the track such as Gwa cyclone of May, 1982. No region is free from the strong wind hazard as rainstorms and squalls can occur all over the country.

❖ *Flood and storm surge*

The potential hazard level for flood and storm surge is classified as "**High**" for low flat regions, where floods are used to occur at least every other year caused by one of the large river systems of Ayeyarwady, Chindwin, Sittaung and Thanlwin or by storm surge, "**Medium**" for the region with moderate floods and flash floods history, "**Low**" for the region with the flash flood history.

❖ *Intense rain*

The potential hazard level for intense rain may be classified as "**High**" for the regions having long exposure to the southwest monsoon flow from the Bay of Bengal and the Andaman Sea; "**Medium**" for lower Myanmar and northwestern part of the country and regions with some intense rain history; and "**Low**" for the regions with a few heavy rainfall history.

❖ *Extreme day temperature*

In the case of extreme day temperature, the potential hazard level may be classified as "**High**" for the regions with high annual mean temperature and relatively flat regions in central dry zone; "**Medium**" for the transitional zones, and Bago Region and Kayah State; "**Low**" for the mountainous regions and regions with low annual mean temperature.

❖ *Drought*

The potential hazard level for drought may be classified as "**High**" for the regions in dry zone, "**Medium**" for Bago Region and eastern mountain ranges, and "**Low**" for the remaining regions except Yangon and Tanintharyi Regions.

❖ *Sea level rise*

The potential hazard level for sea level rise may be classified as "**High**" for coastal deltaic region with extensive flat low land, "**Medium**" for the region with short coastal strip or narrow coastal strip, "**Low**" for the region with tide effects and coastal areas with higher ground; and "**None**" for inland areas. According to "IPCC 2007, Impacts, Adaptation and Vulnerability", there would have an accelerated rise in sea level of 0.2-0.6m or more by 2100 as a result of climate change. It should be noted that Pathein in Ayeyarwady Delta is 4 m above mean sea level which is situated about 100 km from shore line. Therefore shore line can be potentially retreated about 10 km due to sea level rise of 0.5 m at the end of 2100.

The potential hazard levels for climate change impacts due to global warming may assume a pattern which is presented in (Figure 4.36).

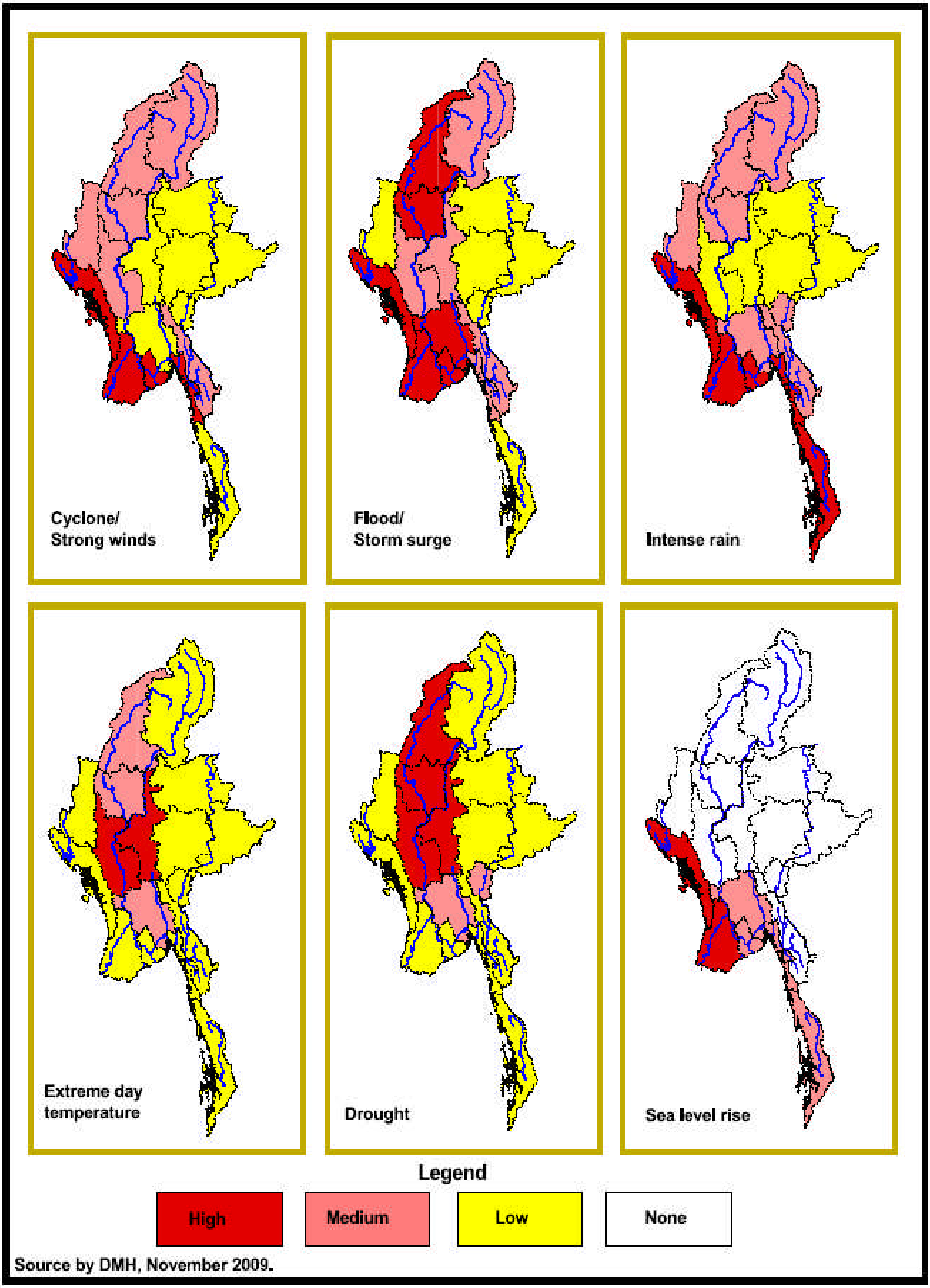


Figure 4.36: The potential hazard levels for climate change features due to global warming.

Vulnerability of different sectors

Agriculture

Myanmar is an agricultural country with about 11 million hectares of cultivated land, being grown by about 60 crops. In 2006-07, agricultural sector accounted for 37% of the country's Gross Domestic Product (GDP) and 13.3% of its export earnings (Myanmar Agriculture in Brief, Ministry of Agriculture and Irrigation, 2008). Crop production is the major agricultural activity and is largely dependent on weather. After 1988, the Government put forward continuous efforts in the construction of dams and reservoirs throughout the country by utilizing large capital investment, man power and machineries. Available domestic resources and expertise were used for making some machineries. As a result, irrigation facilities now exist in groups in localized zones across the country.Irrigation coverage increased from 12.5% of the sown area in 1987-88 to 18.0% in 2006-07.

Soils and climatic conditions in many parts of Myanmar favor rice cultivation and Myanmar is a rice-surplus country. Rice is the principal agricultural crop, and is the staple food of the entire population. Myanmar is one of the countries with the highest level of per capita rice consumption in the world.

Rice production in the country has increased significantly due to introduction of summer rice. The utilization of high yielding varieties together with advanced agricultural practices and proper irrigation system also help increase rice production. Rice production of 21 million tons in 2000-2001 had increased to over 31 million tons in 2007-2008 as shown in (Table 4.7).

Although rice yield and production in Myanmar have been showing positive trends, some interruptions could take place if there would have severe climate change impacts due to global warming.

Table 4.7: Annual rice production in Myanmar

Year	Sown ('000 ha)	Harvested ('000 ha)	Yield (Mt*/ ha)	Production ('000 Mt*)
1995-96	6138	6033	3.08	18580
2000-01	6359	6302	3.38	21324
2002-03	6488	6377	3.42	21805
2004-05	6858	6808	3.64	24752
2005-06	7389	7384	3.75	27683
2006-07	8125	8074	3.83	30924
2007-08	8090	8011	3.93	31451

*Metric ton

Source: Department of Agricultural Planning, Ministry of Agriculture and Irrigation, 2009.

Water resources

Myanmar has eight river basins namely Chindwin, Upper Ayeyarwady, Lower Ayeyarwady, Sittaung, Rakhine, Tanintharyi, Thanlwin and Mekong. According to 2003 data, the annual average potential of surface water is 827.946 km^3 and ground water is 494.713 km^3 and they are given in (Table 4.8).

Water withdrawals in Myanmar have been in the increase particularly in the agricultural sector (Table 4.9) shows total water use in different sectors for the year 2004-2005 (Zaw Win, 2006). It is found that agricultural sector is by far the largest water user in Myanmar. Previously, government investment strategy with respect to the irrigation was strongly oriented towards increasing the water supply by developing storage capacity, particularly construction of dams, weirs and sluice gates.

Table 4.8: Annual average water resources potential (km^3) by river basin

Region/ River basin	Surface water (km^3/yr)	Ground water (km^3/yr)
Region 1, Chindwin	104.72	57.578
Region 2, Upper Ayeyawady	171.969	92.599
Region 3, Lower Ayeyawady	229.873	153.249
Region 4, Sittaung	52.746	28.402
Region 5, Rakhine	83.547	41.774
Region 6, Taninthayi	78.556	39.278
Region 7, Thanlwin	95.955	74.779
Region 8, Mekong	10.58	7.054
Total	**827.946**	**494.713**

Source: Water Resources Management in Myanmar, 2003. Ministry of Agriculture and Irrigation

Table 4.9: Water usage (km^3) in Myanmar

Sector	Surface water	Ground water	Total	Percent
Irrigation	40.69	0.81	41.5	91
Domestic	1.15	2.55	3.7	8
Industrial	0.32	0.08	0.4	1
Total	42.16	3.44	45.6	100

In recent decades water resources in the Dry Zone were highly vulnerable to climate change. Projected impacts indicate that increasing number of reservoirs will experience seasonal water shortage while there will be year round shortage of water in some reservoirs. These water-shortage situations prompted initiation of river water pumping projects, with priority being given to the Dry Zone.The projects make the best use of existing water resources of perennial rivers and streams. It creates an enabling environment for the farmers by securing water availability in all seasons. River water pumping projects already implemented in the Dry Zone is shown in (Table 4.10) and location of pump sites is shown in (Figure 4.37). However, since all the projects are situated on the bank of the rivers, they are vulnerable to a number of factors such as erosion, changes of water course, emergence of sand dune by intense rains and high floods, drought and low water inputs due to climate change.

In fact, groundwater is a major component of the available water resources. In the coming years the groundwater utilization is likely to increase manifold because of the expansion of irrigated agriculture for increased food production. At present, Water Resources Utilization Department under the Ministry of Agriculture and Irrigation is implementing two groundwater irrigation projects in Meiktila, Thazi, Pyawbwe and Yamethin Townships, in Mandalay Region, where extreme droughts occurred in 2008 and 2009. However, renewable groundwater is directly tied up to the near surface hydrologic processes. It is also intricately tied to the overall hydrologic cycle and could be directly affected by climate change. In many cases, the rate of groundwater withdrawals exceeds the rate of recharge, resulting in over exploitation of renewable groundwater aquifer. For example, the amount of initial discharge of free-flowing artesian wells under "Yinmabin 99 Ponds Project" in Sagaing Region was 3.1 m^{3}per second at the completion of the project in 1995. It brought about gradual decrease in the discharge of free flow, and by the year 2000 discharge had dropped to 0.61 m^3 per second. Thus, climate change could directly affect the groundwater recharge rate and therefore the sustainability of renewable groundwater as well.

Table 4.10: Completed river water pumping projects in Dry Zone

Sr. No	Regions	Special projects (electric)		WRUD's schemes				Total	
				Electric		Diesel			
		No of sites	Irrigable areas (ha)	No of sites	Irrigable areas (ha)	No of sites	Irrigable areas (ha)	No of sites	Irrigable areas (ha)
1	Sagaing	4	28,329	11	10,530	37	13,977	52	52,836
2	Magway	4	13,355	24	18,335	23	3,157	51	34,847
3	Mandalay	8	23,148	20	11,307	49	9,822	77	44,277
	Total	**16**	**64,832**	**55**	**40,172**	**109**	**26,956**	**180**	**131,960**

Source: Water Resources Utilization Department (WRUD), 2009.

Due to climate change, extreme events such as high floods have occurred in Ayeyarwady delta. Although embankments were designed to exceed the previously known high floods with freeboard, maximum water levels often exceeded from time to time. There were 4 incidents concerning with the failure of embankment in the delta with some casualties and damages. A study on maximum water levels at a key station in delta showed that there was a rising trend and considerable magnitude could be expected. In addition, there are problems of saline intrusion during the dry season owing to the low volume of fresh water in the river systems.

Today, climate scientists predict that global warming will havoc countries lying in the coastal seas and Southeast Asia will be the region hardest-hit. Ayeyarwady delta would be endangered by rising sea level and storm surge. Rising sea level may lead to increased saline intrusion into coastal and island aquifers.

Ministry of Agriculture and Irrigation
Water Resources Utilization Department
River Water Pumping Stations along Ayeyawaddy-Chindwin River in Sagaing, Mandalay and Magway Regions

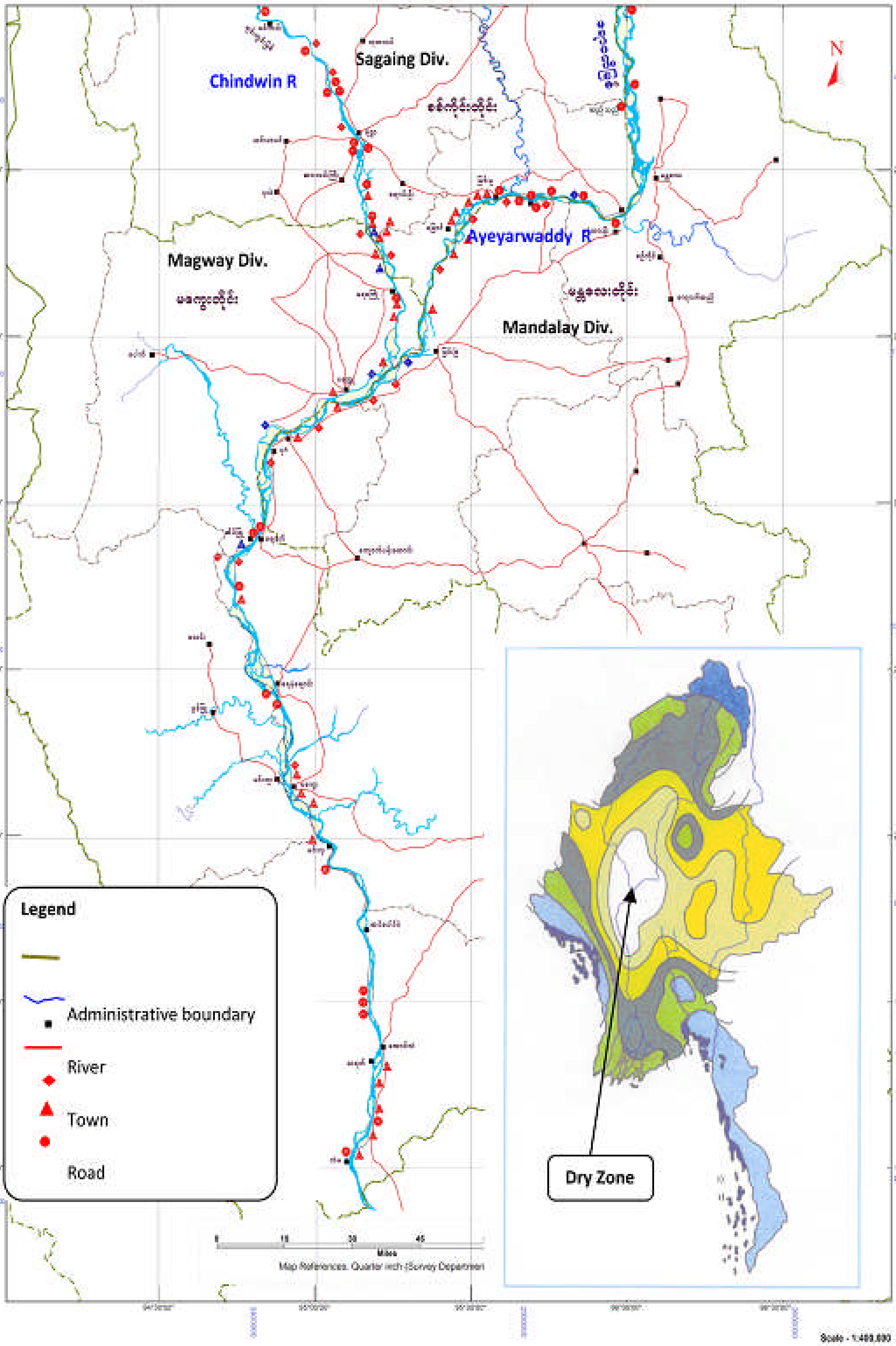


Figure 4.37: Location of pump sites in Dry Zone

Public health

Increase in water-related and heat stress health diseases could be expected as the foremost effect of climate change on health sector. Water can get polluted during floods, droughts and typhoons which are considered to be closely related to climate change and preventive and curative measures are needed to control water-related problems. Rising temperatures can lead to increased heat stress, heat exhaustion, dehydration, etc. Public awareness and education to prevent health problems which may be caused by heat stress should be raised. . The following (Table 4.11) shows the health concerns to vulnerabilities due to climate change.

Table 4.11: Health concerns and related problems due to climate change

Health concerns	Related problems due to climate change
Temperature - related morbidity	Heat & cold - related illness
	Cardiovascular System (CVS) illness
Vector borne diseases	Change of patterns of diseases
	Malaria, Filarial, Dengue & other diseases of pathogens carried by mosquitoes, ticks & vectors.
Health effects of extreme weather	Diarrhea, Cholera & poisoning caused by biological & chemical contaminants in water
	Damaged public health infrastructure due to cyclones
	Injuries & illness
	Social & Mental stress due to disasters & displacement.
Health effects due to insecurity in food production	Malnutrition & hunger especially in children.

❖ *Malaria*

In Myanmar, malaria is one of the notorious endemic vector-borne diseases with high morbidity and mortality rate. Based on the reports of clinical suspected malaria cases and malaria deaths in Myanmar from 1995 to 2004, some inferences are made below. Occurrence of malaria epidemics in States/Regions and their causes are shown in (Figures 4.38 and 4.39).

The inferences on malaria morbidity and mortality are:

1. Malaria-related outpatient cases have increased due to increasing malaria cases although total outpatients in hospitals are decreasing.
2. Outpatient cases are increasing due to increasing numbers of health facilities and better services in some areas.
3. Malaria inpatients and death cases are reduced because of improved health facility coverage and wide availability of artesunate implementation policy.
4. Malaria morbidity and mortality are declining in the whole country except in Rakhine State.

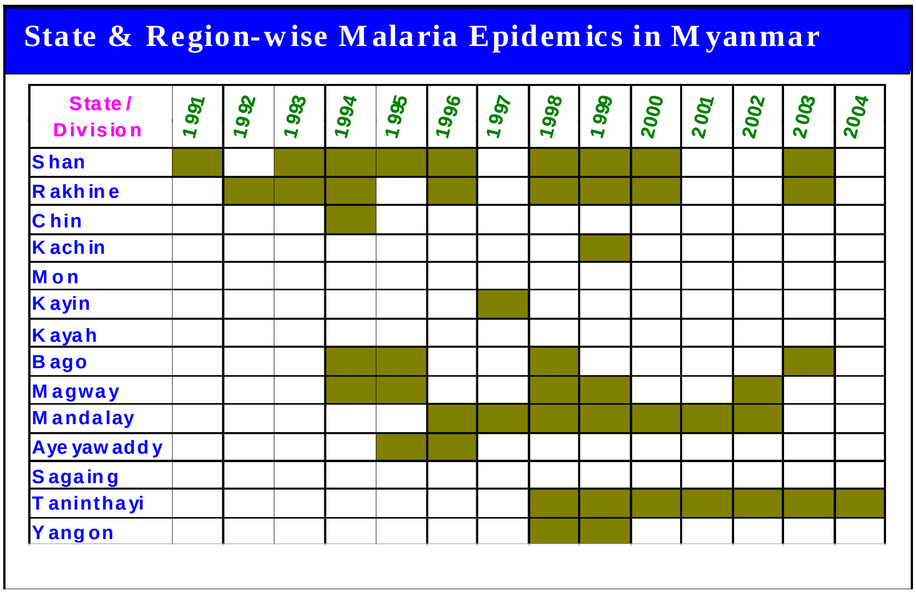
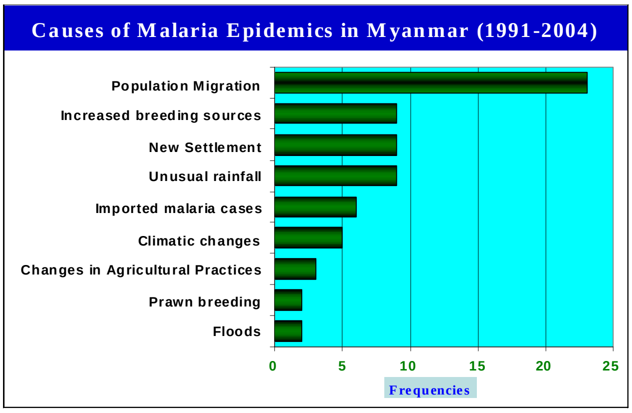


Figure 4.38: State and Region-wise malaria epidemics in Myanmar (1991 to 2004)



(Figures 4.38 and 4.39) show that frequencies of occurrence of epidemics are more in Shan and Rakhine States, and Mandalay and Tanintharyi Regions. Major causes include population migration, increased breeding sources, new settlement and unusual rainfalls, and they represent the effects of climate change. Increased rainfalls due to climate change may result in malaria epidemics. Potential health effects of climate variability and change are shown in (Figure 4.40).

Figure 4.39: Causes of malaria epidemics in Myanmar (1991 to 2004)

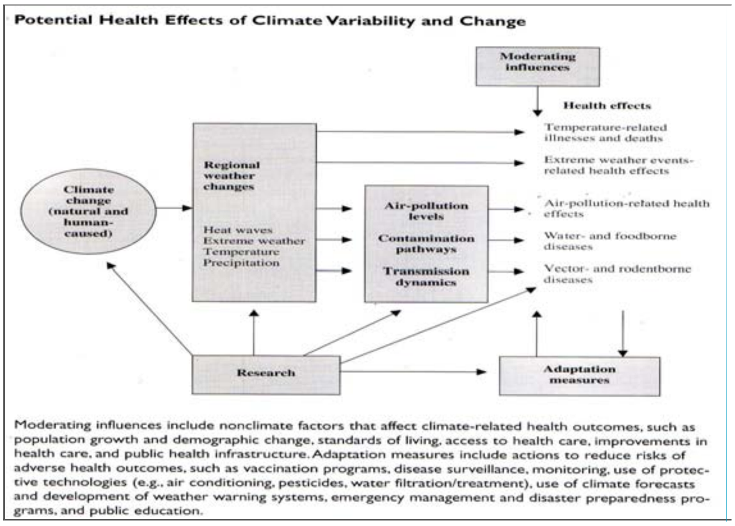


Figure 4.40: Potential health effects of climate variability and change

Forestry

Major forest types found in Myanmar are Tidal Forests, Beach and Dune Forests, Swamp Forests, Evergreen Forests, Mixed Deciduous Forests, Dry Forests, Deciduous Dipterocarp or Indaing Forests and Hill Forests.

Many of these forest areas have been destroyed by cyclones, strong winds, floods, extreme temperatures and droughts in addition to the human pressure. The dominant type of forest in the country is the deciduous forest that sheds leaves during dry season when the climate is extremely hot to catch fire easily. There was a maximum evidence of 35,333 forest fire cases per day during the second ten days of March 2008, in Shan State.

It is interesting to note the social attitudes towards forest conservation. In the Dry Zone of Central Myanmar, agriculture is now at its upper limit and further horizontal expansion is almost impossible. The agricultural lands under private ownership are now being managed intensively and scientifically. The 1995 surveys had observed these management practices in some areas. The good practices have been spreading to other private lands under cultivation. Tree planting in private lands as well as in religious compounds is now-a-day a common practice in the Dry Zone. All religious premises either monasteries or pagodas are well kept under good tree cover. Deity god places have more dense cover because people hardly cut down trees from these small local gods' premises. To reduce deforestation and forest degradation, cutting of trees for firewood has been prohibited in the dry zone by local authorities. Local people have properly solved the firewood shortage on their own. The grove of wild jujube (*Zizyphus jujuba*) plants which are now privately owned are considered as a gold mine. The cotyledon fruit seeds are now being used as a high-energy fuel in special stoves developed by local people. These stoves are used mainly for toddy juice industry and even for brick-baking industry which are cited as main consumers of fuel wood in the area. Pigeon pea stalks which are usually burned as a waste in Shan State have now become a major fuel in the dry zone. A local folk from Mye Thin Dwin village explained that their annual pagoda festival which usually needs 12 cartloads of firewood now needs only three cartloads of pigeon pea stalks, thanks to a village engineer from Mye Thin Dwin, who has modified some gasifiers. Further developments should be encouraged and extended. For protected forest areas, if they are protected sufficiently will become well covered with tree vegetation, improving environmental stability. However it is very essential that management system is efficient and effective. Work of 5 or 6 years period can be destroyed within days by extreme events.

Managing the common land by the local people and authorities is also a helpful means to the development of forests. Good examples can be seen in Mye Thin Dwin community forest project and War Khin Gyi area project. Dry Zone Greening Department (DZGD) has been implementing the first project jointly with Japan International Cooperation Agency (JICA), and the second one was implemented by the Forest Department (FD) jointly with Japan International Forestry Promotion and Cooperation Center (JIFPRO). User groups are assured of their ownership and they have to take the responsibilities for managing their community forests. The projects are very successful and awareness of local people on the values of forests is really significant. Village woodlots have been successfully established by FD with peoples participation since 1970s.

Present land tenure laws were written in colonial British times. Most of these laws encouraged new agricultural expansion at a time when population was low compared to the agriculture area. In the past, expansion of agriculture onto new lands had never been under sound land use planning in Myanmar. Dry Zone cases clearly show how people can manage if the land is entirely entrusted to them in the name of private ownership. Sustained production could be expected only from the privately owned lands Land tenure laws should be reviewed and updated as appropriate not only for the benefits of local farmers but also for the country as a whole.

Coastal zone

Myanmar has three coastal regions, and they are Rakhine, Ayeyarwady Delta and Tanintharyi. Different types of coasts are found: coastal banks are generally steep in Rakhine; mangroves and sandy beaches common in the Ayeyarwady Delta; and rocky islands, rock pinnacles, mangroves and coral reefs in the Tanintharyi. The Myeik archipelago near Tanintharyi coast comprises more than 800 islands.

The Myeik Archipelago is one of the few areas left on earth where there still exists a continuous transition from rain forest to coastal mangrove swamps.

❖ *Coral reefs*

The vast and diverse coral reefs of Myeik Archipelago are of immense ecological and economic importance for the country. But, the sea level rise is likely to affect the social and economic situation of the coastal areas including Myeik Archipelago reefs significantly. Recent risk analysis of coral reefs suggests that between 24% and 30% of the reefs in Asia are projected to be lost during the next 2 to 10 years and 10 to 30 years respectively. A new study suggests that coral reefs, which were severely affected by abnormally high Ssea Surface Temperature (SST) in recent years, contain some coral species and their reef-associated micro-algae symbionts that show far greater tolerance to higher SST than others. Coral reefs of South and Southeast Asia are reported to have been destroyed in 1998, largely due to coral bleaching induced by the 1997-98 El Nino event. Coral reefs from neighbouring countries are experiencing coral bleaching, so coral reefs of Myanmar will face similar threats caused by rising sea temperature. In 2004, Tsunami also affected some of the coral islands and sandy beaches along the Archipelago. The Tsunami destroyed coral and transported debris to the shore. Due to 2º to 4º C rise of SST above the current threshold SST, increases in cyclone intensity are predicted in Southeast Asia.

The destructive effects of climate change and human-induced pressure damage the coral reefs in this region. If coral reefs are bleaching, the production of lucrative fish, fish farming, pearl oyster culture, farming of deep sea lobster and seaweed will all be threatened and damaged. Many species of marine fishes will disappear and some will seek migration to the colder region. Some native species of whale and dolphin will also move to the areas of cold water too.

❖ *Coastal erosion*

Many sandy beaches along the coastal areas of Myanmar face with the problems of coastal erosion due to structural development, changes in living pattern and recreational activities which are undertaken to promote ecotourism development. These developments and changes initiate the enhancing degradation of the marine turtle nesting beaches, such as Maungmakan beach in Tanintharyi coastal region.Some of the islands located along the Rakhine coastal area are also affected by sea waves during monsoon season. These islands are essential resources for the marine fisheries production. For example in Thandwe District, Kalayaung village tract faced the problem of coastal erosion. In this village tract, two out of three villages were already displaced by coastal erosion. Since the villagers become uncomfortable with monsoon season, some move to other villages and some are seeking shelter at the monastery of their village. The situation could be more difficult if sea level rise due to climate change continues to take place.

Biodiversity

❖ *Forest wildlife and wild plants*

Myanmar is often cited as being rich in biodiversity in Asia. By nature, forests are highly vulnerable to climate extremes such as warming and drought. But specific studies are needed for this issue. Wildlife species and wild plants are abundant in Myanmar as shown in (Table 4.12).

Table 4.12: Wildlife species and wild plants in Myanmar

No	Description	Number of species
1	Birds	1000
2	Mammals	300
3	Reptiles	360
4	Butterflies	1200
5*	Plant species	7000

Source: Asian Disaster Preparedness Center - ADPC, 2009: Forest Fire, Hazard Profile of Myanmar and *Myanmar Agenda 21

However, many species of wildlife and wild plants are highly endangered and at risk of extinction. Strenuous efforts through the establishment of a network of protected areas are needed to arrest the biodiversity loss. Myanmar has established 30 wildlife sanctuaries and six national parks by the year 2009 (ADPC, 2009).

❖ *Fresh water fishes*

Very little is known in Myanmar about freshwater and marine fishes and priority should be given to carry out studies in this area. The number of fish species recorded in Myanmar is 196 (Denerstein et al.1993). Giant Catfish (*Pangasianodon gigas*), and Asian Arowana (*Scleropages formosus)*, are endangered. According to the 2004 IUCN Red List of Threatened Species (BI 2005) they both are listed to be present in Myanmar. However neither species has been confirmed as yet.

❖ *Marine fish species*

The commercially important marine fish species are changing in Myanmar coastal waters every year. With decrease in size and quantity of fish herds, the record of Catch Per Unit (CPU) is decreasing in the coastal waters.

The SST is different along the coast from the southern coastal area (Tanintharyi) to northern area (Rakhine). Fishing fleet moved every year up to the Rakhine coastal area, and found that the marine fish species composition, size and quantity had changed between the southern and the northern areas.

❖ *Marine turtles*

Marine turtles are long lived, highly migratory reptiles that can be found in the tropical and sub-tropical oceans worldwide. Of the seven living turtle species which are found around the world, six are known to reside in Southeast Asia. Myanmar has 5-species, namely, Green turtle (*Chelonia mydas*), Loggerhead (*Caretta caretta*), Hawksbill (*Eretmochelys imbricata*), Leatherback (*Dermochely coriacea*) and Olive Ridely (*Lepidochelys aolivace).* They are currently considered as endangered species. Conservation of marine turtles can be done only through international cooperation as they are the shared resource of the world. The habitats of marine turtles should also be adequately protected and efficiently managed.

❖ *Sea grass beds*

Sand sedimentation on sea grass beds in coastal waters along the beaches and between the islands of Myeik Archipelago is increasing, and it is attributable to heavy rains. Sand sediments covering the sea grass beds threaten the habitats of dugongs and sea turtles. The production of giant tiger shrimp and sea cucumber is also threatened by sand sedimentation.

❖ *Mangrove ecosystems*

In some coastal areas of Asia, a 30 cm rise in sea level can result in 45m of landward erosion (Tun, M.T. 2009). Since sea level rise tends to aggravate the currently eroding coastal areas, mangrove forests and swamp areas along the Myanmar coast will be facing this problem. The tropical cyclone Nargis and Tsunami not only destroyed mangrove ecosystems in the coastal area of Myanmar, but also brought about undesirable social, economic and environmental effects on the area. Mangroves provide products such as charcoal, firewood and housing materials and they provide services such as feeding and spawning grounds for aquatic species, nesting place for wildlife and protection against strong winds and sea water intrusion as bio-shield. Loss of mangrove ecosystems means loss of these products and services.

❖ *Marine mammals*

It is widely recognized that climate change impacts on marine mammals will be mediated primarily via changes in prey distribution and abundance. SST is a good predictor for marine mammal distribution. A few species may move between different temperature zones during regular migration.

❖ *Plankton booming*

During the Myanmar-India Joint Oceanography Cruise conducted in 2002, the occurrences of patches of phytoplankton (*Trichodesmiun*) blooms were observed to the west of 96º east. The phytoplankton blooms appear to be common in stratified surface layers where the surface nitrate was in traceable concentration. It is the indication of plankton blooming. Studies found that increase in nitrate concentration in sea waters was caused by land-based pollution. Rains with high intensity over the mainland Myanmar would bring down pollutants into the sea swiftly, contributing to increased nitrate concentration in sea waters.

4.4. Vulnerability Indices and Maps for Key Socio-economic Sectors

Methodology

Myanmar is committed to disclosing the vulnerability indices to climate change impacts in the Initial National Communication for which Myanmar has little experience. The index is the complex representation of key socio-economic information for all localities by applying various mathematical models. In a short period of time, it is hard to effectively undertake capacity building in the areas of technology, expertise, human resources and institution. Therefore a tentative approach that could generally represent the vulnerability index is explored based partially on the presentation of George Manful (2008), as shown in (Table 4.13).

Table 4.13: Vulnerability of key sectors to the impacts of climate change

Sub-regions	Food and fibre	Biodiversity	Water resource	Coastal ecosystem	Human health	Settlements	Land degradation
North Asia	+1/H	-2/M	+1/M	-1/M	-1/M	-1/M	-1/M
Central Asia and West Asia	-2/H	-1/M	-2/VH	-1/L	-2/M	-1/M	-2/H
Tibetan Plateau	+1/L	-2/M	-1/M	Not applicable	No informatio n	No information	-1/L
East Asia	-2/VH	-2/H	-2/H	-2/H	-1/H	-1/H	-2/H
South Asia	-2/H	-2/H	-2/H	-2/H	-2/M	-1/M	-2/H
South-East Asia	-2/H	-2/H	-1/H	-2/H	-2/H	-1/M	-2/H

Vulnerability:
- -2 - Highly vulnerable
- -1 - Moderately vulnerable
- 0 - Slightly or not vulnerable
- +1 - Moderately resistant
- +2 - Most resist

Level of Confidence:
- VH - Very High
- H - High
- M - Medium
- L - Low
- VL - Very Low

The vulnerability of a region is presented with number and letter combined. To represent the vulnerability of a sector of the country with index, the affected extent of area or community such as High, Medium, Low and None (if not applicable) and the level of confidence such as High, Medium, and Low should be considered as follows and shown in the (Table 4.14).

Table 4.14: Quantification of levels for vulnerability assessment

Description of level	Quantification of level		
	Low	Mediumm mm	High
Vulnerability level of an indicator	1	2	3
Confidence level of an indicator	1	2	3
Population level of a region	1	2	3

Vulnerability index may be calculated for a given region by systematic consideration on each socio-economic sector as follows.

Indicator score = Impact level x Confidence level
Sector score = Mean of indicator score of a sector
Vulnerability Index = Mean of all sector scores x Population density level

In this context the equation used for the vulnerability indices is as shown below:-

$$VI = \left\{\frac{1}{n}\sum_{k=1}^{n}\left[\frac{1}{n}\sum_{j=1}^{m}\left\{\frac{1}{n}\sum_{i=1}^{l}(CL \times AL)_i\right\}_j\right]_k\right\} \times PD$$

where **VI** = **V**ulnerability **I**ndex,
CL = **C**onfidence **L**evel,
AL = **A**ffected **L**evel,
PD = **P**opulation **D**ensity Level,
i = Number of climate change impacts; ***i*** = 1, l = 6 (in this context),
j = Number of indicators for a sector; ***j*** = 1, m = 3 (in this context),
k = Number of sectors; *k* = 1, *n* = 6 (in this context).

4.5. Climate Change Impact Parameters and Key Socio-Economic Sectors

Climate change impact parameters and Vulnerability Level (VL)

The meteorologists and climatologists from DMH have indentified the following six climate change impact parameters:

1. Cyclone and strong winds,
2. Flood and storm surge,
3. Intense rain,
4. Extreme day temperature,
5. Drought and
6. Sea level rise.

Their **Vulnerability Level (VL)** and its "Criteria and Scores" for the States and Regions of Myanmar are judged by the meteorologists and climatologists from DMH, as three Levels – High (**H**), Medium (**M**) and Low (**L**), numerically **3**, **2** and **1**. The score of **zero** or None (**N**) indicates that the effect is not applicable at all, see (Table 4.15).

Key socio-economic sectors and Confidence Level (CL)

The Vulnerability and Adaptation Assessment Team members indentified six key socio-economic sectors. Each sector has three indicators which are to be used for evaluating vulnerability scores. These indicators were determined by team members based on the available baseline data. The assumption for the unavailable data was made and scores were worked out based on experts' opinions.

The data used in the indicators of the sectors to assess the score levels of confidence are taken from the data/ statistics of Myanmar Progressive Report, Myanmar Agriculture Statistics, Department of Health, Department of Fisheries, Forest Department and Chronicle of National Development Comparison between Period Preceding 1988 and After 1988 (up to 31-12-2008) together with the expert opinion.

The **Confidence Level (CL)** of the indicators from all sectors for the States and Regions of Myanmar are shown in (Table 4.15).

Affected Level (AL)

The **Affected Level (AL)** is the last or 3rd basic factor of the climate change impact on the key socio-economic sectors for the calculation of Vulnerability Indices (VI). It is derived from the 1st and 2nd factors of the **Vulnerability Level (VL)** and **Confidence Level (CL)** by the team members.

Vulnerability Indices (VI) and maps

In accordance with the specified equation of the **Vulnerability Index (VI)**, Sector Scores (S) and their Mean Score (S_M) are worked out for the States and Regions. The vulnerability maps of key socio-economic sectors for the States and Regions of Myanmar are shown in (Figure 4.41), and "Population density of the States and Regions of Myanmar" is shown in (Figure 4.42) as the second map. The third map is "Vulnerability indices of theoverall key socio-economic sectors for the States and Regions of Myanmar" and it is shown in (Figure 4.43).

Table 4.15: Identification and justification "Confidence Level (CL)" of climate change impacts on the Indicators of the key socio-economic sectors

Sector	Indicator	Identification & justification
Agriculture	(1) Crop yield and production changes	**H, M, L** is defined by Expert opinion.
	(2) Crop pattern change	**H, M, L** is defined by Expert opinion.
	(3) Pest & disease	**H, M, L** is defined by Expert opinion.
Water Resources	(1) Rural water supply coverage	**H** = Above 2,000 villages **M** = 1,000 to 2,000 villages **L** = Less than 1,000 villages
	(2) Supply for hydro power	**H** = Above 100 Megawatts **M** = 50 to 100 Megawatts **L** = Less than 50 Megawatts
	(3) Irrigation works and beneficial area	**H** = Above 50 Dams **M** = 10 to 50 Dams **L** = Less than 10 Dams
Public Health	(1) Malaria	**H, M, L** is defined by Expert opinion.
	(2) Diarhorea	**H, M, L** is defined by Expert opinion.
	(3) Unavailability of safe water	**H, M, L** is defined by Expert opinion.
Forestry	(1) Forest cover (000 ha. of Natural forest)	**H** = Above 5,000 **M** = 1,000 to 5,000 **L** = Less than 1,000
	(2) Forest fire (Number of occurrence per year)	**H** = Above 100,000 **M** = 40,000 to 100,000 **L** = Less than 40,000
	(3) Species composition (000 ha. Closed forest)	**H** = Above 2,000 **M** = 750 to 2,000 **L** = Less than 750
Coastal Zone	(1) Fish yields and production changes	**H, M, L** is defined by Expert opinion.
	(2) Mangrove ecosystem	**H, M, L** is defined by Expert opinion.
	(3) Coral reef	**H, M, L** is defined by Expert opinion.
Biodiversity	(1) Forest biomass (growing	**H** = Above 1,000 mcm **M** = 500 to 1,000 mcm **L** = Less than 500 mcm
	(2)Habitat loss (Closed forest from 1975-2006)	**H**=Above 1,000 Sqml (Max = 3600.2Sqml) **M** = 500 to 1,000 Sqml **L** = 0 to Less than 500 Sqml **N** = less than zero [Min = (-)21.0 Sqml] Sqml]
	(3) Fishery species composition	**H, M, L** is defined by Expert opinion.

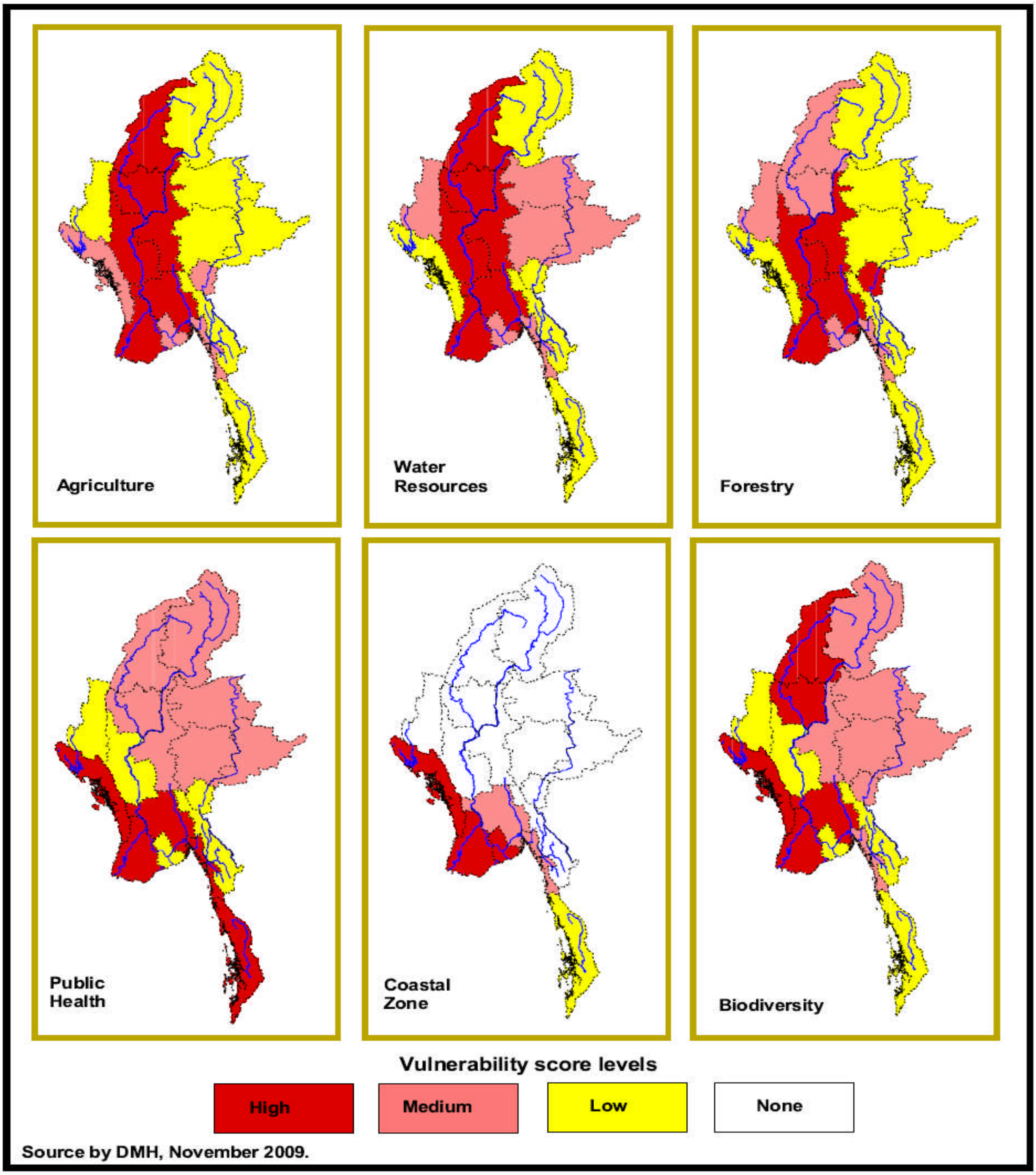


Figure 4.41: Vulnerability scores of the key socio-economic sectors for the States and Regions of Myanmar

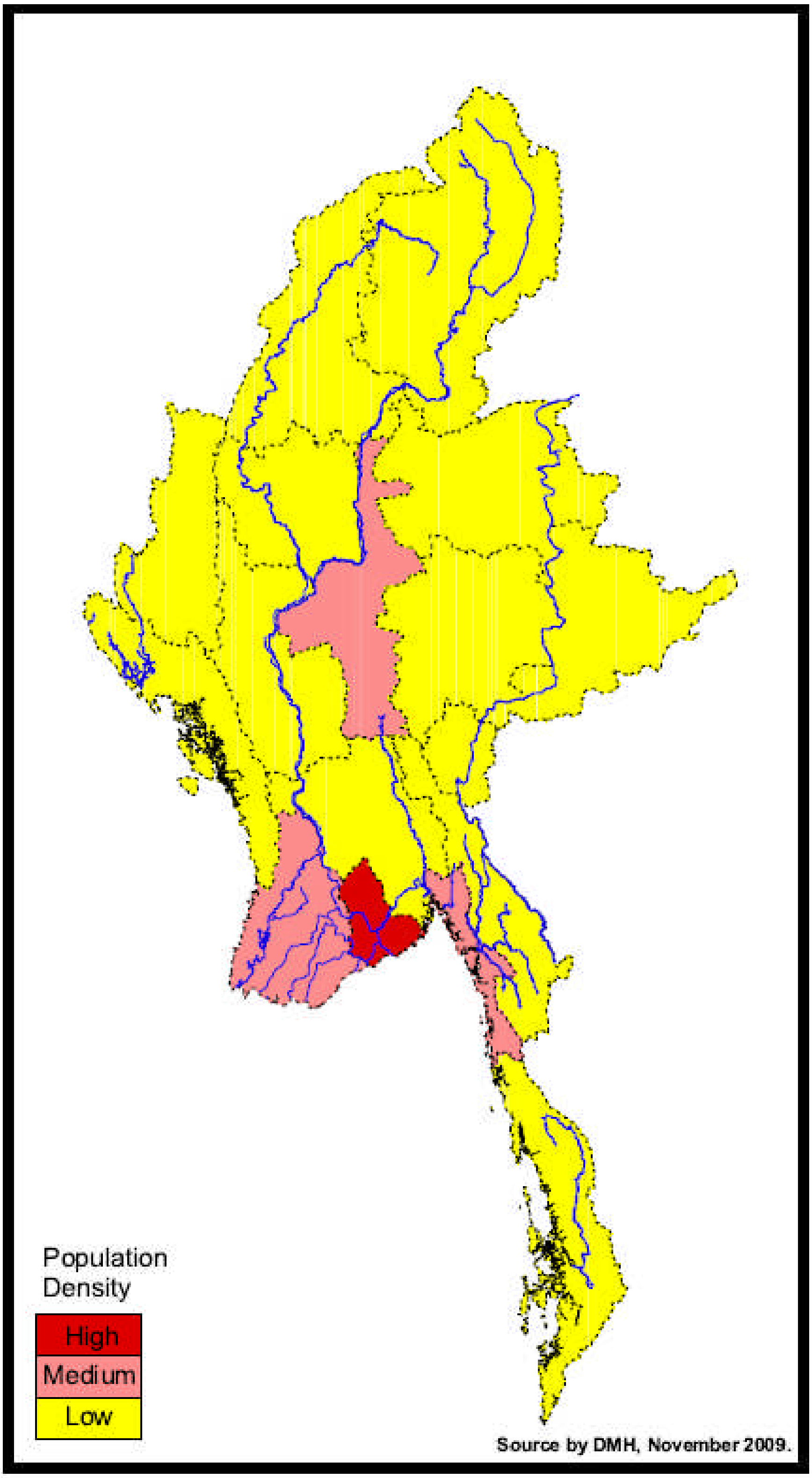


Figure 4.42: Population density of the States and Regions of Myanmar

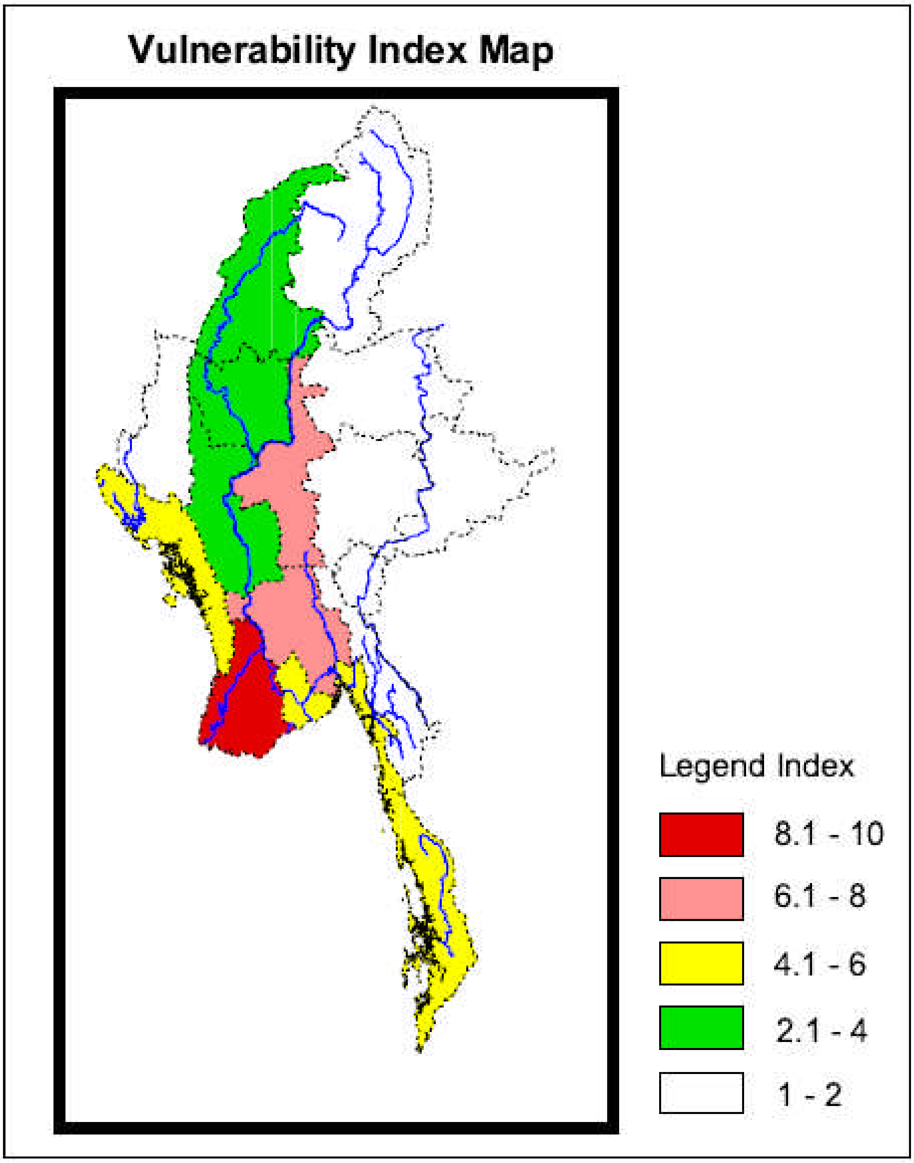


Figure 4.43: Vulnerability indices of the overall key socio-economic sectors for the States and Regions of Myanmar

In Myanmar, the highest sector score for Vulnerability is the Public Health sector followed by Biodiversity, Water Resources , Forestry , Coastal Zone and Agriculture sectors.

The Public Health sector score is maximum (5.3) in Ayeyarwady Region followed by Rakhine State, Tanintharyi Region, Bago Region and (3.9) in Mon State. It is minimum (2.0) in Chin State.

In Biodiversity sector, score is maximum (4.7) in Sagaing Region followed by Rakhine State, Bago Region, Ayeyarwady Region and Tanintharyi Region, and (2.0) in Mon State. It is minimum (1.1) in Yangon Region.

In Water Resources sector, score is maximum (4.5) in Mandalay and Bago Regions followed by Sagaing, Ayeyarwady and Magway Regions. It is minimum (0.9) in Kachin and Rakhine States.

In **Forestry sector**, score is maximum (3.4) in Magway Region followed by Mandalay, Bago, Ayeyarwady Regions and Kayah State. It is minimum (0.7) in Tanintharyi Region.

In **Coastal zone sector**, score is maximum (2.9) in Ayeyarwady Region followed by Rakhine State, Yangon, Bago Region and Mon State. It is minimum (1.3) in Tanintharyi Region. There is no score in the eight inland States and Regions.

In **Agriculture sector**, score is maximum (1.6) in Ayeyarwady Region followed by Bago, Sagaing, Mandalay and Magway Regions, It is minimum (0.2) in Chin State.

Vulnerability index is maximum with (6.13) in Ayeyarwady Region and minimum is (1.19) in Chin State. The index is relatively high in Ayeyarwady and Yangon Regions followed by Mandalay Region, Mon State and Bago Region. It is relatively low in Sagaing Region and Rakhine State. It is lowest in the remaining States and Regions with minimum in Chin State.

4.6. Targeted Researches

Global warming, climate change and sea level rise are the global issues to which high attention are paid by all nations particularly the agricultural countries like Myanmar. Adaptation strategies and measures adaptive to climate change impacts can be effectively undertaken if various aspects of climate and climate variability are well understood.

Climate variability

Climate variability is meant the variation of climate parameters. These are temperature, rainfall, rainy days, humidity, sunshine hours, solar radiation, thunder storm days, soil temperature and moisture, river stages and run off, floods levels, etc., which represent meteorological/hydrological related elements.

Studies on climate variability will include studies related to rainfall intensity, area coverage, duration of the spells, month of occurrence, and time hour of the day of occurrence, spatial and temporal distributions. Extreme climate events are also important areas to be studied. Possible research areas on climate variability are shown in (Table 4.16).

Table 4.16: Possible research areas for the study of climate variability

No	Research areas on climate variablity
1	Variability of south west monsoon onset/withdrawal over Myanmar.
2	Variability of monthly rainfalls in Deltaic Ayeyarwady Region.
3	Variability of heavy rain spells in Dry Zone of Myanmar.
4	Variability of dry spells in different areas of Myanmar.
5	Variability of rains in the pre-monsoon and the post monsoon periods.
6	Variability of dry season rainfalls in Myanmar.
7	Extreme climatic events and their impacts on the production of major crops.
8	Some synoptic situations responsible for the extreme rainfall episodes in Central Myanmar.

Climate change

Climate variability comprises many aspects and so does the climate change. Climate change studies focus on magnitude, intensity, and spatial and temporal distributions, characteristic features representing short-term, medium-term and long-term aspects. Climate change studies will focus on the magnitude, intensity and spatial and temporal distributions of rains, dry spells, extreme events and short-term to long-term characteristic features of climate. Possible research areas on climate change are shown in (Table 4.17).

Tropical storms

Tropical storms in the Bay of Bengal are important as the rain producing phenomena on one part, and as the potential hazards on the other. The global climate change scenarios indicate that tropical storm frequency and intensity are on the increasing trend and their tracks are going to be abnormal. After 2002, Myanmar coast has been crossed by the cyclone every year except 2005. Therefore Myanmar needs intensive studies on this issue. The examples of possible research areas are provided in (Table 4.18).

Table 4.17: Possible research areas on climate change

No	Research areas on climate change
1	Climate change aspect of south west monsoon onset/withdrawal over Myanmar.
2	Climate change of monthly rainfalls in Myanmar.
3	Climate change aspect of heavy rain spells in Dry Zone of Myanmar.
4	Climate change aspect of dry spells in different areas of Myanmar.
5	Climate change aspect of rains in the pre-monsoon and the post monsoon periods.
6	Climate change aspect of dry season rainfalls in Myanmar.
7	Assessment of extreme climatic events.
8	Changing patterns of extreme climates in Myanmar.
9	Analysis of climate change scenarios for sub states and division levels.

Table 4.18: Possible research areas on tropical storms

No	Research Area
1	Tropical storm landfall frequency and distribution along Myanmar coast.
2	Vulnerability index of tropical storm along Myanmar coast.
3	Cyclonic storm associated excessive rain spells in Myanmar.
4	Attempt to quantitative forecasting of cyclone rainfall in Myanmar.
5	Forecasting of cyclonic storm track in the Bay of Bengal.
6	Study on the influence of the sea surface temperature pattern upon the cyclogenesis in the Bay of Bengal and the Andaman sea.
7	Changing upper air circulations responsible for the abnormal movement of cyclones in the Bay of Bengal.
8	Regeneration of cyclones in the Bay of Bengal due to typhoon remnants of the South China Sea.
9	Storm surge prediction for Myanmar coastal zones.
10	Scenarios of different abnormal cyclone tracks and their potential impacts on Myanmar.

Droughts and warming trend

Droughts are very frequent phenomena in central Myanmar. These phenomena are not confined in the area but spread to the nearby regions. In the face of world-wide warming and the warming trend in Myanmar, drought characteristic changes call for extensive studies. Possible research areas on droughts and warming trend are shown in (Table 4.19).

Table 4.19: Possible research areas on droughts and precipitation warming trend

No	Research Area
1	Spatial frequency and distribution of drought in Myanmar.
2	Temporal distribution of drought and frequency in Myanmar.
3	Changing pattern of drought frequency in Myanmar.
4	Synoptic situations responsible for the significant drought of Myanmar.
5	Synoptic situations responsible for the drought of a specific time in Myanmar.
6	Synoptic situations responsible for the extended drought duration in the Dry Zone of Myanmar.
7	Hydrological features due to specific significant drought of Myanmar.
8	Impact of specific significant drought upon the water resources aspect of central Myanmar.
9	Potential threat of dry-zone drought upon the neighboring regions of Myanmar.
10	Potential impacts of cool-season drought in Myanmar.

Extreme climates in relation to El Nino

Myanmar experienced the impacts of El Nino and ENSO. It still needs detailed assessment of these impacts in different places of the country in terms of intensity, spatial extent and duration of the impact.

With the sea level rise and warmer sea surface temperature induced by global warming, understanding the characteristic pattern of El Nino impacts on the climate of Myanmar would be advantageous for identifying the climate change adaptation measures. Possible study areas are as shown in the (Table 4.20).

Table 4.20: Possible study areas on extreme climates in relation to El Nino

No	Study Area
1	Impact of El Nino upon the extreme temperatures of different States and Regions in Myanmar.
2	Impact of El Nino upon the extreme heavy rainfalls of different States and Regions in Myanmar.
3	Impact of El Nino upon the extremely warm spell duration of different States and Regions in Myanmar.
4	Warming pattern in Myanmar in the early stage of El Nino.
5	Rainfall pattern in Myanmar in the early stage of El Nino.
6	Drought characteristics during the period of El Nino.
7	Significant climate pattern in Myanmar in the wake of El Nino.
8	Significant intensity/track of cyclones in the Bay of Bengal during El Nino period.
9	Flood frequency and duration along the Ayeyawady River system due to impact of El Nino.
10	Abnormally low water level in dry season due to impact of El Nino.

There may have some cross-cutting issues between sectors under the studies mentioned above and research should also address these issues. The research works at various institutions are to be encouraged and supported by the government.
To be fully abled to conduct research programs, Myanmar is in need of supports from local and internationalnon-governmental organizations (NGOs) and international/regional bodies of the United Nations, among others.

Policy options for adequate adaptation and response strategies

The degree of climate change impact is hard to predict but scenarios show plausible general situations. The changes in climate in the world might be faster than as anticipated in the model output. The normal activities of many communities, infrastructure, developments, investments, natural resources and human resources, and major enterprises may get considerably disrupted or destroyed merely just by a single extreme event. Post-event restoration of the damages will further delay the development of the region in particular, and the country in general.

For successful adaptation, responsible personnel in the key socio-economic sectors have to be conversant with the tools and methodologies for data analysis and assessment so as to enable to properly identify the impact of climate and the climate change trend, which are likely to be dominant in the region. Then, these tools and methodologies of analysis and assessment have to be transferred to and disseminated among the stakeholders. Information which is a prerequisite requirement for the methodologies has to be reliable, transparent and consistent.

The policy options for adequate adaptation and response strategies are to improve socioeconomic conditions across the country by upholding the national economic objectives such as “development of agriculture as the base and all round development of other sectors of the economy as well”, and “development of the economy inviting participation in terms of technical know-how and investments from sources inside the country and abroad” as stated in the “Four Economic Objectives of State Peace and Development Council of Myanmar”.

Agricultural sector

Myanmar is making great efforts to enhance the development of agriculture sector to ensure food security within the country and to step up the export volume so as to generate increased foreign exchange. It will help Myanmar to make further investment to develop the overall economy of the nation. At national level food production is sufficient for the country's domestic consumption. However, food situation in some parts of the country is unsecured, especially in the dry zone, border areas and remote areas, due to harsh weather conditions, remoteness, and poor access to information on appropriate technology. In order to enhance food production, crop production has been intensified with the three main objectives as follows :

i. To fulfill the needs of local consumption;
ii. To export surplus agricultural products for increased foreign exchange earnings; and
iii. To provide assistance to rural development based on agriculture.

In order to meet the above objectives, two different approaches have been designed for implementation. The first approach is cropping area expansion and the second one is increasing per unit area production by mobilizing all available resources. Cropping systems will include double cropping, multiple cropping and mixed cropping on productive lands.

In addition, agricultural policy has been adopted by the Government with a view to improving the agricultural sector and enhancing national economy. The policy stipulates:

i. To allow freedom of choice in agricultural production.
ii. To expand agricultural land and to safeguard the rights of farmers.
iii. To encourage the participation of private sector in the commercial production of seasonal and perennial crops, and the distribution of farm machineries and other inputs.

Rice cultivation will be particularly encouraged to meet at least the local demand in all States and Regions. Development of new drought resistant varieties and intercropping will be encouraged. Irrigation facilities including river water pumping system would be extended in areas where rain water is not enough.

For flood-prone areas, development of structures will be intensified to prevent floods and inundation of low lying areas. Promotion of alternative crops, adjustment of planting and harvesting schedules, and floating agricultural system in wetlands or areas subjected to long-time inundation should be carried out.

As an agro-ecological based country, adaptation to climate change is particularly important in order to protect the production of staple food. In addition, income from the agricultural sector with crops of short rotation represents the main income source for the majority of population in Myanmar. Year-round cultivation of crops which are resistant to climate variability shall be developed through coordinated researches. For this purpose regional/ national agricultural research activities needs to be encouraged and assisted technically and financially.

Measures relating to the introduction of high yield, resilient crop, systematic handling and application of fertilizers and insecticides, effective irrigating methods etc. could be beneficial. Flexibility of cash crop selection might be encouraged in the event of severe climate.

In order to maintain or regain soil fertility, rotation of crop species, management of irrigation and controlling the loss of soil moisture may be among the important agricultural practices, calling for further research. Loss and damage of harvested crops from the field to the consumers should be minimized.

Storage methods for staple food and other crops during the event of extreme disastrous climate shall have to be transferred or exchanged between the countries. Research activities focusing on replacement of seeds in cropping areas damaged by extreme events should be encouraged. Seed replacement method for use in the crop-damaged areas may be transferred down to the grass root level of the country.

Water sector

Myanmar is an agro-based country where development of agriculture is placed on top of the priority as it acts as the base for all round development of other sectors of the economy. For boosting up crop production, availability of water is imperative and all possible means are therefore being sought to improve access to water availability. . Measures were taken in accordance with annual investment plan under the guidance and supervision of the Ministry of Agriculture and Irrigation. Measures undertaken to expand irrigation are:

- ❖ To construct small and medium dams and weirs — this will deliver quick-yielding solution for low yields and low cropping intensities, and a large number of farmers in selected poverty-stricken areas can enjoy the benefits;
- ❖ To improve the management of water storage and to promote the use of runoff water from upland watersheds
- ❖ To rehabilitate and renovate the existing government-maintained irrigation facilities and village irrigation works efficiency and economy in water storage and use — greater emphasis will be given to on-farm water management;
- ❖ To construct dams and sluices to impound backwater of the Ayeyarwady and Chindwin rivers during floods for late-rain cropping;
- ❖ To irrigate cultivated lands through river water pumping; and
- ❖ To irrigate cultivated lands by groundwater tapping.The agricultural sector is the basis of the economy and the main source of livelihood of rural areas, where about 70 percent of the population live. Hence, Myanmar has laid down and implemented five rural development tasks to bring progress to the whole nation. One of these is adequate supply of water for irrigation and for domestic use.

Up to May 2009, a total of 360 dams and reservoirs have been constructed for irrigating 1.68 million hectares of cropland. In parallel with the irrigation projects, 322 pump irrigation projects from main rivers, consisting of 129 electric-pumps and 193 diesel-pump irrigation projects, and installation of 8001 tube wells with a combined imigarted area of about 0.23 million hectares were undertaken. Irrigation coverage increased from 12.5 percent of sown area in 1987-88 to 17.0 percent in 2008-2009. Rural water supply is sufficient for 13.9 million out of 39.27 million of rural populace.

The central Dry Zone where the annual rainfall is low and unreliable has a high potential for crop diversification. Severe droughts with increased frequency of occurrence due to climate change are the most serious natural hazards facing the people living in this area. In this region, the cultivated areas along the major rivers are irrigated through river water pump projects. In other regions, where runoff is significant, reservoirs can be constructed and gravity irrigation could be applied at cheaper cost. In areas where hydro-geological conditions are favorable tube wells are sunk for irrigation and domestic purposes. In the mountainous region where hydropower and irrigation are undertaken, there is a high potential for agricultural development on some low-lying flat lands.

Rice is the major crop in Delta Region where the population density is the second highest in the country. In this region, about 40% of the areas are still affected by flood damage and sea water intrusion. Construction of sluice gates and drainage canals will provide the benefits of irrigation, flood control and prevention of sea water intrusion.Advanced forecasting technologies and early warning systems are essential in mitigating the affects of floods.

There is evidence that flooding is likely to become a challenging problem in the Delta and the Dry Zone. While floods can cause damages to agriculture, transport, and communication, they pose a growing concern on the safety of dams. Adaptation to drought and chronic water shortage is another growing problem. Increased intensity and decreased frequency of rainfalls in these regions will induce certain changes in surface runoff and groundwater characteristics. Such changes will in turn disrupt the existing land use pattern and management practices. Due to deforestation and land cover changes in upland watersheds, some of the dams in Myanmar are facing the heavy siltation problems, threatening the life span of reservoirs. To reduce siltation, Forest Department shall continue and further step up its annual operations of forest conservation and restoration in critical watersheds.

The coupled reservoir and irrigation system should be developed. It will allow for the redistribution of water during wet seasons and for carry-over use in the dry seasons of above-normal water years. The system will thus minimize the impacts of drought.

Other adaptation measures have been the use of levees and dams, which will protect communities against heavy precipitation and high flood flows during extreme wet periods. But, climate change might challenge these conventional measures, and more aggressive strategies such as recharging aquifers artificially or developing integrated strategies that optimally operate reservoirs in combination with artificial recharging of aquifers.

The Government has formulated national sustainable development strategy which reflects Myanmar Agenda 21 and the Millennium Development Goals (MDGs) stipulated in the United Nations Millennium Declaration, 2000. In Myanmar, growth in agriculture productivity has been achieved and it will raise the incomes of the rural poor and thus reduce poverty, a priority MDG of the country. Adequate water supply is one of the basic requirements for boosting up the production of crops. Accordingly, agricultural infrastructures are being built throughout the country within a short span of time. However, rapid construction of irrigation facilities such as dams, reservoirs, weirs and river pumping stations may eventually lead to contamination and depletion of water resources. Water management is seen as a key area to be addressed, and laws and regulations to prevent water-related environmental degradation should be strengthened.

Although cause and effect of many environmental issues are cross-cutting in nature, in Myanmar. The ministries are taking on development planning and programs primarily orienting on their own sector-wise policies, strategies and targets. Sectoral coordination and environmental implications particularly in the area of cross-cutting issues are thus paid little attention. This leads the government to establish National Commission for Environmental Affairs (NCEA) in 1990.

To cope with the climate change impacts, the strategy for water resource development will focus on the issues of ever-increasing water demands and shortages. It will be similar to those strategies currently under practice. A prerequisite to adaptation is the application of an Integrated Water Resources Management (IWRM) strategy at both catchment and river basin levels.

Public health sector

Due to global warming, Myanmar climate also has become markedly warmer especially in recent years. The warming extends to the regions of higher elevations as well. Accordingly, the habitats for mosquitoes and air born diseases are not confined to the low lying plains only, but are expanding to the mountainous regions of higher elevations. Malaria, cholera and dengue fevers, etc. may become all year round normal diseases. Influenza cases may become extensive and high rate of mortality may be expected during the extreme events, particularly among the aged and infants. Basic medical care and needs should be provided to the rural folks systematically to reduce the climate change impacts.

According to projected changes in the hydrological cycles, associated with global warming, increase in morbidity and mortality due to diarrheal disease primarily associated with floods and droughts are expected in developing countries in East, South and Southeast Asia (IPCC 2007). Increase in coastal water temperature would exacerbate water toxicity and/or the outbreak of cholera. Natural habitats of vector borne and water borne diseases are reported to be expanding. Diseases originated in the tropical low lying areas are likely to spread towards the high land area. Enhancements of public education on health matters are essential.

For successful adaptation, stakeholders involved in this key sector have to be conversant with the IPCC tools and methodologies for analysis, assessment to properly identify the impact of climate and the climate change trend likely dominant in the region. Then, this practice should be disseminated among the stakeholders. Information which is prerequisite requirement for the methodology has to be reliable, transparent and consistent to meet the international standard.

Myanmar has reduced the import of ODS substances and is now using non-ODS chemicals in the medicine.

To mitigate health hazards, Myanmar is undertaking certain measures such as improvement in the construction of houses and health infrastructures with new designs, improvement in environmental practices and preparation and implementation of disaster management plans. . For disease control activities, vaccination against diseases, basic health care and preventive services and community awareness raising against the disease outbreaks are carried out.

The effects of climate change on health include direct effects such as illness and deaths due to extreme temperatures, e.g. effect of heat wave in India in May 2009. Similarly, storms and heavy rains may occur in some areas and may cause floods. Not only water contamination but also air pollution can arise in these water-flooded areas. Indirect effect is that there might have increased incidence of diseases and high mortality rates due to epidemics, such as malaria epidemic due to mosquitoes. Confounding factors are sensitivity of human health to elements of weather and climate, differing vulnerability and movements of vectors.

Adaptation measures will include use of vaccines against diseases, improved use of weather forecasts and early warnings, improved environmental practice, preparation and implementation of disaster management plans, and improvement in public health infrastructure. Disease surveillance and emergency response capabilities should also be enhanced as important adaptation measures.

Forestry sector

Myanmar has been implementing a large number of forest conservation and development programs that have the potential to reduce the vulnerability of forest ecosystems to the impacts of climate change, and they include, among others:

- ❖ Enactment of new Forest Law in 1992, enactment of Protection of Wildlife, Wild Plants and Conservation of Natural Areas Law in 1994, and promulgation of Myanmar Forest Policy in 1995 and issuance of Community Forestry Instructions in 1995 . These laws and forest policy will contribute to conservation of forest resources including biodiversity and reduction of forest fragmentation.
- ❖ A large reforestation program to reduce demands on forests for timber, industrial wood and fuel wood. It will lead to conservation of biodiversity and reduction of forest degradation.
- ❖ Involvement of local communities in forest protection and regeneration and creation of long term stake in forest health, through the Community Forestry program.

The performance and impacts of these measures in quantitative terms are however not clear. To prevent the deforestation and to increase reforestation particularly in dry zone of Central Myanmar, it is essential to provide financial and technical supports to the Dry Zone Greening Department. Increased investments are needed for implementing mangrove reforestation works in the deltaic areas and coastal region. Village woodlots should be established in each and every village or village track to meet the local demand for timber and firewood and it should be included in the long term development / disaster preparedness plans. Traditional slash and burn agricultural system prevailing in some mountainous areas may be oriented to more sustainable livelihood systems.

With increased warming, forest areas are bound to experience high temperatures easy to catch fire. Forest fire at one place can wildly spread out to other areas during dry summer. Forest fire management encompassing standard layout, landscape planning, dead timber salvaging, , and wild life rescue is an important policy matter. One of the policy objectives is to increase the extent of Permanent Forest Estate up to 30% of total land area of the country.

In forestry sector, appropriate land use and management, planting of stress-resistant tree species, control of shifting cultivation and increased efficiency of wood industry are among the options which can improve the forest adaptability to climate change. Therefore recommended adaptations are:

- ❖ planting of more tolerant tree species,
- ❖ increased forest fire control,
- ❖ increased forest products processing efficiency,
- ❖ use of wood substitute materials,
- ❖ provision of financial assistance to forest communities affected by climate change,

- provision of subsidy on substitute fuels and building materials for people of hilly regions,
- change from productive to protective functions of forests and establishment of forest corridors to assist migration through forests.

Coastal zone sector

Emphasis should be given to protect the coastal zone erosion by structural defense and development of mangrove forest zones. Establishment of settlements inside the potentially danger zones which are at risks of sea level rise, storm surges and sea water intrusion is to be restricted with the help of law enforcement. Construction of storm shelters is necessary for each of the village tracts in the deltaic region to escape from strong winds and sea waves. It is necessary to provide local communities with facilities which can receive weather news, weather forecasts and early warnings round the clock. All public ferries and boats should carry radio receivers to avoid any possible mishap due to the extreme weather event. Coastal impact development should be considered in the coastal development plans.

For successful adaptation, stakeholders involved in this key sector have to be conversant with the IPCC tools and methodologies for data analysis and assessment so as to ensure the proper identification of climate change impacts and the climate change trend likely to dominate in the region. Then the methodologies are to be disseminated among the stakeholders. Information which is a prerequisite requirement for the methodology has to be reliable, transparent and consistent to meet the international quality standard.

Biodiversity sector

In this section, biodiversity of fishery will be emphasized. Myanmar Fisheries will promote the fishery products from both aquaculture and capture fisheries. To increase the production, support from and collaboration with national and international scientists will be needed. The vision of the Myanmar Fisheries is to promote total fishery production and to earn foreign exchange from the export of fishery products.

Myanmar owes the richness of her fresh water fisheries to the extensive river systems: Ayeyarwady with a length of 2150 km, Chindwin (a tributary of the main Ayeyarwady) 844 km, Sittaung 536 km and Thanlwin 2400 km . All these rivers can be considered nationally owned productive water assets. The other resources such as Indaw Gyi Lake (the largest lake of Myanmar in Kachin State), Inlay Lake, (famous lake in Shan State), ponds, reservoirs and dams will also provide fish for local consumption annually. The total inland fisheries production will increase by 4.11 mmt or 2.20 tons per hectare.

Myanmar will improve aquacultural practices by replacing the traditional methods currently in use with modernized techniques such as Pen Culture and Cage Culture for Seabass, Grouper and Milkfish species in the Rakhine and Tanintharyi coastal areas.

The main responsibilities of the DoF are to conserve aquatic resources, to undertake licensing and surveillance by applying the existing fisheries laws as necessary. To ensure effective management of fishery resources, the Government has promulgated four fisheries laws, namely:

1. The Law relating to the Fishing Rights of Foreign Fishing Vessel, promulgated on April 25, 1990.
2. Myanmar Marine Fisheries Law, promulgated on April 2, 1989.
3. Freshwater Fisheries Law, promulgated on March 4, 1991, and
4. Law relating to Aquaculture, promulgated on September 7, 1989.

Fattening of mud crab and processing of soft shell mud crab are the booming business in Kyun Su Township of Tanintharyi Region. Marine finfish culture using net cages has also been a common practice in area although seed production of marine finfish has not been successful as yet. Farmers have to collect seed from the wild. The species are groupers and snappers. Marine circular net cages are made at Myeik in the same area. Farming of seabass in earthen ponds is another practice, currently gaining interest among the farmers and private sector. It has been successful to produce seabass recently. Moreover, experimental culture of seaweed, *Eucheuma cottoni* has been introduced in the area. The DoF intends to promote Pen Culture and Cage Culture for Seabass, Grouper and Milkfish along the Rakhine and Tanintharyi coastal shore. As planned by the DoF, there would be a total of 200,000 ponds by 2031 along the coastal shore. The sustainability of marine living organisms is entirely dependent on coastal mangroves and coral reefs. The coastal islands and mangrove ecosystems provide environmen-tal protection against tsunami, bank erosion, strong winds and sea water intrusion.

In order to conserve fingerlings and juvenile shrimps and to avoid conflict between the artisanal fishermen and the trawler, the DoF bans fishing by trawler in the near-shore zone: fishing by trawler is not allowed within five miles from the shore line for the Rakhine coast and within ten miles for the Tanintharyi coast. In the Tanintharyi coastal area, Myanmar has dynamic Myeik Archipelago.Insular waters are characterized by an abundance of coral reefs and extensive sea grass beds. The area is characterized by a large number of rare and endangered species including five species of marine turtle and a number of marine mammals such as dolphins, porpoises, whales, dugongs and elasmobranches such as whale shark and rays. The DoF is exerting continuous efforts to conserve these national heritages with the following objectives:

- ❖ To preserve and restore spawning, feeding and nesting habitats;
- ❖ To make nesting beaches acceptable to turtles by eliminating beach pollution through law enforcement;
- ❖ To implement beach cleaning program and prevent exploitation activities;
- ❖ To minimize waste and to prevent pollution of the marine environment, and
- ❖ To increase public awareness and participation in sea turtle conservation through extension and education activities.

Adaptation options

Vulnerability index of different economic sectors of states and Regions has been presented based on different level of vulnerability indicator scores. For the adaptation assessment reduction of vulnerability level indicator will enforce the lowering of vulnerability level and strengthening of adaptation measures for each sector.

❖ *Agriculture*

The mean score of indicators is relatively high in Sagaing, Mandalay, Magway, Bago and Ayeyarwady Regions. The indicator could be manipulated to reduce the vulnerability to take effective adaptation options such as;

a) Maintenance of the target crop yield and production under continuous watch and care with advanced technologies and facilities
b) Preparation of crop calendars for various regions.
c) Availability of seeds and seedlings of various species
d) Proper utilization of fertilizers, pesticides, insecticides and water.

❖ *Water resources*

The mean score of indicators is relatively high in Sagaing, Mandalay, Magway, Bago and Ayeyarwady Regions. The recommended adaptation options could be:

a) Expansion of rural water supply coverage
b) Establishment of new water supply sources
c) Compliance with irrigation regulations for beneficial areas
d) Application of integrated water resources management strategy at different levels of usage

❖ *Public health*

The mean score of indicators is relatively high in Rakhine and Mon States, Bago, Ayeyarwady and Tanintharyi Regions. The recommended adaptation options could be:

a) Eradication of malaria (mosquitoes) habitat in the areas
b) Extension of public education to limit diarhorrea outbreak
c) Reservation of preventive pills and medicines for epidemics
d) Securing financial support to make safe water available without difficulties

❖ *Forestry*

The mean score of indicators is relatively high in Mandalay, Magway, Bago, Ayeyarwady Regions and Kayah State. The recommended adaptation options could be:

a) Enforcement of forest regulations
b) Establishment of groups of forest fire fighting volunteers
c) Control of slash and burn practice in the forest areas
d) Creation of alternative livelihoodopportunities for forest dwellers
e) Control of forest products
f) Conservation of wild life species

❖ *Coastal zone*

The mean score of indicators (defined by fish yields and production changes, mangroves ecosystem, and coral reef) are relatively high in Rakhine State, Yangon and Ayeyarwady Regions. The recommended adaptation options could be:

a) Enforcement of fishing regulations in mangrove areas
b) Rehabilitation and expansion of mangrove forest areas
c) Encouragement to the people to conserve coral reefs for sustainable development

❖ *Biodiversity*

The mean score of indicators (defined by forest biomass, loss of habitat or closed forest and fishery species) are relatively high in Rakhine State, Sagaing, Bago and Ayeyarwady Regions. The recommended adaptation options could be:

a) Regulation of biomass extraction from the forest
b) Promulgation of special law and regulations to protect species of near extinction
c) Encouragement to set up special wild life fund
d) Creation of alternate livelihood means or income generation opportunities.

In assessing the vulnerability of a sector, selection of indicators for the specific purposes of the sector should be given high priority so that most appropriate adaptation options could be identified. Adaptation may follow according to the "Priority list of the States and Regions for the sectors and indicators" in (Table 4.21) and "Priority list of sectors for the States and Regions" in (Table 4.22).

Response strategies

Global warming and climate change impacts are growing issues that can impede the sustainable development of nations all over the world. Abnormal occurrences of weather systems are taking place in many parts of the world due to climate change. To enable to properly respond to the future climate change impacts, a nation needs to enrich its capacity to undertake climate change assessment and vulnerability assessment of the key socioeconomic sectors by analyzing observational data and model outputs on regular basis.

To be able to make proper assessment, the subject of climate change impact has to be familiar to all stakeholders including ministries, institutions, non-governmental organizations and the private sector. In this regard, DMH has been organizing Monsoon Forums since 2007 in cooperation with Asian Disaster Preparedness Centre. The forums generally review climate projection, analytical results of observed data and agricultural planning. The major output of the forums is the proposal for adaptation strategies. Therefore climate change oriented forums and workshops are the indispensable corridors for the review and exchange of data and for formulating the most appropriate policy and strategies. Research projects, covering the areas of climate change impact, vulnerability to climate change and adaptation strategies, may be carried out in collaboration with both regional and international institutions. It may be necessary to insist that Myanmar is financially and technically constrained to undertake research studies on its own.Geographical setting of Myanmar is exposed to natural disasters such as cyclones, storm surges, floods and drought. Myanmar people are therefore used to adaptation to climate change. However, Myanmar has to respond to the adverse climates with high vulnerable situation.

Table 4.21: Priority list of States and Regions for the sectors and indicators

Sr No	Sector/Indicator	Score	States and Regions
1	**Agriculture**	**1.56**	**Ayeyarwady**
	(1) Crop yield and production changes	3	Ayeyarwady
	(2) Crop pattern change	0.83	Ayeyarwady
	(3) Pest & disease	1	Bago
2	**Water resources**	**4.5**	**Mandalay and Bago**
	(1) Rural water supply Coverage	8	Ayeyarwady
	(2) Supply for hydro power	5	Sagaing
	(3) Irrigation works And beneficial area	4.5	Bago
3	**Public health**	**5.28**	**Ayeyarwady**
	(1) Malaria	4	Kachin
	(2) Diarhorea	8.5	Rakhine, Ayeyarwady and Tanintharyi
	(3) Unavailability of safe Water	4	Ayeyarwady
4	**Forestry**	**3.44**	**Magway**
	(1) Forest cover (1000 ha: of Natural forest)	2.67	Mandalay, Magway and Ayeyarwady
	(2) Forest fire (Total occurrence per year)	5	Magway
	(3) Species composition (1,000 ha: Closed forest)	3	Bago
5	**Coastal zone**	**2.89**	**Ayeyarwady**
	(1) Fish yields and production changes	3	Rakhine and Ayeyarwady
	(2) Mangrove ecosystem	3.5	Mon, Bago and Yangon
	(3) Coral reef	3.3	Rakhine
6	**Biodiversity**	**4.67**	**Sagaing**
	(1) Forest biomass (growing stock)	5	Rakhine
	(2) Habitat loss (closed forest from 1975-2006)	5.5	Sagaing and Bago
	(3) Fishery species composition	5	Sagaing

Table 4.22: Priority list of sectors for the States and Regions

Sr. No	States And Regions	P1	P2	P3	P4	P5	P6	Remarks
1	Kachin	PH	BD	FR	WR	AG	-	No CZ
2	Kayah	PH	BD	FR	WR	AG	-	No CZ
3	Kayin	PH	BD	FR	WR	AG	-	No CZ
4	Chin	PH	WR	FR	BD	AG	-	No CZ
5	Mon	PH	CZ	BD	FR	WR	AG	Coastal
6	Rakhine	PH	BD	CZ	FR	AG	WR	Coastal
7	Shan	WR	PH	BD	FR	AG	-	No CZ
8	Sagaing	BD	WR	PH	FR	AG	-	No CZ
9	Mandalay	WR	PH	FR	BD	AG	-	No CZ
10	Magway	FR	WR	PH	BD	AG	-	No CZ
11	Bago	WR	PH	BD	FR	CZ	AG	Coastal but no CZ
12	Ayeyarwady	PH	WR	BD	CZ	FR	AG	Coastal
13	Yangon	PH	CZ	FR	WR	AG	BD	Coastal
14	Tanintharyi	PH	BD	CZ	WR	FR	AG	Coastal

Note:- **P1**, **P2**, **P3**, **P4, P5** and **P6** are represented for the sectors in priority.
AG = Agriculture**, PH** = Public health, **WR** = Water resources,
FR = Forestry, **CZ** = Coastal zone and **BD** = Biodiversity.

With the global warming IPCC foreshadows unprecedented extreme climates and increasing frequency of disasters among others, in the decades to come. Therefore, Myanmar needs systematic studies on the climate change adaptation strategies with international/regional cooperation and assistance.

For providing climate information to the international communities and centers, selected station of DMH should be equipped with Automatic Weather Observing Systems (AWOS) and computers for data quality control and analysis and data archive. DMH staff should be upgraded thought capacity building refresher courses and on- job trainings at the regional climate centers. Numerical climate model should be familiarized and regional joint studies on adaptation strategies performed.

Modern facilities must be provided to DMH for effective dissemination of current climate, extreme climate and climate related hazards. An information system needs to be developed to ensure timely information to the public, government agencies and key socio-economic sectors including NGOs. DMH has recognized the importance of improved assessment of climate change to help identify adaptation measures and response strategies most suited to the country. DMH will thus attempt to undertake the following prioritized actions as shown in (Table 4.23) to ensure improved assessment of climate change.

Table 4.23: Prioritized action for improved assessment of climate change

No.	Description	Objectives
1	Replacement of instruments for observation	To upgrade the quality of the observation for improved climate change assessment.
2	Providing Automatic Weather Observing System (AWOS) to selected stations	To provide quality information to Regional / Global climate centers.
3	Data analysis with computer facilities	
4	Capacity building for data archive	Data analysis and numerical model.
5	Planning of schemes jointly with experts from key-socioeconomic sectors	To study the past climate change/ severe climate impact upon key socioeconomic sectors.
6	Workshop/ forum on climate change	To raise the awareness and response strategies. Seek opportunities to do researches in key-economic sectors

Climate change information

According to the "Climate Change 2007 of IPCC, impact, adaptation and vulnerability", global warming is evident in the data series of the period 1991-2005 as a continuous process. It is the result of Greenhouse Gases (GHGs) emission and changing socio-economic pressures such as population growth, urbanization, land-use change, etc. in addition to natural climate forcing. It is difficult to differentiate a climate variability or climate change from the current knowledge. Therefore, IPCC defines the climate change as any change in climate over time (time range is not specified but it should be at least one decade or more).

Climate change may be occurring with different patterns of climate variables and physical phenomena, some violently impending such as tropical cyclones and floods, while some of them are slowly damaging such as drought.

As a result of global warming, increasing temperature and decreasing rainfall in central Myanmar may lead to the expansion of the country's Dry Zone area where annual rainfall is less than 1,000 millimeters.

The late onset of monsoon consequently delays the paddy crop planting and will reduce crop yield while the early withdrawal of monsoon will adversely affect on the successful harvest and crop productivity.. The unprecedented cyclonic track after landfall across Myanmar coast would bring copious rains and strong winds damaging the crops already ripened and will disturb harvesting activities.

Normal livelihoods of people, existing infrastructure, buildings, etc. in the coastal region can be severely damaged by the tropical cyclones. Therefore, warning system should be upgraded, and effective follow-up response to the warning should be enforced or encouraged. Weather stations should be upgraded with the digital sensors. Data compilation/ dissemination should be improved by relevant up-to-date equipments and internet access.

Needs and concerns arising from adverse effects of Climate Change

The loss and damages due to Cyclone "Nargis" in the Ayeyarwady Delta reflect, to a certain extent, the vulnerability level of the whole country as well. As a developing country, people's livelihood mainly depend on the favorable climate conditions and natural resources such as land, water and forest resources.

In agricultural sector, late monsoon onset will delay the agricultural activities such as soil preparation for paddy cultivation. This delay will disturb the paddy growing in the subsequent months. During the growing season, abnormal climate will damage the crops. In the harvesting period attention has to be paid more to the adverse climate which can damage the ripening crop. Replenishment of cultivating lands urgently in a short duration is very costly and very risky due largely to the fact that crops grown under suitable climate condition may normally go out of phase.

Disruption in agricultural activities will affect not only the livestock industry but also the socio-economic development of the nation. High prices of basic commodities and higher transport costs will cause problem to the general population of the country. For example, during the relief and recovery period after the Cyclone "Nargis" of May 2008, the prices of basic food items had risen significantly, because of the fear that there would have decreasd food supply from the Ayeyarwady Delta. In fact, rice production from the Ayeyarwady Delta contributes only about 10% of the country's total rice consumption. This fear remained over a couple of months, keeping high prices unchanged.

Fresh water resources in the coastal areas are mainly the impounded waters in ponds and reservoirs and the groundwater. In the event of cyclones, fresh water storage facilities were devastated by strong winds and sea water inundation. There were disruption of municipal water supply and ground water supply owing to problems in electricity supply. Water shortage problems induce negative impacts, especially in the urban and downtown areas. Hygiene level in these areas becomes low which may be followed by the outbreak of water borne diseases.

In the event of climate extremes, forests are vulnerable not only to the climate change but also at high risks of being over-exploited. If climate-sensitive sectors such as agriculture, livestock and fisheries are largely disrupted by climate extremes, food security of rural communities could be impaired. Under such situation, they have no alternatives, but have to turn to the forests for intensified exploitation of wood and non-wood forest products for their subsistence living, and the process may finally destroy the forests.

During the extreme dry period due to El Nino episodes of the Pacific, most of the forests will become much drier. There will be more forest fires which will be difficult to extinguish. Forests are very vulnerable to extreme climate events, particularly severe droughts. Rural communities inside and around the forests should therefore be supported financially and technically to enable them to adapt to the impacts of extreme events.

4.7. Conclusion

Myanmar, being a tropical coastal country, with north-south running mountain ranges and river systems is endowed with substantial water resources mainly due to southwest monsoon. It is rich in biodiversity due to natural extensive coverage of forests. Myanmar has fertile river valleys, extensive deltaic plain and has long coastal line with diverse marine resources. The climate is generally favorable for various agricultural practices, growth of forest stands and fishery industries, all of which support the livelihood of majority of the population. Extreme events and climate variability disrupt the livelihoods of rural populace, particularly the farmers and the national sustainable development as a consequence. Cyclones from the Bay of Bengal usually cross the Rakhine coast at least about once in every two years. Floods and droughts in certain areas occur annually.

The landfall of Cyclone "Nargis" in 2008 over Ayeyarwady Delta has proven that Myanmar is vulnerable to cyclones originated in the Bay of Bengal, though it is very unusual in the cyclone history of Myanmar. In the global context, climate change scenarios show increasing frequency of cyclones, intense rains, more floods and droughts, extreme temperatures and sea level rise. Therefore Myanmar has to pay high attention to climate scenario of the IPCC.

According to the numerical model MAGICC/SENGEN, Myanmar will be warmer by 1.25 – 1.60 °C during June-November, 2.0°C during March-May and 2.5°C during December- February by the end of 2100. As for the precipitation, the whole country will generally experience 10 % increase during March-November including rainy season at the end of the year 2100. PRECIS model shows an increase of temperature 2-3°C with standard deviation of about 0.9°C for the whole country. Regarding rainfall, there is an increase of 1582 mm at Sittway, about 600 mm at Myitkyina, Pathein and Dawei stations and about 300 mm elsewhere in the country at the end of the year 2100. Scenario's temperature and precipitation are within the reasonable ranges in the Southeast Asia region. Myanmar still needs more exercises with the climate change related numerical model studies.

In the vulnerability assessment, six potential climate change impacts are selected such as tropical storm/ strong wind, flood/ storm surge, intense rain, extreme day temperature, drought and sea level rise. The climate change impacts are applied to three selected vulnerability indicators identified for each of the key socio-economic sectors which are water resources sector, agricultural sector, forestry sector, health sector, coastal zone sector and biodiversity sector. The highest sector score is observed at public health sector followed by sectors of biodiversity, water resources, forestry, coastal zone and agriculture.

Being an agricultural country, measures are taken by the Government to ensure the nation's food security which is one of the principal requisite for national development. There have proven progress in the irrigation system such as construction of new reservoirs and dams, installation of more river water pumping stations and increased groundwater harvesting. Systematic utilization of fertilizers and introduction of some advanced technologies are also being undertaken. Summer rice production and wetland cultivation in addition to rain fed cultivation are the practices being promoted. However, adaptation plans for this sector should be further enhanced for increased earning of foreign exchange and national economic development.

The vulnerability index have been estimated by treating the mean vulnerability score with population density level of States/Regions. The vulnerability index is relatively highest in Ayeyarwady and Yangon Regions followed serially by Mandalay Region, Mon State and Bago Region. It is low in the remaining States and Regions has the lowest Chin State.

For adequate adaptation measures and strategies, to be developed, vulnerability analysis is very important. Vulnerability analysis has been based on the selected impact indicators of the sector concerned, and the indicators were based on the available baseline data and information.

Vulnerability and adaptation measures are to be enhanced through:

- ❖ Improvement of monitoring systems for flood, drought, water quality, pests and diseases.
- ❖ Institutional strengthening, capacity building and networking.
- ❖ Development and implementation of appropriate response strategies for socioeconomic sectors.
- ❖ Mainstreaming of adaptation measures and response strategies into development plans.
- ❖ Promotion of national/ regional/ international coordination.

Information about current climate change and possible climate in the near future may be disseminated timely and effectively to the key socioeconomic sectors and different stakeholders including public through various media available, but with special emphasis on the targeted region. A National Climate Centre should be established and dedicated staff assigned to the Centre so that climate change information of the WMO standard is ensured and the immediate need of DMH satisfied.

To reduce the vulnerability to the possible climate change impacts, policies, legislations and other supporting tools are to be developed collectively. It will help identify and implement adaptation strategies, ensuring the continued progress of Myanmar towards a peaceful modern developed country. In this context, institutional strengthening, technology innovation and transfer, provision of advanced tools and equipment, enabling condition with adequate funds and collaboration with relevant institutions and agencies at the national, regional and international levels are indispensable.

Chapter 5 Mitigation Options Assessment and Strategies

5.1 Introduction

5.2 Mitigation Options Assessment for Key SocioEconomic Sectors

5.3 National Strategies on GHG Emission Reduction

Chapter 5

Mitigation Options Assessment and Strategies

5.1. Introduction

In accordance with the provisions of the Convention and the Kyoto Protocol, Myanmar is under no obligation to quantify reduction or limitation of greenhouse gas emission. However, Myanmar has been making efforts for the positive contributions to the mitigation of greenhouse gas emission and protecting global climate by making mitigation options assessment and strategies in key economic sectors of the country.

This chapter describes emission reduction measures and impact mitigation measures and strategies which are applicable to the current national development plans in Myanmar. Emphases have been placed to identify available assets and barriers encountered for the implementation of the mitigation strategies. The associated ministries of the State have to set up effective strategic plans, schemes and projects to carry out activities with direct or indirect reduction potentials for GHG emissions. Moreover, measures for mitigating emission of GHG and climate change impacts should be integrated in the national development programs.

5.2. Mitigation Options Assessment for Key Socio Economic Sectors

For a comprehensive assessment of mitigation options, the same categories used in the GHG inventory were applied. These categories also represent the key socio- economic sectors of Myanmar, such as energy, industrial processes, agriculture, land use change and forestry and waste. In relation to the reduction of GHG emissions, the assessments taken into account were higher share of gas fuel (particularly in transport sector), development of less energy intensive industries, development of good agricultural practices, afforestation and reforestation in the forestry sector, enforcement of legislative measures influencing directly or indirectly the GHG mitigation processes, and so on.

Energy, Industrial and Product Use Sectors

The mitigation assessment for energy is based mainly on pre-feasibility case studies of different aspects of energy and non-energy sectors. The mitigation analyses include industrial processes, fossil fuels, renewable energy, thermal power plants, residential and commercial and transportation. Myanmar focused its efforts on mitigating emissions arising from fossil fuels. The predominant greenhouse gas is CO_2 produced by the combustion of fossil fuels for both stationary and mobile use. This is because of the total reliance of the economy on energy derived from fossil fuels. Mitigation option performed in the present study relied mainly upon desegregated analysis or methods using emission coefficients which were dependent on a variety of parameters including the type of end use device, as against using overall emissions from each fuel type given in GHG inventory report.

Reduction of CO_2 emissions depends on the development of conversion technologies and efficiency, and on fuel characteristics. Hence, mitigation options considered in the assessment to reduce CO_2 emissions can be grouped into three categories: (i) energy conservation or efficiency improvements, (ii) replacing carbon-intensive energy sources with less carbon-intensive sources and (iii) promoting new and renewable sources of energy. The options available for Myanmar in mitigating GHG emissions in these sectors are as follows:

(i) Hydro power project

Myanmar with many rivers is endowed naturally with abundant hydropower resources. Myanmar has already identified 267 sites with the total capacity of 39,624 MW. Existing hydro power stations generating (320) MW constitute only 1% of the total potential resources of the country.

Establishment of large hydroelectric plants could also be important but is a relatively costly option compared to small hydro power plants.

(ii) Solar electric panel to replace diesel generator

Today's electricity supply in Myanmar is generated by fuel generators and hydroelectric power plants. However, rural areas which are away from National Grids cannot enjoy the electricity generated by these sources. Since Myanmar is a land of plentiful sunshine, solar energy is available all over the country. Photovoltaics(PVs) are the most attractive among renewable energy options. Due to the high initial cost of the solar energy generating system and unfamiliarity with it, solar electricity had not been popular in the past in Myanmar. However, PV has become more common for larger application with the decline in the cost of the solar panels and realizing the fact that solar energy is relatively most cost-effective in the long run. Besides, the solar energy is attractive to consumers because it is reliable, clean, and environmentally friendly.

(iii) Electric vehicle

An electric car is an automobile that uses an electric motor for propulsion, in place of more common propulsion methods such as the internal combustion engine. Electric cars produce no pollution at tail pipe, but their use increases demand for electricity generation . Vehicle greenhouse gas saving depends on how the electricity is generated. For electric vehicles, the reduction of carbon emission will improve further if the electricity is generated from renewable energy sources. For everyday use rather than long journeys, electric cars are very practical forms of transportations. In Myanmar, some electric vehicles are now being used in the areas, such as hotel zones, zoological gardens, parks, etc.

(iv) Waste engine oil recycling

The engine lubricant industry is a big business in Myanmar, with an annual consumption of about 4.5 million gallons (20.24m liters) and turnover ranging from US$ 25 to 40 million. Small amount of lubricant oil is lost during use and the rest are released into the environment. Used lubricant, a valuable resource, is wasted if improperly disposed off. It can also be used as refinery feedstock to become part of crude oil. Used oil can be refined again and again after blending with suitable additives and with no compromise on quality.

(v) HFCs recycling

Recovery and recycling of HFCs help to decrease HFC emissions during equipment service and disposal. The approach involves the use of a refrigerant recovery device that transfers refrigerant into an external storage container prior to servicing of the equipment. Once the recovery process and source operations are complete, the refrigerant contained in the storage container may be recharged back into the equipment, cleaned through the use of recycling devices, sent to a reclamation facility to be purified.

This analysis assumed that 50 percent of emissions are released during equipment servicing and disposal, while the remaining 50 percent occur as a result of leakage during normal operations.

Transport

As transport sector is the largest consumer of fossil fuels, and consumption in this sector is projected to increase more dramatically, mitigation options in this sector are given due consideration.

Much of the petroleum consumed in Myanmar is in the transport sector where the use of other forms of energy is insignificant. As a result, it is a major contributor to GHG emissions. Better efficiency in the transport sector also means reduced pollution from exhaust emissions. Recent trends in fuel switching from gasoline to Compressed Natural Gas (CNG) in motor vehicles due to financial benefits have already helped to reduce GHG emissions in this sector. The primary mitigation options identified for GHG emission mitigation in the transport sector are as follows:-

a) Road maintenance
b) Modal shift from road to rail (passenger & freight)
c) CNG vehicles and electric vehicles (In terms of CO_2 mitigation potential, the most attractive option in the transport sector is fuel switching to CNG for Myanmar.)

Renewable energy

The adoption of GHG abatement measures, particularly renewable energy production systems avoid generation of other pollutant emissions like sulfur dioxide(SO_2) and nitrous oxides (NO_x), and contribute to the country's pursuit of sustainable development objectives. Broad introduction of renewable energy sources will not only help to mitigate GHG emissions, but also increase the degree of electrification, especially in remote areas. Myanmar has considered and identified these renewable energy resources as important response options to mitigate emissions of GHGs. They are emerging as a large source of untapped alternative energies with very high potentials for uplifting Myanmar's socio-economy. Studies on cost implication for these options are supportive of their integration into the GHG Mitigation option policy of Myanmar. In line with the poverty-alleviation plan and the rural energy development target, the Myanmar Government has implemented a series of policies and measures to support new and renewable energy development. Renewable energy is an important source of energy for lighting and heating processes at present in Myanmar. In spite of increase in generation of electricity from hydropower in the country, biomass energy is increasingly becoming a potential source of domestic energy supply in the countryside.

Based on years of experience under the Government's rural electrification program, a new direction would be to extend the use of PVs to supplement household electricity supply in urban areas and to reduce load dependency on the national grid. Electricity generated from households can also be sold to utilities, reducing the investment required for installing generation plants to meet peak demand. Reducing load dependency will allow for more effective management of the nation's electricity grid, because daytime demand levels can be lowered as households switch to supply via PVs. CO_2 emission reduction potential and cost effectiveness for some identified mitigation options are given in(Table 5.1). These abatement assessments have shown that significant amounts of GHG emissions can be reduced in these sectors through certain abatement options.

Agriculture sector

Agriculture

The agriculture sector is characterized by large regional differences and possible mitigation measures which vary with the emission levels and management practices in different regions. Comprehensive analyses of land use, cropping systems and management practices are needed at regional level for the effectiveness of various mitigation measures. Options for reducing emissions, such as improved farm management and increased efficiency of nitrogen fertilizer use, will maintain or increase agricultural production with positive environmental effects. These multiple benefits will result in high cost-effectiveness of available technologies. In Myanmar there are four relevant options for reducing GHG emissions in the agriculture sector, namely, (1) mitigation of carbon dioxide emissions,(2) mitigation of methane emissions,(3) mitigation of N_2O emission from agricultural soils and (4)mitigation of GHGs from field burning of agricultural residues.

Mitigation options of Carbon dioxide Emissions

(a) Conservation tillage on crop lands

Options for increasing the role of agricultural land as a sink for CO_2 include carbon storage in managed soils and carbon sequestration after reversion of surplus farm lands to natural ecosystems. Currently, only half of the conversion of tropical forests to agriculture contributes to an increase in productive cropland. The only way to break out of this cycle is through more sustainable use, improved productivity of existing farmland and better protection of native ecosystems. These practices could help reduce agricultural expansion and hence deforestation. There are different kinds of conservation tillage systems, including no till, ridge till, minimum till and mulch till. It increases carbon storage through enhanced soil sequestration. Management practices to increase soil carbon stocks include reduced tillage, crop residue return, perennial crops (including agro forestry), and reduced bare fallow frequency. However, there are economic, educational and sociological constraints to improve soil management in much of the tropics. Many tropical farmers cannot afford or have limited access to purchase inputs such as fertilizer and herbicides. Crop residues are often needed for

Table 5.1: GHG mitigation potential and costs of some options in energy sector

Sr. No	Option	GHG mitigation potential (Ton CO_2)	Present total costs (US$, mil.)	Incremental costs (US$, mil.)	Abatement cost (US$/t CO_2)
1	Hydro power project (E1)	1,123,020	178,974	-521,131	-0.01
2	Small hydro power project(E2)	116,695	80.1	-276.36	-67.66
3	Solar panel (E3)	$5{,}732*10^6$	14,269,187	-4,283,266	-37.37
4	LED Street Lighting (E4)	$349*10^6$	328,128	-44,894	-6.43
5	Modal shift from road to rail(freight)(E5)	1789	8.73	-2.6	-72.62
6	Modal shift from road to rail(passenger) (E6)	5,768	23.07	-5.19	-44.97
7	Road improvement(rail)(E7)	20,677	53.68	-5.47	-26.47
8	Efficient air conditioner(E8)	19,619	289.7	-7.76	-3.14
9	Efficient motor with variable speed drive(E9)	1,486	1.28	-0.07	-3.16
10	Electronic ballast(E10)	24,235	3.6	-3.14	-129.7
11	Energy management (E11)	146,458	185.7	-11.37	-7.76
12	Building design(E12)	30,294	107.97	-2.33	-2.2
13	Electric vehicle(E13)	63,063	1214	-187.29	-148.5
14	Electric fork lift(E14)	172,822	332.95	-78.22	-22.63
15	Rice husk gasifier(E15)	129,982	229.77	-261.18	-200.93
16	Biogas cookstove(E16)	$130*10^6$	165,051	-24794	-37.98
17	CNG vehicle(E17)	1,559,250	33,327	-10049	-322
18	Production process change(E18)	278,871	88.53	-0.17	-0.03
19	Waste engine oil recycling(E19)	48,405	0.61	-2.05	-2.12
20	HFC recycling(E20)	10,746,123	0.23	-3.76	-0.02

livestock feed, fuel or other household uses, which reduce carbon inputs to soil.

(b) Use of biofuel

Energy utilization in Myanmar traditionally depends upon energy sources such as fuel wood, charcoal and biomass. Because of the fuel wood scarcity, farmers use crop residues as fuel instead of placing them to their fields. Agricultural by-products such as pigeon pea stocks, cotton stems, paddy straws, rice husks, peanut husks, sesame stalks and palm leaves offer as sources of energy. As a consequence, the fields get inadequate amount of organic matter replenishment. Moreover, biomass in the form of wood and charcoal used as fuel contributes to deforestation, and consequently threatens the environment.

In order to boost the crop production, utilization of farm machineries is increasing in rural areas for field operations such as land preparation, threshing and harvesting and demand for fuel is rising. Physic nuts (*Jatropha curcus)* are a potential non-edible crop to produce bio-diesels in Myanmar. Jatropha plantations have been targeted to reach 3.44 million hectares within three years, starting from 2006-2007. The promotion of *Jatropha* cultivation for bio-diesel production is intended to allow rural households to reduce their dependency on diesel fuel for cooking and lighting.

(c) Rice husk and saw dust gasifier for electrification

Another alternative is to use gasifier, in which biomass is only partially combusted, to generate producer gas. Producer gas is composed of hydrogen, carbon monoxide and carbon dioxide. It is another low heating-value gaseous fuel that can be used for high temperature heating applications. All types of biomass, including rice husk and saw dust, can be used to generate producer gas. Although cost of grid electricity run by government is the cheapest, the electricity produced by gasifier is still cheaper than that produced by diesel generator. Small scale industries are using gasifiers instead of diesel generators. Rice-husk gasifier consumes 9 basket of rice husk in an hour which in turn generates 100 KVA electricity. There are many projects in Myanmar totaling more than 600 units.

Mitigation of CH_4 emissions from rice cultivation

In Myanmar, rice is the staple food and its economy mainly depends on rice production for domestic consumption and export. Rice grows well in almost all regions of the country and about 30% is irrigated and the rest are under rain-fed condition. According to its cropping patterns and agro-ecological regions, rice varieties used and the agronomic management practices, such as water and nutrient management considerably vary among the different regions of Myanmar. Rice is mostly grown in flooded fields under anaerobic conditions and it has been recognized that significant amounts of CH_4 are released to the atmosphere, consequently contributing to global warming more than any other crops. Based on the scientific research findings, several cultivation practices have shown promise for reducing methane emission from rice. The following are the options of reducing methane emissions from rice cultivation:

(i) Fertilizer management practices

The higher CH_4 emission arises from fertilizer application. Use of sulphate- containing fertilizers and slow release nitrogen fertilizers such as mud ball, prilled urea, urea super granules, ammonium thiosulphate, could be used instead of urea to mitigate CH_4 emission. Moreover, the use of the nitrification inhibitors such as Nimin or placement of urea super granules in flooded rice fields can be considered as suitable options for mitigating CH_4 emission without affecting grain yields. Application of gypsum to rice fields and multiple fertilizer application can limit the CH_4 production. Application of organic sources is known to enhance CH_4 emission from flooded rice fields.

(ii) Water management practices

Proper water management is considered a good strategy to mitigate CH_4 emission. Intermitted irrigation is recommended for mitigation instead of continuous flooding. Interval time between irrigation should be lengthened up to 2- 3 weeks and water level and amount of water can be controlled without sacrificing yields.

(iii) Selection of high yielding rice cultivars with low CH_4 emission potential

Rice plants play an important role in the flux of CH_4 from rice fields to the atmosphere and significant differences exist among rice cultivars. For example, the number of tillers per plant was positively correlated with CH_4 emission rate, and there was a significant positive correlation between above ground biomass and emission and between root biomass and emission. Screening of rice cultivars that have higher harvest index and more effective tillers may be a promising strategy to mitigate emission.

Mitigation of N_2O emission from agricultural soils

Chemical fertilizers play a key role in modern crop husbandry and are essential to produce high yields. Over application of fertilizers may reduce farm profit, create a risk of soil degradation and cause environmental pollution. Nitrous oxide emissions during both oxidations of NH_4 and denitrification are increased by N fertilizer application to soil. Volatization of ammonia occurs when urea or ammonium fertilizers are surface-applied to pastures or to soils. To meet the food demand of the growing population worldwide, application of synthetic fertilizer for the increased crop production has risen up rapidly.

Organic agriculture not only enables ecosystems to better adjust to the effect of climate change but also offers a major potential to reduce the emission of agricultural GHG. In addition, the influences of the incorporation of crop residues, compost and animal manures on N_2O emission were well documented. It is noted that the quality (C/N ratio) of organic materials is an important factor affecting N_2O production. N_2O production was increased by organic matter with decreased C/N ratio such as vetch, soybean, corn, wheat crop residues, groundnut, maize, chicken manure.

Possible options to minimize potential harmful N_2O emission in different agro-ecosystem are as follows:

- Use of slow release fertilizer
- Adjusting the timing of fertilizer and manure application so that the crop makes maximum use of N
- Incorporation of crop residues with high C/N ratio
- Surface application of liquid manures
- Development of organic agriculture

Mitigation of GHGs from field burning of agricultural residues

The emissions of CH_4, CO, N_2O and NO_x from the open burning of crop residues and weeds are well recognized. However, use of crop residues for animal feed, fuel wood and household use are very common for the small holder farmers across Myanmar. Farmers usually burn only a few amount of residues of previous crops and weeds in their fields at the land clearing time. The crop residues of paddy, wheat, corn and sugarcane are traditionally burnt to prepare land for next crops. However, the practice of burning and the amount of burning materials vary from region to region, and even from plot to plot. In the dry zone of central Myanmar, where the animal feed and fuel are becoming scarce, crop residues of paddy, pulses, peanut and corn are used for cattle feeding and stems/ stalks sesame, pigeon pea, and cotton are used for household fuel and jaggery industry. Compost making of crop residues should be encouraged through the use of effective microorganisms. Awareness raising programs should be carried out to reduce the field burning.

Livestock

The present national herd of 13.74 million heads of cattle and buffaloes are grazed mainly on natural grass during the monsoon season, and are fed on paddy straw during the dry season. Cattle and buffaloes are the most important sources of methane from enteric fermentation because of their numbers, large body size, and ruminant digestive system. Methane emissions from manure management are usually smaller than that from enteric fermentation.

There are many strategies options that could be considered for reducing methane emissions from cattle. There are three principal ways to mitigate methane emissions from livestock. First, decreasing the numbers of ruminant animals can reduce emissions. Second, improving manure handling can reduce methane emissions. A third way to decrease methane emissions from livestock is to improve the enteric fermentation process in ruminant animals

Mitigation options for CH_4 emission from enteric fermentation

The concept of methane emission reduction from livestock sector is prioritized via mechanical and chemical feed processing, feed supplementation, genetic improvement, and reproductive improvement.

The following are the most appropriate mitigation options for CH_4 emission from enteric fermentation in the livestock sector in Myanmar.

(i) Supplemented feeding system with urea molasses block

The use of Urea Molasses Block reduces the methane emissions from enteric fermentation by up to 25 percent and also raises milk productivity by as much as 20 percent. Feeding trials have indicated the acceptability of feeding with urea molasses mineral block. It is more favorable than feeding with urea treated straw. Urea Molasses Blocks are very useful and handy ways to supplement the deficient nutrients like fermentable nitrogen and all the macro and micro essential minerals.

(ii) Treatment of straw with urea

The treatment of straw with urea reduces the methane emissions from enteric fermentation by up to 10 percent and also increases the milk productivity by up to 20 percent. Paddy straw is a very important resource in Myanmar. If the paddy straw harvested from half of the present rice paddies were treated with urea, there would be enough roughage feedstuffs for the whole country. This treated paddy straw would have a 70 percent digestibility instead of 60 percent; the nitrogen content would increase from 0.5 percent to 1-1.2 percent and the voluntary intake by animals would increase by about 20-30 percent.

Use of urea-treated straw results in an increase in digestibility of straw dry matter/ organic matter and improves voluntary consumption. However, the acceptance by farmers in Myanmar has been still limited due to economic and sociological reasons.

The investment costs per animal for the options of improving feed by using urea molasses blocks or treatment of straw with urea are $43.8 and $20.8, respectively, and the incremental yield for these options are 330 kg/head/yr and 247.5 kg/head/yr, respectively. From the investment cost and incremental yield analysis, the urea molasses block option is the better option for treatment of straw with urea.

Mitigation options for CH_4 emission from manure management

In Myanmar, among the pastoralist communities, most animal manure is left uncollected. On the other hand, farmers who practice mixed agriculture animal wastes are collected and composted and later applied directly as crop fertilizer.

Methane emissions from the manure can be managed by using various technologies to help reduce methane emission during storage.

Biogas production by recovering the methane emission from anaerobic fermentation is now considered as a potential mitigation option in Myanmar. The recovered methane gas can be used directly on the farm to supply various energy end uses, or can be collected and sold, or used to fuel boilers that provide the energy to generate electricity. The remaining by-product of anaerobic decomposition, contained in the slurry or liquid effluent, can be used as crop fertilizer, animal feed, and as supplements for aquaculture.

Biogas produced from animal manure could be used for household cooking and lighting purposes. The slurry/liquid effluent is used as farm fertilizer. It is therefore needed to make the technology more affordable to rural households in order for them to benefit from its use. The use of biogas as an alternative energy source, especially in the high potential areas is one way to alleviate fuel-wood shortage, minimize destruction of forests and woodlands, and increase carbon sequestration while abating increases of methane emission by transforming into carbon dioxide and thus reducing the methane warming potential. Mitigation options, mitigation potential and costs for the livestock sector are shown in (Table 5.2).

Land Use Change and Forestry Sector

In the forestry sector, several mitigation options can be considered, including the conservation of forests, enhancement of the forest area, and fuelwood conservation. To enhance the forest areas, consideration were given to participatory community and fuelwood plantation projects and natural regeneration and protection projects. A reduction in forest products consumption were achieved by replacing traditional fuel wood stoves with more efficient cook stoves and / or by using biogas systems at village level.

If mitigation in forestry becomes an important component of overall climate change policy, future land uses will change substantially. Within the range of carbon prices of $60 to more than $200/t C,

Table 5.2: Mitigation options, mitigation potential and costs for the livestock sector

Country	Mitigation Options	Mitigation Potential (kg/head/yr)	Mitigation Cost ($/kg CH_4)	Investment Cost ($/head/yr)	NPV of Benefits ($/kg CH_4)	Impact on Milk Yield (%)
Myanmar	• Urea-molasses block	14	3.13	43.8	1.75	20
	• Urea treatment of straw	6	3.47	20.8	3.06	-10

there could be as many as 1 billion more hectares of land in forests by 2100. These carbon prices are well within the range of current estimates of the costs of stabilizing future climate, suggesting that if forestry is ultimately included as a creditable opportunity, then large land use changes could take place. The mitigation efforts largely imply reductions in deforestation, thus preservation of existing forest areas in tropical regions. Some mitigation measures in forestry sector are shown in (Table 5.3).

Afforestation/reforestation activities in deforested areas, rehabilitation of degraded forest areas, enhancement of natural regeneration are the potential mitigation options in forestry sector of Myanmar. Mitigation practices can also be linked to international cooperation activities for additional financial and technical support. Kyoto Mechanisms adopted in 1997, allows the developing countries to host Clean Development Mechanism (CDM) projects to enter global carbon market. Afforestation /reforestation projects can be linked to AR CDM projects. Moreover, conservation of natural forests and sustainable forest management practices are in line with Reducing Emission from Deforestation and Forest Degradation (REDD) mechanism.

Mitigation options assessment by ALGAS project

In Myanmar, an assessment of the mitigation options was carried out by Asia Lowcost Greenhouse Gas Abatement strategies (ALGAS) project in 1997. The following 5 options in forestry sector were examined for various parameters:

(i) Reforestation with short rotation species (ten years) for community plantation and fuel wood plantation (SR),
(ii) Reforestation with long rotation species (40 years) for commercial plantation and watershed management plantation (LR),
(iii) Natural Regeneration (NR),
(iv) Reforestation for bio-electricity generation (RB), and
(v) Forest Protection (FP).

The examined parameters and the results of the analysis were shown in Table 5.4. It was also found that the mitigation potential of options ranged from 33 tC/ha for natural regeneration to 155 t/ha for reforestation with long rotation. The investment cost for forestry mitigation options is low, being in the range of $0.1 per tC abated for the natural regeneration option to $21.4 per tC abated for the option of reforestation for bioelectricity production. Investment cost is high only for the bioelectricity option at $21/tC abated, as it includes the cost of plantation forestry and the cost of establishing a power generation system.

The mitigation scenarios considered in ALGAS project were the programmatic scenarios, the biomass demand based scenario, and the technical potential scenario. The aggregate mitigation potentials are 30 mtC, 126 mtC, and 583 mtC for the programmatic, biomass demand based and technical potential scenarios, respectively.

Current assessment of mitigation options

(i) Afforestation / Reforestation

Plantation forestry has long been practiced in forestry sector of Myanmar but with limited planted area. Starting from 1990s, annual forest plantation area increased and amounted to morethan 30 000 ha per year. Up to the year 2000, all the plantation activities are implemented by the Ministry of Forestry. The amount of carbon sequestered by the forest plantations vary from 4.5 -10.1 tC/ha/yr. Private sector involvement in the establishment of forest plantation can enhance the growth and economic return of the plantations. In the Dry Zone of Central Myanmar, forest plantations are being established with the objectives of greening the environment, supplying local people with small timbers and fuelwood and restoring the degraded forests. Because of the harsh environment with low rainfall, the plantations in dry zone area are paid special attention to grow well. The growth rate is also slow. However, in terms of AR CDM projects, dry zone is eligible to host an AR CDM project and can get benefit from that mechanism if properly managed.

(ii) Community forestry

Community forestry refers to tree planting activities undertaken by community on communal lands, or the so-called common lands; it is based on the local people’s direct participation in the process, either by

Table 5.3. Examples of mitigation technologies, policies and measures, constraints and opportunities in forestry sector

Key mitigation technologies and practices	Policies, measures and instruments	Key constraints or opportunities
- Afforestation, reforestation **- Forest management** **- Reduced deforestation** **- Harvested wood product management** **- Use of forestry products for bioenergy to replace fossil fuel use** **- Tree species improvement to increase biomass productivity and carbon sequestration** **- Improved remote sensing technologies for analysis of vegetation/soil carbon sequestration potential and mapping land-use change**	- Financial incentives (national and international) to increase forest area, to reduce deforestation and to maintain and manage forests; - Land-use regulation and enforcement	-Constraints include lack of investment capital and land tenure issues. -Can help poverty alleviation.

growing trees by themselves, or by processing the tree products locally. Forest Department of Myanmar issued Community Forestry Instructions (CFI) in 1995 with the objectives of attaining environmental stability and meeting the basic needs of rural communities. According to the CFIs, local people's active participation is intended to play a key role in the afforestation and rehabilitation of denuded and degraded areas.

(iii) Natural regeneration

To accelerate the natural restoration process, the degraded stands can be assisted by two basic types of silvicultural treatments, viz., improvement and enrichment. Choice of suitable silvicultural intervention depends primarily on the structural characteristics and regeneration potential of the degraded stand. If the number of economically valuable trees in the initial stand is not sufficient, or there is a complete lack of such trees, then enrichment may be a better option than improvement.

Forest Department of Myanmar has been practicing natural regeneration activities in the routine forest operations. However, limited funding and labour intensive works are the main barriers in natural regeneration operations. There is also little knowledge on carbon sequestration potential by natural regeneration operations in natural forests of Myanmar.

(iv) Agroforestry

Agro-forestry practices have long been considered as ecologically sound farming practices and offer potential for regaining some of the lost carbons through changes in land uses patterns as much as 176 tC/ha after a period of 10 years (estimated for tropical regions). Improvement in land management practices such as protection of trees on the farm, contour felling and mound-based soil fertility management, etc. could help to regain about 44 tC/ha to 46 t C/ha.

Studies performed in developed countries indicate that the cost per ton of carbon sequestration could be in the range of US$10-26; in the context of Myanmar, the cost could be much lower as these practices are more labour intensive. However, the current institutional mechanism lacks capacity to cope with climate change related forestry sector adaptation, and mitigation policy administration lacks the capacity for accounting framework to measure changes in biomass stocks and to promote sustainable forest management with concrete economic and environmental goals.

Table 5.4: Analysis of the identified forestry mitigation options by ALGAS project

Parameter	SR	LR	NR	RB	FB
Mitigation potential, t of C abated/ ha	55	155	33	78	47
Present value life cycle (endowment) costs, $/ha	496	290	28	-	0
Financial benefits, NPV, $/ha	1,060	346	4	67	67
Investment costs/ha, $/ha	211	122	10	-	77
Cost-effectiveness					
Life cycle, $/tC abated	9.01	1.87	0.86	1.3	0
Investment cost, $/tC abated	3.83	0.79	0.1	21.4	1.64
Cost-benefit analysis, NPV/tC	19.28	2.22	0.13	0.86	2.87

(v) Conservation of natural forests

Conservation of natural forests, which leads to halt deforestation can be coped with REDD mechanism. Myanmar forestry sector aims to conserve up to 30% of natural forests as reserved forests and another 5% as protected area systems. This option can be combined with REDD mechanisms.

(vi) Dissemination of fuel wood improved stoves

Replacing traditional fuelwood stoves with more efficient cook stoves can effectively mitigate the GHG emission in forestry sector by reducing burning of biomass. The GHG mitigation potential of 100, 000 efficient cook stoves (A-1) can be 120,736t CO_2 yr^{-1}. The investment cost per ton of carbon dioxide abated for fuelwoood is about 0.55 USD.

Waste sector

Waste management is the collection, transport, processing, recycling or disposal and monitoring of waste materials. The term usually relates to materials produced by human activity and is generally undertaken to reduce their effect on health, the environment or aesthetics. Waste management can involve solid, liquid, gaseous or radioactive substances with different methods and fields of expertise for each. Management for residential and institutional waste in metropolitan areas is usually the responsibility of local government authorities while management for commercial and industrial waste is usually the responsibility of the generator.

Options for waste handling systems for reducing waste materials

Some areas especially those in less developed countries do not have a formal waste-collection system. Examples of waste handling systems include (a) disposal methods,(b) recycling methods and (c) avoidance and reduction methods.

In Myanmar urban centre curbside collection is the most common method of disposal whereby the city collects waste and recyclables and organics on a scheduled basis. People often dispose of their waste by hauling it to a transfer station. Waste collected is then transported to a regional landfill.

(a) Disposal methods

(i) Landfill

Disposing of waste in a landfill involves burying the waste and this remains a common practice in Myanmar. Landfills are often established in abandoned or unused quarries, mining voids or borrow pits. A properly-designed and well-managed landfill can be a hygienic and relatively inexpensive method of disposing of waste materials. Older, poorly-designed or poorly-managed landfills can create a number of adverse environmental impacts such as wind-blown litter, attraction of vermin and generation of liquid leach, etc.. Another common by product of landfills is gas (mostly composed of methane and carbon dioxide) which is produced as organic waste down an aerobically. This gas can create odor problems and kill surface vegetation.

(ii) Incineration

Incineration is a disposal method that involves combustion of waste material. Incineration and other high temperature waste treatment systems are sometimes described as "thermal treatment". Incinerators convert waste materials into heat, gas, steam and ash. Incineration is carried out both on a small scale by individuals and on a large scale by industry. It is used to dispose of solid, liquid and gaseous waste. It is recognized as a practical method of disposing of certain hazardous waste materials (such as biological medical waste). Incineration is a controversial method of waste disposal, due to issues such as emission of gaseous pollutants.

(b) Recycling methods

(i) Biological reprocessing

Waste materials that are organic in nature such as plant material, food scraps and paper products can be recycled using biological composting and digestion processes to decompose the organic matter. The resulting organic material is then recycled as mulch or compost for agricultural or landscaping purpose. In addition, waste gas from the process, such as methane can be captured and used for generating electricity.

There are large varieties of composting and digestion methods and technologies varying in complexity from simple home compost heaps, to industrial-scale enclosed-vessel digestion of mixed domestic waste.

(ii) Energy Recovery

The energy content of waste products can be harnessed directly by using them as a direct combustion fuel, or indirectly by processing them into another type of fuel. Recycling through thermal treatment ranges from using waste as a fuel source for cooking or heating to fuel for boilers to generate steam and electricity.

(c) Avoidance and reduction methods

An important method of waste management is the prevention of waste material being created also known as waste reduction. Methods of avoidance include reuse of second-hand products, repairing broken items instead of buying new, designing products to be refillable or reusable (such as cotton instead of plastic shopping bags), encouraging consumers to avoid using disposable products (such as disposable cutlery) removing any food/liquid remains from cans, packaging and designing products that use less material to achieve the same purpose, e.g. light weighting of beverage cans. Mitigation measures and biological reprocessing, energy recovering and avoidance and reduction methods should be promoted in order to reduce GHG emission from the waste sector.

5.3. National Strategies on GHG Emission Reduction

In the face of climate change, an urgent need arises to set up the national strategies for GHG emission reduction and for the reduction of climate change impact. Such measures should be emphasized not only on sustainable production in line with the GHG reduction goals, but also on endangered species and communities, certain ecosystems (eg. wet lands) and habitats. So far some strategies which are directly and indirectly related to these issues have been set up in Myanmar.

Energy sector

The abatement strategy in the sector was considered a time frame within 2000 to 2030.The most important actions to mitigate GHG emissions during the period 2000-2030 are economic and effective use of energy and use of renewable energy.

Energy development has always been an important part of Myanmar's national economy and social development plan. In accordance with the guidance of the Government, Ministry of Energy has also laid down Energy Policy and Strategy. The main objectives of the Policy are to utilize optimum amount of energy efficiently, to save non renewable energy resources of the country and to increase the production level of existing energy sources and at the same time to update the energy demand.

Energy utilization in Myanmar mainly depends upon traditional energy such as fuel wood, charcoal and biomass. During 1999-2000, 35 percent of the total energy consumption is contributed by commercial energy such as oil, natural gas, coal and hydropower.

The balanced utilization of different energy types has all along been emphasized and increased production of commercial energy has been prioritized in order to replace traditional energy types and at the same time to meet the requirement of industrial development program. Myanmar has abundant renewable energy sources such as hydropower, wind, solar, geothermal, biomass and other types of renewable energy sources. Renewable energy, i.e., hydroelectricity and biomass contributed 67 percent of total energy consumption. Biomass in the form of fuel wood, charcoal, agriculture waste and animal dung is predominantly used.

Emissions from the energy sector are not significant at present. However, due to the rapid expansion, this sector's contribution to GHG emissions will be more significant in the future. The growing trend of greenhouse gas emissions will continue if the current shift of Myanmar's industrial structure continues and considerable efforts to reduce emissions are not implemented.

To implement appropriate and effective responses to climate change, the following are priorities for Myanmar.

- ❖ Promotion of the use and development of renewable energy
- ❖ The use of clean and efficient energy for industry, transportation, commercial and residential sectors
- ❖ Use of Compressed Natural Gas (CNG) as fuel for commercial vehicles as fuel switching in transportation sector
- ❖ Use of energy saving Light Emitting Diode (LED) lighting to replace mercury and sodium vapour lamps
- ❖ Use of Solar Electric Panel to discourage use of fossil fuels for rural electrification
- ❖ Replacing some biomass or HSD cook stoves with biogas stoves
- ❖ Use of new technologies such as efficient lighting and air-conditioning and refrigeration systems with higher overall energy efficiency to replace the existing less efficient systems
- ❖ Promoting renewable energy technologies in place of fossil fuel generators wherever they are technologically and economically feasible
- ❖ Encouraging energy conservation through promoting good house-keeping practices in industrial, commercial and domestic sectors

GHG projections for energy sector

Carbon dioxide emissions depend on the type and amount of energy consumed, and energy consumption is closely linked to the socio-economic development of a country. Hence, projection of CO_2 emissions from the energy sector is based mainly on projections of the population and economic growth of a country over a specific period in the future.

Of the total energy demand in the country, the residential sector consumes and is expected to consume the largest portion, estimated to be about 78 percent followed by the industrial, transport and commercial sectors. Agriculture remains as the smallest user of total energy. If biomass energy use is not counted or excluded, energy industry is seen to consume the largest amount of energy at 30 percent followed closely by transport and industrial sectors.

Energy use in this country is increasing faster in the transportation sector than in any other sectors. Increase in transportation energy use is a clear indication of a large amount of carbon emissions because virtually all energy requirements of this sector are in the form of petroleum products. Mitigation options to reduce GHG emission in transportation is one of the focal areas in the study. It is an emerging challenge for countries like Myanmar to devise strategies that can take care of the increased mobility of the people and the goods required for meeting the developmental aspirations yet without environmental implications.

Agriculture sector

Agriculture

Being an agricultural country, rice cultivation in Myanmar will continue to increase at its current rate to meet the home consumption and export market. Flooded rice fields produce CH_4 emissions, which can be reduced by improved management measures.

Successful implementation of available mitigation strategies will depend on the facts that:

(i) grain yield will not decrease or may increase;
(ii) there will be savings in labour, water and other production costs; and
(iii) rice cultivars that produce lower CH_4 emissions are acceptable to local consumers.

Since nitrogen is the major component of mineral fertilizers commonly used in the country, there is a rising concern over the extent to which high-input agriculture loads nitrogen compounds into the environment. Nitrogen budgeting, or an input/output balance approach, provides a basis for policies to improve nitrogen management in farming and for mitigating its environmental impact. Management systems can decrease the amount of nitrogen lost to the environment through gaseous losses of ammonia or N_2O, or through leaching of nitrate into the subsoil.

The primary sources of N_2O from agriculture are mineral fertilizers, legume cropping, and animal waste. Some N_2O also is emitted from biomass burning. The underlying concept in reducing N_2O emissions is that if fertilizer nitrogen (including manure nitrogen) is better used by the crop, less N_2O will be produced and less nitrogen will leak from the system. By better matching nitrogen supply to crop demand and integrating animal waste and crop residue management are the possible strategies for reducing emissions.

The following strategies are being carried out for mitigation of GHG emissions and potential reductions of annual emissions of carbon dioxide, methane and nitrous oxide.

(1) Reducing CO_2 emissions:– Reduction in fossil energy use by agriculture, expanded use of minimum and no tillage, and irrigation scheduling
(2) Reducing methane emissions: - Improved rice production practices, irrigation management, nutrient management, new cultivars and other practices
(3) Reducing nitrous oxide emissions: Increase N fertilizer use efficiency, reduce use of nitrogen fertilizers, apply improved technology for nitrogen application, match N supply with crop demand, integrate production systems to maximize manure reuse in plant production, conserve plant residue N on the production site, and irrigation and drainage.

The Ministry of Agriculture and Irrigation has already established the priority framework for the development of agriculture sector. Among others, the following are the strategies related to the mitigation of the impact of climate change.

- ❖ Diversifying crop production and productivity
- ❖ Sustainable water sector development for promoting access to irrigation water
- ❖ Promoting rural development through sustainable development of agriculture sector
- ❖ Strengthening research and extension
- ❖ Technology generation for good agricultural practices and dissemination for integration into current food production chain
- ❖ Rural infrastructures development (Development of farm and rural road networks; Establishment of farmers' markets, warehouses and cold storage; exploring possibility of private sector investment)

Livestock

Livestock farming in Myanmar relies heavily on the agriculture, agro-industrial by-products and natural grass land. Due to the high prices of agro-industrial by-products, most of the livestock farmers cannot afford to provide balanced and well managed ration to their livestock for maximum production. Dairy farming is an additional income to peri-urban farmers and due to seasonal variation and price fluctuation of agriculture by-products, most livestock farmers focus mainly on low profile feeding strategies. Therefore livestock especially dairy cattle are usually given only sub-maintenance ration during dry period.

Strategies for reduction of CH_4 emission

Among domesticated livestock, ruminant animals are the major emitters of methane because of their unique digestive system. The amount of methane produced and excreted depends primarily upon the animal's type of digestive system and the amount and type of feed the animal consumes.

Strategies need to be developed to reduce methane emission from both enteric fermentation and manure management systems, of which the latter is more possible at the farmer level in Myanmar.

Enteric fermentation

When low quality high roughage diets are fed to ruminants the methane production by enteric fermentation is high. Therefore, the first and the foremost step is to improve the diet by improving the nutritive value and digestibility. To do this the following could be suggested;

- ❖ Encourage replacing low quality natural grasses with feeding of improved high quality forage.
- ❖ Manipulate the rumen conditions through appropriate strategies (supplementation) that facilitate better rumen environment to improve efficient microbial activity.
- ❖ Adjust correct energy to protein ratio in the diet, especially in concentrate feeds.

Manure management systems

In order to achieve the proper manure management it is necessary to implement the following strategies:

- ❖ Avoid adding straw to the manure because straw acts as a food source for anaerobic bacteria, resulting in higher methane emissions
- ❖ Apply manure to soil as soon as possible because manure for long period can encourage anaerobic decomposition and result in increased methane emissions
- ❖ Avoid manure application when the soil is extremely wet, as this leads to anaerobic conditions and increased methane emissions

If manure is handled and managed properly, the CH_4 emissions can be easily controlled. In addition this is the most easily controlled measure at the field level.

The level of moisture, pH, temperature, aeration and other suitable conditions for the anaerobic bacteria favors the methanogenesis.

Therefore, most of the methane is generated when manure is deeply heaped up in wet conditions.

- ❖ In heaping make sure that the heaps are well aerated.
- ❖ Store manure in dry conditions
  - ◆ Prevent accumulation of manure in large quantities and dispose (recycle) as early as possible.
  - ◆ If possible recycle for bio energy production (make sure the digesters are fully air sealed).
- ❖ Convert manure into aerated compost.

Currently available mitigation strategies at farm level in Myanmar

Methane is produced by the fermentation of feed within the digestive system. Generally, the greater the feed intake, the higher the methane emissions are. Feed intake is related to animal size, growth rate and production. The following are the currently available mitigation options to reduce methane emissions:

(i) Reducing livestock numbers
(ii) Improving animal productivity
(iii) Improved forage quality
(iv) Manipulating nutrient composition

To overcome the problems in feed formulation and feeding ruminants, the project has already provided basic feeding strategies to both government staff and farmers. Followings are the already developed feeding strategies for dairy farming:

- ❖ Formulation of different types of UMMB co-operated with herbal medicines to control internal parasites of ruminant livestock
- ❖ Development of feeding strategies by using nitrogen rich leguminous tree forage
- ❖ Establishment of feeding strategies on non-conventional feed resources

The following are examples of five nutritional interventions that will improve productivity and reduce methane emissions per unit of animal production (i.e. meat, milk or fibre):

- ❖ Increased feed intake through the use of better quality feed with higher digestibility and lower fibre content
- ❖ Increased feed intake through the use of improved livestock genetics and breeding
- ❖ Improved feed conversion efficiency through the mechanical (chopping, grinding, milling, pelleting) or chemical (ammonia, urea formaldehyde, sodium hydroxide) treatment to improve feed digestibility
- ❖ Improved feed conversion efficiency through the replacement of forage with concentrates, inclusion of more non-structural carbohydrate in the diet and increased fat content of the diet
- ❖ Provision of diets which provide an appropriate balance of energy, protein and other essential nutrients in order to achieve efficient digestion and livestock productivity

Land use change and forestry sector

Climate change could have large effects on forests through the policies that stimulate mitigation, such as afforestation, reduced deforestation, and forest management. There has been considerable research on the potential for mitigation to help reduce the costs of climate impacts. Metz et al. (2001) suggests that 60-87 billion tons of carbon could be sequestered in forests over the coming century, and Sohngen and Mendelsohn (2003) suggest that this amount of carbon could cost up to $187/t C. Such large levels of sequestration would have large effects on land use, potentially increasing the area of forests at the end of the century by 1 billion hectares. Large-scale changes in forest management are also possible.

Factors taken into account in determining the mitigation strategies

The following factors are taken into account in determining the mitigation strategy in forestry sector:

(i) Compatibility with Internationally Recognized Principles of Sustainable Development

(ii) Consistency with Goals and Objectives of National Environmental Conservation Strategy

(iii) Consistency with Nationally Defined Sustainable Development and/or National Development Goals and Objectives

(iv) Consistency with Internationally Recognized Criteria and Indicators for Sustainable Forest Management

(v) Consistency with International and National Environmental Impacts Standards and Guidelines

Mitigation strategies in forestry sector of Myanmar

To implement appropriate and effective responses to climate change, the following are the priority mitigation options for forestry sector of Myanmar.

(a) Mainstreaming climate change into forest policy and legislation

(b) Promoting sustainable forest management to control deforestation and forest degradation

(c) Conserving the existing natural forest in its maximum carbon storage capacity

(d) Strengthening the institutional capacity to handle mitigation and adaptation measures in combating climate change

(e) Rehabilitating the degraded lands through afforestation and reforestation;

(f) Improving technology to reduce fuel wood consumption;

(g) Increasing CO_2 uptake from the atmosphere by converting low productive land into grassland and range lands (especially in central dry-zone)

(h) Promoting private sector involvement in forest industry in particular with climate change concerns

(i) Promoting habitat management for the protected wild animals and plants with particular focus on buffer zones development and management

(j) Developing the accounting framework for measuring potential changes in forest biomass stocks

(k) Promoting people's participation in forest mitigation practices through community forestry, community-based forest management, etc.
(l) Exploring opportunities for carbon trading both at domestic and international levels and
(m) Research and development in forestry-related climate change studies.

Forest mitigation practices that can restrain the rate of increase in atmospheric CO_2 can be grouped into three categories:

(i) management for carbon conservation
(ii) management for carbon sequestration and storage and
(iii) management for carbon substitution.

Conservation practices include options such ascontrolling deforestation, protecting forests in reserves, changing harvesting regimes, and controlling other anthropogenic disturbances, such as fire and pest outbreaks. Sequestration and storage practices include expanding forest ecosystems by increasing the area and/or biomass and soil carbon density of natural and plantation forests, and increasing storage in durable wood products. Substitution practices aim at increasing the transfer of forest biomass carbon into products rather than using fossil fuel-based energy and products, cement-based products and other non-wood building materials.

Implementation strategies for forest mitigation practices

Myanmar national forest policy is a fundamental guideline for systematic development of forest sector. Moreover, the policy is the basis for laws and rules of forest exploitation and preservation, and for development and capacity building of supporting institutions. Myanmar forest law and rule are set as the tools to implement national forest policy.

Goals and action plans of forest policy clearly stated about land use, prevention and administering, forest regeneration and plantation, wood-based industry, marketing and trading, research, planning, coordination, budget and finance, people's cooperation, and people's awareness, etc. Forest policy targeted to manage 30 percent of total land area under Permanent Forest Estate (PFE) comprising reserved forests and protected public forests.

National Forest Master Plan (NFMP) was developed in 2001 to achieve sustainable forest development. It foresees 30 years from 2001/02 to 2030/31 and outlines wide range of forest activities including wildlife and nature conservation in order to realize objectives namely sustainable harvesting of valuable teak, protection of forests against degradation, environmental conservation, and enhancing foreign exchange earnings by exporting more value-added products.

NFMP covers extensive forest activities which intend to protect reserved forests and protected public forests and to extend them for sustenance; to pursue sound programs of forest development through regeneration and rehabilitation; to effectively manage watershed for longevity of dams and water reservoirs; to optimize extraction of teak and hardwood within the available means; to extend forestry research; to enforce effective law against illegal extraction of forest products; to encourage increasing use of fuel-wood substitutes; to promote export of timber and value-added forest products and seek ways and means to export other non-timber forest products; and to promote ecotourism to earn more foreign exchange.

Waste sector

Development of industries in Myanmar

Myanmar's industrial structure and consumption pattern together with economic growth generate a considerable amount of waste. The amount of waste generated in cities of Myanmar has been gradually increasing, including the municipal industrial waste. (general waste and hazardous waste)

Industrial development has been an important economic policy and development strategy of Myanmar. The government introduced the market-oriented economic system in 1989 and since then it has encouraged private sector particip ation and foreign investment in the economic activities. In order to promote small-scale industries utilizing local natural resources as main raw materials, the Cottage Industries Law, enacted in October 1991, enabled the establishment of small, medium and large-scale enterprises.

Table 5.5. Selected examples of measures to mitigate GHG emissions through slowing deforestation and assisting regeneration

Technical Options	Measures	Benefits/Effects
Forest Practices/Goals **– Reduce slash and burn agriculture / ranching** **– Increase field and satellite monitoring** **– Reduce forest fires** **– Improve logging techniques**	– Jointly implement projects with bilateral and multilateral funding (also applies to forestation and substitution management projects) – Promote sustainable forest management – Enact forest conservation legislation (including bans on logging) – Eliminate subsidies for activities that encourage deforestation (cattle ranching, mining, agriculture, etc.)	– Maintain C density, up to 300 t C/ha – Maintain biodiversity, soil conservation and watershed benefits
Fuel Wood Conservation and Substitution **– Improved stoves** **– Charcoal kilns**	– Investment incentives – Licensing/regulation of standards – Government research, development, demonstration and dissemination	– Maintain C density, up to 300 t C/ha – Potential to reduce unsustainably extracted fuel wood
Use of Recycled and More Efficient Wood Products	– Tax incentives to industry – Labelling of products – Consumer awareness Campaigns	– Maintain C density, up to 300 t C/ha – Maintain biodiversity, soil conservation and watershed benefits – Recycling may require disposal of contaminants from treated wood products

There are many state-owned factories under the Ministry of Industry No.1 producing a variety of consumer goods such as textiles and garments, foodstuffs and beverages, pharmaceuticals, and etc. There are also several industries under the Ministry of Industry No.2.

The renovation and expansion of factories undertaken by the Myanmar Industries of the Ministry of Industry No.1 are: five Myanma Foodstuff Industries, four Myanma Pharmaceutical Industries, and two Myanmar Ceramic Industries. Currently Ministry of Industry No.1 and No.2 are combine to Ministry of Industry.

The government has established 27 industrial zones since 1989, most of which are located in large cities such as Yangon and Mandalay. The total number of established factories increased from 27,513 in 1988 to 60,513 by the end of September 2006. The factories could not give any information on wastes and waste disposal including waste water although most of these factories especially the breweries generate a lot of waste water. From the survey taken, it is observed that a large segment of the industrial community in Myanmar is not fully aware of the industry-related environmental problems. Pollution problems resulting from gaseous wastes, waste water and solid wastes are not regarded as significant by most industries as information about these matters are not available due to the lack of monitoring facilities for assessing water and land pollution regularly and comprehensively.

GHG emission reduction

Policies to reduce greenhouse gas emissions in the waste sector may be differentiated into two strategies. One is the minimization of waste and maximization of recycling programs to proactively prevent the greenhouse gas emitted from the generation and decomposition of waste. The other is the expansion of environmental facilities for treatment to reduce greenhouse gas emissions from the unavoidably generated waste.

To mitigate the primary generation of waste, a major source of methane emission, policies to minimize waste are being implemented. To minimize waste at its generation stage, Guidelines for Waste Reduction at Works, indicating the responsibilities of the waste producers, are needed. At the distribution stage, policies to improve the packing materials are being implemented so that they could be recycled or reused especially in Mandalay and Yangon. Furthermore, at the final consumption stage, allocation of waste treatment expenses to the waste producers (volume-based waste fee system), efficient management of food waste and food waste policies for minimizing waste are needed.

Recycling of plastic wastes, reuse and recycling of wood and agricultural residues are also being promoted in recent years. Recycling of waste papers, rubber goods, broken glass wares, steel and various metals, broken plastic and steel pipes, etc are being done in Myanmar long before 3Rs concept has been introduced global wide.

Appropriate mitigation strategies for municipal solid waste

(i) Producer responsibility system

The Extended Producer Responsibility System to promote the reuse and recycling of waste at the manufacturing stage should be implemented. It requires the manufacturers to be responsible for the waste generated during the production process. Furthermore, for manufactures of resource waste such as paper, glass containers, plastic, iron & steel, businesses with a certain production scale and higher and designated businesses devoted to resource recycling, a certain quota for the use of waste resource as material must be met. In addition, the government needs to support domestic recycling industry, provide loan support for the installation of recycling facilities and development technology. Furthermore, to expand the consumption of recycled products, public institutions must be the first to purchase products manufactured from recycled material.

Waste minimization and recycling policy has to be implemented. A certain amount of waste is unavoidably generated. As a measure, Myanmar need to expand the installation of Basic Environment Facilities to minimize greenhouse gas emissions through sound and adequate waste treatment of wastes that have been unavoidably generated.

Reduction on greenhouse gas emissions can be achieved through systematic treatment of sewage collected from households and factories. Furthermore, to treat the high density industrial wastewater generated from factory concentrated areas such as industrial complexes, waste water treatment facility sites are necessary.

Greenhouse gas emissions from waste are expected to increase annually between 2000 and 2020. The waste management policy instituted by Myanmar government, which proposes more landfills and incineration, is expected to increase emissions of CO_2 and N_2O from waste incineration and landfills.

However, the growth rate by gas is expected to vary depending on the changes in waste components. Therefore, the proportion of greenhouse gases emissions from incineration is projected to continually increase, while the proportion of emissions from landfills is estimated to decrease.

(ii) Payment system for waste

Greenhouse gas emissions from industrial wastewater, which is influenced by the amount of industrial water converted into waste water, are also estimated to show a slow growth rate. Therefore, the proportion of greenhouse gas emissions from domestic sewage and industrial waste water in the waste are projected to slowly decline.

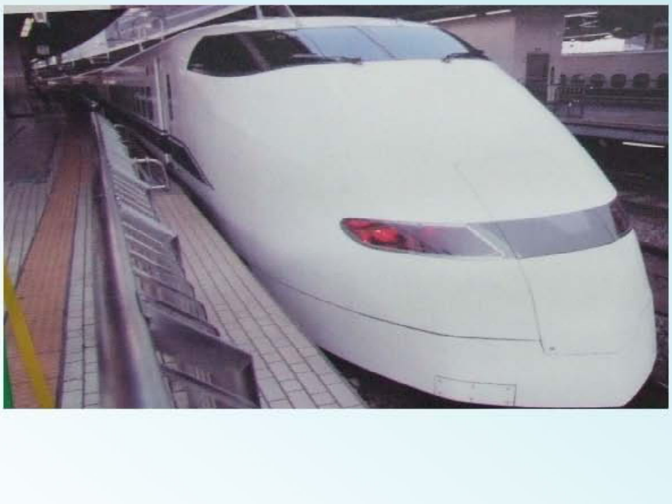
To provide guarantee to effective waste treatment, Myanmar needs to set up a payment system for waste discharge run by City Development Committee. The notice requires all fees levied should be used for waste collection, transport and treatment, and as a supplement to the investment and operation expanse of waste treatment facilities. The reform of waste management system and competition mechanism need to be introduced and a bidding process to be used for the selection of qualified enterprises running civil waste treatment.

(iii) Pricing system and management mechanism

The proposal for industrializing municipal sewage and waste treatment requires reform of the pricing system and management mechanism of sewage and garbage treatment, encourages various entities to invest in and run waste treatment, and gradually build up an investment, financing and operation management system in consistent with market mechanism. Proposals are also needed to encourage waste recovery facilities to be built as well as a cost compensation and incentive pricing system.

Chapter 6 Development and Transfer of Environmentally Sound Technologies

6.1 Technology Needs Assessment
6.2 A database for ESTs
6.3 Establishment of technology information network and information clearing house



Chapter 6

Development and Transfer of Environmentally Sound Technologies

Environmentally Sound Technologies(ESTs) are technologies that" protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, and handle residual wastes in a more acceptable manner than the technologies for which they are substitutes". Environmentally Sound Technologies therefore, have the potential for significantly improved environmental performance relative to other technologies.

Article 4.1 (c) of the UNFCCC stated that all parties shall promote and co-operate in the development, application and diffusion, including transfer of technologies, practices and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol in all relevant sectors, including the energy, the transport, the industry, the agriculture, the forestry and the waste management sectors. It was also stated in Article 4.5 that the developed country Parties and other developed Parties included in Annex II shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, ESTs and know-how to other Parties, particularly developing country.

Being a developing country depending mainly on the primary sector such as agriculture, livestock and fisheries, and forestry, Myanmar is vulnerable to climate change. At the same time, as the industrial sector has been expanding since the last two decades, Myanmar also has the potential for GHG emissions. Therefore, the transfer and development of ESTs are important for adaptation as well as for mitigation and prevention purposes.

6.1. Technology Needs Assessment

In order to identify EST need for mitigation of, and adaptation to climate change, Technology Needs Assessment (TNA) was carried out by the National Commission for Environmental Affairs (MOECAF) under the INC project.

According to the TNA, a large segment of the industrial community in Myanmar is not fully aware of the industry-related environmental problems. Due to the fact that air, water and land pollutions have never been regularly or comprehensively monitored so far, information and data on pollution problems arising from gaseous wastes, waste water and solid wastes are not available to the industrial sector nor to the public. Thus, these problems are merely regarded as insignificant by most people concerned. Many industries surveyed are also not familiar with the term ESTs and do not know the advantages or benefits that can be gained from using ESTs.

It was also found that except for new plants and factories set up in recent years, many factories are still using old machines and obsolete technologies. Their boilers, ventilation system, factory layout and waste disposable systems are in need of upgrading.

Most industrial zones lack basic infrastructure and modern facilities. A major problem of the industries in the industrial zones is the lack of constant power supply. Frequent power failure has made many factories to keep and use power generators that use diesel or gasoline. These generators cause noise pollution, emit hazardous gases and increase the cost of production. Individual or central waste water treatment system and proper waste water disposal facilities are also lacking in most industrial zones. A large number of vehicles including trucks and lorries used for the delivery of raw materials and manufactured goods are old emitting a lot of smoke and exhaust gases.

Research and development on ESTs including endogenous technologies are carried out only on a small scale. Since recent years, alternative energy/fossil fuel-saving technologies have been being researched and developed. These include research and development (R & D) on bio-diesel, bio-ethanol, bio-gas, bio-briquettes, CNG vehicles, solar stoves and fuel efficient stoves.

Recycling of plastic wastes, re-use and recycling of wood and agricultural residues are also being promoted. Waste papers, rubber goods, broken glass wares, broken plastic and steel pipes, waste metals, rusted steel and iron, etc, have being recycled in Myanmar long before reduce, reuse and recycle (3Rs) concept was introduced worldwide. When an old building is dismantled, all the good building materials are resold and reused. Old cars are reconditioned and reused. Virtually, almost all the recyclable wastes in the country are recycled as much as possible, however, there is a need for more advanced recycling technology.

As the environmental awareness is rising gradually in the country in recent years, some private and public organizations have been conducting research and development on eco-housing and eco-transportation to save energy and raw materials. Research and development relating to V&A have also been initiated in the agriculture, livestock, fisheries and health sectors but, R&D needs to be promoted in all the sectors.

Most of the entrepreneurs considered that the environmental protection measures including the adoption of ESTs incurred additional costs and extra investment. From the TNA survey, it was found that there are also many industries which have great interest in securing ESTs. But, for most industries, especially the small and medium enterprises (SMEs), there are financial and technical barriers to adopt or adapt the cleaner production technologies or the ESTs. Therefore, financial and technical support, as well as economic and financial incentives will be needed for the application of the ESTs to those industries. Some industries surveyed also indicated that there was a need for developing an environment policy that would promote transfer and application of the ESTs. It is found that in most private and government owned industries there are no separate or special funds for environment programs.

When the TNA questionnaires were distributed to various types of industries including those related with V&A, it was not possible to include in these questionnaires a list of ESTs in order to ensure the selection of the most preferred technologies. Therefore, the industries with no knowledge or access to EST information were not able to identify specifically their preferred technologies. Only a few industries stated their needs for a certain type of technologies, machineries and equipments. Nevertheless, although they could not identify specific ESTs, most of them mentioned that they required 3Rs technologies as well as final disposal technologies including incineration technologies.

From the present TNA and the pilot TNA carried out in cooperation with the New Energy and Industrial Technology Development Organization (NEDO) of Japan, it was found that most ministries and the industries preferred technologies shown in Table 6.1.

With regard to the EST needs for V&A, the response received from the ministries and industries were not so specific although most of them stated their concern about the impending impacts of climate change. Based on their concern, the following EST needs could be identified.

1. High efficiency flood controlling technology
2. Water and soil preservation technology
3. Technology for observation and pre-warning against floods and droughts
4. Technology for observation and pre-warning against agriculture calamity
5. Agriculture biotechnology
6. Agriculture seedling technology
7. Technology for observation, pre-warning and forecast of sea level rise, coastal and marine environment
8. High standard dyke and embankment construction technology
9. Technologies for prevention and treatment of desertification, recovery of soil deterioration.
10. Other relevant technologies for protection of biodiversity vulnerable to climate change.

Table 6.1: Preferred technologies of ministries and industries

Renewable energy technologies	Energy saving technologies	Energy efficient technologies	Cleaner technologies
1.Solar power generation	1.Rehabilitation of refineries	1.Making boiler plants more efficient	1.Spread of low pollution vehicles, clean energy automobiles
2.Wind power generation	2.Rehabilitation of petrochemical plants	2.Introduction of high efficiency lighting	2.Promoting increased use of eco-cement and ready made cement
3.Waste power generation	3.Rehabilitation of dye-works	3.Making electric household equipments more efficient	3.Fuel conversion of power plant, switching crude oil or coal to natural gas
4.Utilization of energy from methane fermentation	4. Rehabilitation of food factories	4.Making buildings more energy efficient	4.Promoting increased use of biodegradable plastics.
5.Utilization of bio-mass energy such as from wood chaff	5.Rehabilitation of steel mills	5.Making water and sewage treatment plants more energy efficient	
6.Medium and small scale Hydraulic power generation	6.Rehabilitation of cement mills		
	7.Rehabilitation of pulp and paper mills		
	8.Introduction of energy saving equipments in all the above-mentioned industries		
	9.Repair and optimization of gas pipelines		
	10.Methane gas recovery from coal mines		
	11.Associated gas recovery from oil fields		
	12.Reduction of transmission & distribution and losses of electric power		

It should be mentioned here that if further TNA could be made, the most appropriate and suitable ESTs could be identified. This could facilitate the transfer and development of ESTs. There has been no prior TNA project in Myanmar supported by GEF. The present TNA was undertaken by the MOECAF and the TNA survey questionnaires were prepared by the MOECAF's own initiatives. The TNA was conducted with limited financial and technical capacities. It is therefore recommended that the GEF supports an additional TNA project to enhance and update the present TNA efforts of the MOECAF.

It is obvious from the TNA survey that there is a great need for environmentally sound technologies in Myanmar for both mitigation and adaptation purposes. At present the application and development of EST is not so easy as there are various financial, technical, institutional and infrastructural constraints. Therefore, necessary supports from the government as well as from the multilateral and bilateral sources are much needed for the transfer of ESTs to Myanmar.

The following are the most needed EST projects to be undertaken under the CDM; bilateral; and multilateral funding.

1. Wind power generation project
2. Waste power generation project
3. Utilization of energy from methane fermentation
4. Rehabilitation of dye-works, introduction of energy saving equipments
5. Making boiler plants more efficient
6. Spread of low-pollution vehicles, clean energy automobiles
7. Transport modal shift
8. Solar power generation
9. Rehabilitation of petrochemical plants, use of energy saving equipments
10. Fuel conversion and fuel switching.
11. Promoting increased use of biodegradable plastics
12. Rehabilitation of refineries, introduction of energy saving equipments
13. Introduction of new transportation systems (dual mode bus system, etc)

With respect to V&A the following projects can be considered for bilateral; and multilateral funding.

1. High efficiency flood controlling technology project
2. Water and soil preservation technology project
3. High standard dyke and embankment construction technology project
4. Technology for observation and pre-warning against floods and droughts
5. Protection of biodiversity vulnerable to climate change project

6.2. A Database for ESTs

The establishment of a user friendly data base for EST is essential for the development and transfer of ESTs to Myanmar. The EST Information System (ESTIS) that has been developed by UNEP's International Environmental Technology Center (IETC) can be adopted. But, first and foremost, there is a need to learn the use of this system. Appropriate staff from the MOECAF can be trained at the IETC. They should also participate in relevant sub-regional, regional and international workshops and conferences to share experience with other countries.

So far, capacity building for the MOECAF staff for the establishment of EST data -base has not yet been carried out, as the center is not yet ready to provide the required ESTIS training. At present, EST data base is being developed at the MOECAF using the information and data obtained through TNA. The difficulties encountered at present with regard to EST include the lack of training on ESTIS, the lack of information on ESTs and the lack of experience on ESTIS.

6.3. Establishment of Technology Information Network and Information Clearing House

A technology information network and information clearing house on EST are being initiated by the MOECAF. Network members from the ministries and the departments concerned as well as from all related organizations have been identified. They have also been requested to provide relevant information on climate change mitigation and adaptation measures to share with the network members. All useful information on ESTs will also be relayed to them through the clearing house based at MOECAF.

At present, there is limited internet facility for networking within the country or with the outside world. Networking within the country can be carried out through other means such as dissemination and sharing of information by post or office dispatch and through convening of regular network meetings to exchange information, views and ideas. Networking with regional and international organizations would be somewhat difficult.

There are several difficulties with respect to a successful implementation of the technology information network and information clearing house. These include among others: inadequate internet facility, limited climate change related information at the MOECAF to properly function as a clearing house and limited practice of sharing information among departmental personnel.

Chapter 7 Research and Systematic Observation

7.1 Introduction
7.2 Observing stations
7.3 Data publications
7.4 Research on climate change
7.5 Warning systems on natural disasters
7.6 Networking
7.7 Needs and recommendation
7.8 Conclusion

Chapter 7
Research and Systematic Observation

7.1. Introduction

The Government of Myanmar, acknowledging the importance of meteorological, climatological and hydrological information upon the socioeconomic development activities of the country, created Department of Meteoro-logy and Hydrology (DMH) in 1965 by renaming the preceding Burma Meteorological Department (BMD) which was established on the 1 April, 1937.

DMH, under the Ministry of Transport, is entrusted with the work of meteorological, hydrological and seismological related measurements, data archive and issue of bulletins, warnings and public education. DMH upholds six objectives:

- ❖ To exchange information with other centers on weather, water and earthquakes,
- ❖ To safeguard the people from losing their lives and property by issuing the early warnings and bulletins for all natural hazards related to weather, water,flood and earthquake,
- ❖ To expand public awareness and education programs on natural disasters, natural hazards and environmental issues,
- ❖ To monitor on climate change, water resources, air and water quality of Myanmar,
- ❖ To assist all government organizations,NGOs and stakeholders providing weather, hydrological and seismological information, and
- ❖ To assist all national projects effectively by capacity building through WMO, International/ Regional/ Bilateral cooperation.

There are six technical divisions in the Department such as;Meteorological d Aeronautical Meteorological Division Seismological Division and Instruments and Communication Division . DMH is successfully operating its functions and responsibilities under the close supervision of the Director General.

Literature review

Myanmar climate data are analyzed from time to time by various experts. In 1985, "*Agricultural Atlas for Burma*" (Myanmar) were published under WMO/UNDP Project BUR/80/016. Most of the materials used in the atlas was based on 20 year averages except some stations like Sittway, Mandalay, Yangon and Myeik (Mergui) where the rainfall observation started about the end of the 19th century. These stations somehow represent the western, central, deltaic and southern parts of Myanmar respectively.

In year 1997, Htay Aung analyzed the climatic data, i.e. rainfall, temperature and storms, and summarized the major findings in "*Climate change in the Union of Myanmar*". He highlighted that the average rainfall depth over Myanmar is generally negative since the year 1979. The exceptional years were 1985 and 1996. Assessment of the monsoon rainfall of the Union of Myanmar revealed that the rainfall anomaly from 1951–1980 average was almost negative since the year 1979. The annual number of drought departure from the 1951-1980 average showed a positive anomaly since the year 1980 except for the years 1985, 1990 and 1995. Moreover there is a general warming trend of mean annual temperatures in the whole country since the year 1979. The average increases for the periods of 1979- 1994 and 1951-1980 were 0.2 °C. The total number of storms and depressions that formed annually in the Bay of Bengal and Andaman Sea during 1984 and 2000 had reduced significantly.

In year 2002, Tun Lwin made excellent climate review paper "*The Climate Changes over Myanmar during the Last Five Decades*". In the paper, he emphasized on changes of Southwest Monsoon characters and activities over Myanmar. The monsoon onsets were late starting from 1977 in heat indices. There existed two distinct phases – one prior to and the other after 1977. The period before 1977 was somewhat a wet phase and the period after

1977 was a dry phase. During the period from 1877 to 2000, there were a total of seven years during which the storm frequencies were the lowest numbering 4 per year. Out of total seven years, six were observed in the 1990s.

The fact that most of the El Nino episodes, which occurred more frequently in 1980s and 1990s, probably accounted for the phase change in 1977, and it was observed in annual temperature and rainfall. The studyon climate change over Myanmar (Lwin T., 2002) clearly reveals that there has been sharp rise in temperatures and significant falls in rainfall during and around major episodes of El Nino. Higher maximum temperatures, later onset, earlier withdrawal, shorter duration of monsoon season and deficit monsoon rain had been observed in most of the El Nino years. A higher potential for drought and a substantial decrease in the number of annual storm frequency were also observed in El Nino years.

During the previous 40 years, all El Nino – Southern Oscillation (ENSO) years resulted in large deficient rainfall in Myanmar. In the 1997-98 ENSO year, excessive 24 hour rainfalls, record-breaking 24 hour maximum temperatures, large deficient annual rainfall and unprecedented floods occurred in parts of the country, particularly in the deltaic and southern parts. (Thaw S. H. and Pike, 1998). All ENSO years coincided with these long dry spells but other were due to the break or failure of monsoon. The year 1998 was found to have the longest dry spell ever recorded in the country and the floods in major rivers set new highest water level records and longest duration of stay above danger levels. In 1999, a study on El Nino and its impact on the climate of Myanmar was carried out by Tun Lwin. He highlighted that the annual storm frequency in the preceding years of peak of El Nino events were below normal. However, during the following years of the peak of El Nino events, the annual storm frequencies were found to be below normal to normal.

7.2. Observing Stations

Myanmar has 161 observing stations related to weather and climate information as shown in (Table 7.1)The stations are not evenly distributed. Most of hestationswere setup,based upon the favorable logistic conditions, rather than technicals equirements. Therefore the stations are denser in accessible plain areas than mountainous remote areas. In the World Weather Watch (WWW) program, 27 meteorological stations are participating. The meteorological stations at Yangon, Mandalay and Sittway are included in the Global Surface Network (GSN) stations. The sea level stations at Mawlamyine and Sittway are listed in the Global Observing Sea Stations (GLOSS). The spatial distributions

Table 7.1: Observing stations

Sr. No.	Type of stations	Quantity	Remarks
1	Meteorological stations	63	Including 27 WWW stations and 3 GSN stations
2	Meteorological and Hydrological stations	39	
3	Hydrological stations	30	
4	Agrometeorological stations	18	
5	Cyclone detection radar station	1	
6	GLOSS stations	2	
7	Solar Radiation stations	5	Joint project with Thai Meteorological Department
8	Automatic Raingauge Network	3	Gwa, Thayawady and Shwegyin along the 18^{o} N in the GEWEX Asian Monsoon Experiment with Tokyo Metropolitan University, Japan.

of selected meteorological and hydrological stations are shown in (Figure 7.1) and (Figure 7.2) Solar radiation is being monitored at Kaba-Aye, Pyay, Meiktila, Mandalay and Shwebo under the project jointly undertaken by Thailand and Myanmar on renewable energy and energy conservation since August 2008.

Acid rain analysis is being carried out at the DMH Office, Mandalay for Upper Myanmar stations and at Hydrological Division of DMH Office, Yangon for Lower Myanmar stations. River flow and sediment discharge are monitored as control checking to readjust the flow-discharge curve of the rivers. Water quality monitoring is also carried out at the selected river sites as programmed.

Figure 7.1: Meteorological stations

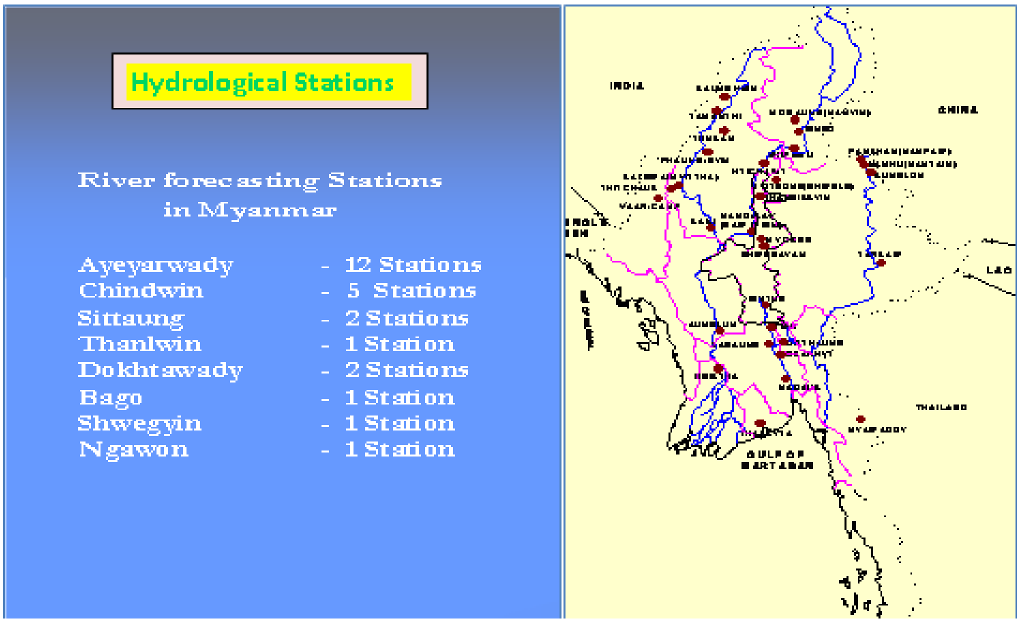


Figure 7.2: Locations of hydrological stations and river forecasting stations in Myanmar

7.3. Data Publications

Data collection and archive

For real time meteorological/ hydrological data collection from out-stations, telephones and Single Side Band (SSB) transceivers are used. Confirmation of the data is made when the register books are obtained through public mail service.

Then quality control of the data is processed manually by experienced observers. Data archive is carried out manually using CLImat COMputing (CLICOM) format for meteorological data and GO6 format for hydrological data, which are the standard formats of WMO.

Climate/Hydrological data publications

Department of Meteorology and Hydrology has been publishing Climatological data regularly. The 1950-60 climate record of three climate elements for (26) stations was published in 1962; the 1961- 1970 record for (48) stations in 1982; the 1971- 1980 record for 57 stations in 1984; the 1981- 1990 record for 60 stations in 1992; and; the 1991- 2000 record for 60 stations in 2005. Mean monthly rainfalls for the period 1947-1972 including 58 stations were prepared in 1972. Five days, ten days and monthly mean accumulated rainfall (inches) from June to October of 58 stations were published in 1973.

The climate data from 60 stations for the decade 1981-1990 was published in 1992. It contained meteorological elements such as pressure, maximum and minimum temperature, wet bulb temperature, relative humidity, and monthly rainy days and 24 hours maximum rainfall. In 2005, the 1991-2000 climatological data from 60 stations was published. It contained the maximum wind of the month in addition to the elements published for the decade, 1981-1990.

Normal values of meteorological data for pressure, temperature, relative humidity and rainfall of 36 stations for the period 1961-1990 were published in 1996. Moreover extreme values of 24- hour temperature and rainfall are updated as required as shown in (Table 7.2).

Table 7.2: List of climate data publications

No.	Period	No. of Stations	Climate Data	Elements *	Issued Year
1	1950-1960	26	Monthly climatic data	T, RF, RH	1962
2	1961-1970	48	Do	T, RF,RH,P	1982
3	1971-1980	57	Do	T, RF,RH,P	1984
4	1981-1990	60	Do	T, RF,RH,P	1992
5	1991-2000	60	Do	T, RF RH,P,W	2005
6	1961-1990	36	Normal climatic data	T, RF,RH,P	1996
7	1961-1990	44	Normal rainfall for states and divisions of Myanmar	RF	1999
8	From opening date to 1990	27	Pentad mean, maximum and minimum temperature	T	2001
9	1947-1972	58	Annual and monthly rainfall of Myanmar	RF	1972
10	1951-1970	58	Five days, Ten days and monthly mean accumulated rainfall from June to October	RF	1973

Aspecial study on floods, associated meteorological phenomena and the costs of the flood-induced damage, provided by the Relief and Resettlement Department, are included in the yearly published Volume II as a separate section.

Climate/Hydrological reviews

In Sittway, the long-term average annual rainfall was 5011 mm. For the period 1861-1901, the rainfall was below the average, for 1902-1925 above the average, and for 1926-1983 also below the average. **In Mandalay**, generally, 1892-1947 was a wet epoch, 1948-1967 was a dry epoch. But, the 1949-1954 was exceptionally dry with about 25% below the average annual rainfall. The 1968-1978 was a wet period while 1979-1983 showed a trend of dry period due to the very dry years of 1979 and 1983. The long-term average of the Mandalay station was 912 mm. **In Yangon,** the long-term annual rainfall record for 1870-1922 generally indicated a dry epoch, followed by wet spell for sixty-two years until 1983. The long term average normal rainfall was 2629 mm during 1870-1983. **In Myeik**, there were three short term dry epochs. They were observed in 1872-1880, 1913-1922 and 1951-1959. The remaining periods had the annual average rainfall**s** hovering about the long term average of 4137mm (“*Agricultural Atlas for Burma*”, DMH, 1985).

Climate analysis for the period 1961 to 1990

Climate of Myanmar for each of fourteen States and Regions based on the features depicted for 1961-1990 are briefly mentioned below following the WMO definition of normal.

- **In Kachin State**, the rainfall departures in 1983-1998 were 2% above the previous average value during 1950-1997 at Myitkyina. The temperatures were about 0.5°C warmer during 1991-1997. The region is the upper catchments of the Ayeyarwady River. There were 7 floods in 41 years at Mtitkyina.

- **In Chin State**, the average annual rainfall in the period 1981-1996 was -15% to 25% below the previous average. The temperatures in the 1981-1990 were 0.2°C to -2.2 °C cooler in all seasons compared to previous average (Aung H., 1997).

- **In Shan State**, the rainfall in the 1961-1990 period was 3%-5% less than the previous normal values. The mean temperature has been above the 1961-1990 average particularly all the years after 1990. But, the mean temperature at Taunggyi was below the previous normal values in 1993 and 1994.

- **In Rakhine State**, the annual rainfalls during 1981-1995 showed a decrease of 19% below the previous normal. At Sittway, temperature anomalies during 1947-1995 are positive, particularly after 1975. This region is often hit by cyclones from the Bay of Bengal. Eight severe cyclones have crossed the area within 26 year since 1967.

- **In Kayah State**, the average rainfalls at Loikaw station during 1961-1990 were about 10% less than the previous normal . The annual mean temperature departures were generally positive during 1986-1998. This area is less prone to natural disasters.

- **In Bago Region,** the 1961-1990 average annual rainfall was changed by +1% to -9% compared to previous average. The highest maximum temperature was recorded in 1905 was 108°F (42.2°C) at Taungoo and it remained so until 1997 But, new record of 109.2°F (42.9°C) in 1998 was observed due to the impact of El Nino phenomenum. (Aung H., 1999)

- **In Mon State**, the average annual rainfall for the period 1981-1994 was 3-6% below the previous normal. The mean temperature in 1991-1995 was 0.5°C higher than the 1961-1990 temperature.

- **In Kayin State**, the average annual rainfall during 1981-1997 was 8-14% below the previous normal. Temperature was up to 1.0°C warmer than the 1965-80 average at Pa-an station. Thanlwin river flood reached the highest level of 922cm in August 1991.

- **In Sagaing Region**, the average annual rainfall during 1961-1990 was slightly below the previous normal. The departure of annual mean temperature during 1991-1998 was generally positive compared to the 1955-1990 mean value. It was 1.5°C above the mean value in 1998 at Katha station. The Region experienced extensive floods from the Chindwin River and Ayeyarwady River, about once to twice per year. The floods in the region were attributed to successive floods in the lower reaches of the rivers, down to Ayeyarwady Delta. The heavy rains due to remnants of severe cyclones that crossed Rakhine coast induced flash floods in the Sagaing Region .

- **In Mandalay Region**, the average annual rainfall during (1981-1995) was 7-20% lower than the previous period. Annual temperature anomalies from 1983-1995 were all positive. It reached 1.5°C above the average in 1994, at Mandalay. The region is prone to flood caused by the Ayeyarwady River. Flood frequency has been indicating a declining trend at Nyaung U station and the Region was worst affected by the 1997-98 El-Nino. In 1998, the Region received ever recorded least rainfall. The highest maximum temperatures ever recorded were also observed at some places in the Region .

- **In Magway Region** , the average annual rainfall during 1981-1995 was below the previous normal by 1% to 17%. Annual temperature difference between 1961-1990 period and previous period was only +0.1°C. The Region experienced Ayeyarwady River floods 24 times in 32 years with the highest flood record in 1974. The Region was also affected by remnants of typhoon from the South China Sea and those from the cyclones in the Bay of Bengal.

- **In Ayeyarwady Region** , the average annual rainfall in 1981-1998 showed small positive departure from the previous values. As for mean annual temperature, it was continuously above the 1950-1980 average until 1998.

- **In Yangon Region** , the rainfall during 1981-1995 has increased by about 4% above the previous normal. The temperature departures were positive from the 1950-1980 mean values, particularly between 1977 and 1994; at times departure was up to 0.6°C. As the Region has some coastal areas, it is vulnerable to the effects of severe cyclones. Damage due to the floods was minimal.

- **In Tanintharyi Region** , the 1981-95 annual average rainfall was 3-7% below the previous values. The mean temperatures were -0.1°C to +0.5°C above the previous normal. This region is often affected by the typhoon remnants from the South China Sea. But loss and damage were minimal compared to Rakhine State.

Recent observed climate change in 1991-2000

In Kachin State**,** Chin State and Mandalay Region**,** annual mean temperatures had increased by 0.4°C, 0.1°C and 0.2°C, and annual average rainfalls had also increased by 4 mm, 160 mm and 78 mm respectively. But in Sagaing and Bago Regions, temperatures were decreased by 0.2C° and 0.5°C, and annual average rainfalls had decreased by 6 mm and 65 mm respectively.

In Magway Region , temperature had decreased by 0.8°C, a large value which needs further verification and the average annual rainfall had decreased by 28 mm.

In Rakhine State, while temperature remained practically unchanged, rainfall had increased by 339 mm.

In Shan State, temperature had decreased in eastern part by 0.5°C and increased by 0.1°C and 0.6°C in the northern and southern parts respectively. The rainfalls had decreased by 9 mm , 46 mm and 118 mm in the eastern, northern and southern parts of the region.

In Ayeyarwady Region , the trends were increasing in temperature by 0.1°C and rainfall by 54 mm. In Yangon Region , while temperature had decreased by 0.2°C, rainfall had increased by 72 mm. In Kayah State both temperature and rainfall had increased by 0.5°C and 2 mm.

In Kayin State, Mon State and Tanintharyi Region, temperatures had increased by 0.3°C, 0.1°C and 0.2°C, with increases in average annual rainfalls by 303 mm, 135 mm and 204 mm respectively.

During the period 1965-2000, heat indices showed three types of phase, namely: (i) a change from cooling to warming, (ii) a change from warming to cooling, and (iii) a change from less warming to more warming. The areas in the northern and central parts located in the higher latitudes have a trend change from warming to cooling starting from 1977. In the remaining areas, there had been a trend change from cooling to warming though some isolated spots had a trend change from less warming to more warming. A distinct rise of area averaged heat indices was noted in 1977 and onwards in Myanmar. Annual rainfalls had increased generally in the whole country within the 10 % of the normal, except for Sagaing Region , Bago Region and Shan State.

In general the average annual mean temperatures for the several selected weather stations revealed an increase in the 1990s. In 1997, the average annual mean temperature of 17 stations was 0.27°C higher than the 1951-80 average. In 1998, it was even higher. The average minimum temperature for the months of January was 0.45°C higher than that of the January months of the 1951-1980. In the hottest months, the maximum temperatures were 1.02°C and 1.60°C higher than those of the 1951-80 in April and May respectively. A continuous negative anomaly in monsoon rainfalls were observed during the entire period from 1989 to 1998 with an exception of a single year 1990 which had a weak positive anomaly. The year 1998 was the worst with the negative highest anomaly during the last 42 years. The study on drought anomaly in Myanmar showed that drought years with moderate intensity were more frequent in the 1980s and 1990s. There were 13 positive drought anomaly years out of 18 years.

Public information

Public information on the extreme events is prepared and issued as the situation calls for. The climate data are distributed to various government agencies and private users on request. Monthly weather summary and annual weather summary are also informed to the public through mass media at the end of every month and year.

Climate/ Hydrological data distribution and exchange

The meteorological and hydrological data were distributed to government agencies and UN local agencies on request. The data are also made available to private enterprises. Any other agencies and institutes which are interested in the climate study can receive the data on request. The data are also sent to the ASEAN Sub-Committee on Meteorology and Geophysics Data Center, Malaysia on request and CLIMAT data are sent to the World Data Centre, USA.

7.4. Research on Climate Change

Region-wise annual mean temperature

The annual mean temperature of Myanmar is lowest with 15.8°C in the Chin State, the northwest mountainous region followed by 19.1°C in the eastern Shan State, and it increases to 27.4°C in Yangon Region. It is the highest with 27.5°C in Magway Region in the central dry zone of the country for the WMO normal period of 1961-1990. If the longer term 1951-2007 is considered, the annual mean temperatures generally increase in nine out of 17 Sub States and Region s. The rate of warming per decade is the highest with 0.32°C at Hpa-an, Kayin State in the southeastern part followed by 0.30°C at Monywa, Lower Sagaing Region of the central dry zone. Cooling trends of -0.23°C and -0.16°C per decade were observed at Magway of Magway Region and Bago of Bago Region in the lower Myanmar region respectively. The trend is shown in (Table 7.3) and (Figures 7.3 and 7.4). There is no appreciable change in six States and Regions, mostly located in the southern part of the country.

Table 7.3: Temperature trend till 2007 of Sub-States/Regions of Myanmar

Sub-State/ Region	Station	WMO Mean Annual Temp (°C) for 1961-1990	Period till 2007		Warming (°C) per decade
			Since	Mean Temp (°C)	
Kachin State	Myitkyina	24	1951	24.1	0.2
Upper Sagaing Region	Hkamti	24	1961	24.1	0.04 *
Lower Sagaing	Monywa	27.1	1961	27.3	0.3
Mandalay Region	Mandalay	27.3	1951	27.5	0.2
Magway Region	Magway	*27.5*	*1971*	*27.2*	*-0.23 Cool*
Chin State	Hakha	15.8	1981	16	0.13
Rakhine State	Sittway	25.8	1951	27	0.13
Northern Shan State	Lashio	21.8	1951	21.9	0.14
Southern Shan State	Taunggyi	19.1	1951	19.4	0.16
Eastern Shan State	Kengtung	23.2	1951	23	0.01 *
Bago Region	Bago	*26.9*	*1951*	*26.9*	*-0.16 Cool*
Ayeyarwady Region	Pathein	27	1951	27.2	0.08 *
Yangon Region	Kaba Aye	27.4	1951	27.4	-0.04 *
Kayah State	Loikaw	22.3	1951	27.4	-0.04 *
Kayin State	Hpa-an	27	1961	27.2	0.32
Mon State	Mawlamyine	27	1951	27.1	0.14
Tanintharyi Region	Dawei	26.6	1951	26.6	-0.01 *

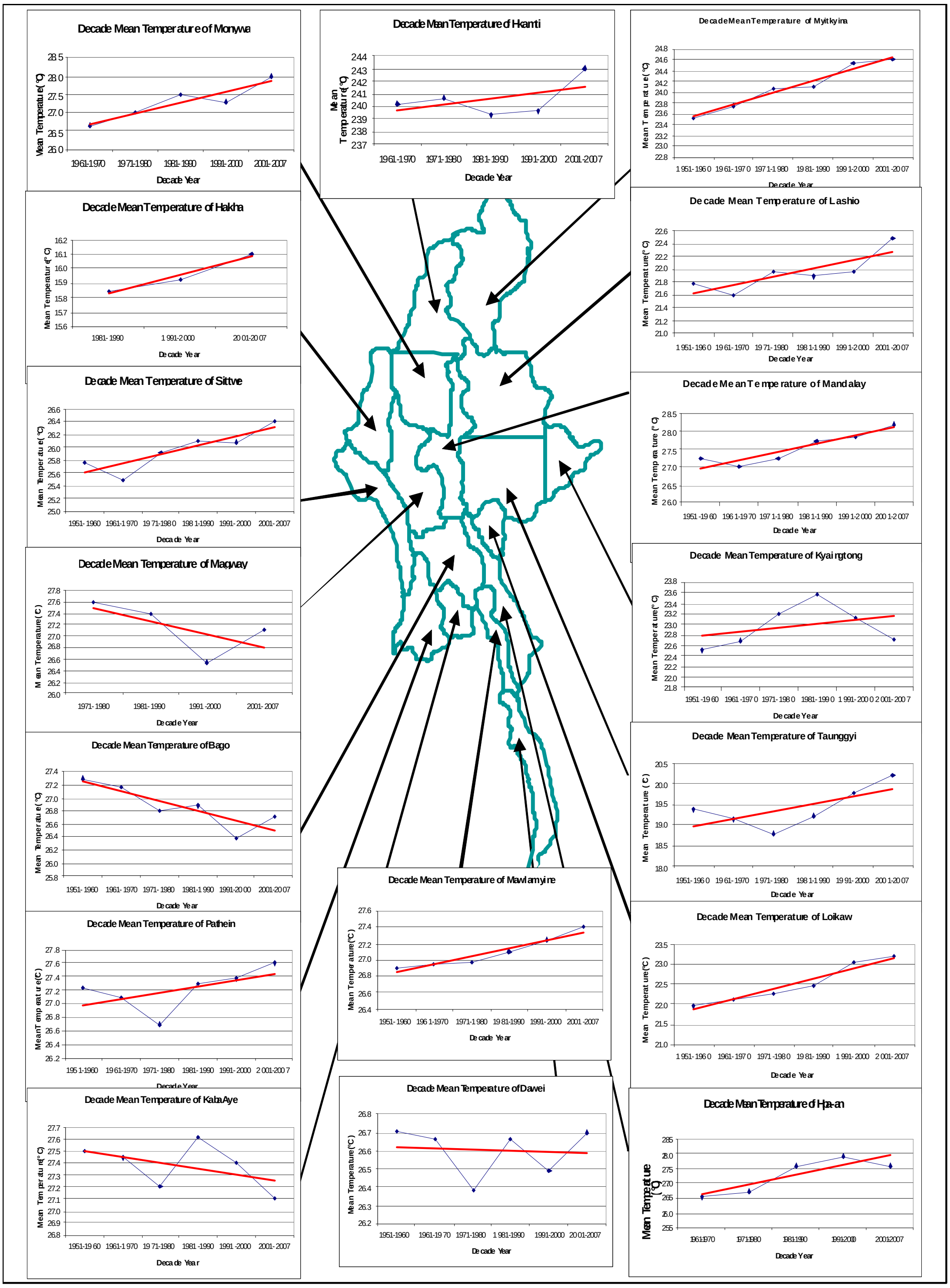


Figure 7.3: Annual mean temperature trend (graph) in various Sub-States/Regions

Region-wise extreme mean temperature geat waves

When the maximum temperatures exceed 9°F (~ 5ºC) than the normal at a given location, DMH defines them as heat waves, and they may extend to the neighboring areas. If the occurrence of the heat wave prolongs, the foremost impact is the scarcity of water. The long duration of the water scarcity causes drought which further leads to health problems and even the loss of lives of the living beings including human. Infants and the aged are particularly affected. Normal socio–economic activities are disrupted in many cases.

During 1951-2000, annual mean frequencies of heat wave occurrence were five in Kachin State, two each in northern Shan State, and Magway Region , Mandalay Region and Lower Sagaing Region , and one each in Bago Region and Mon State. However, there is no particular place in States or Regions which suffered heat wave every year on regular basis. Heat wave is practically seldom in the remaining States and Regions.

Heat waves used to occur during the months from March to June. Seven percent of the annual heat waves occurred in March in Kachin , Rakhine and northern Shan States. For the Dry Zone of Central Myanmar, heat waves were never experienced in March. The heat wave frequency in April was 23 % of the annual total, and it occurred mostly in Kachin State. The waves also occurred in northern Shan State and the Dry Zone. The heat wave frequency was the highest with 50% of the annual total in May with the most frequent occurrence in Kachin State and Magway Region . The heat waves were found spreading from north to south till 15°N parallel. The areas in lower Myanmar suffer heat waves only in the month of May. The annual heat wave frequency was 20% in June. It was found in Kachin, and northern Shan States, Dry Zone, and Bago, Ayeyarwady, Yangon and Tanintharyi Regions. Most of the heat waves are in the range of 9°F -11°F above mean maximum.

Heat waves with 12°F-15°F higher than the mean maximum were found in Kachin State, Northern Shan

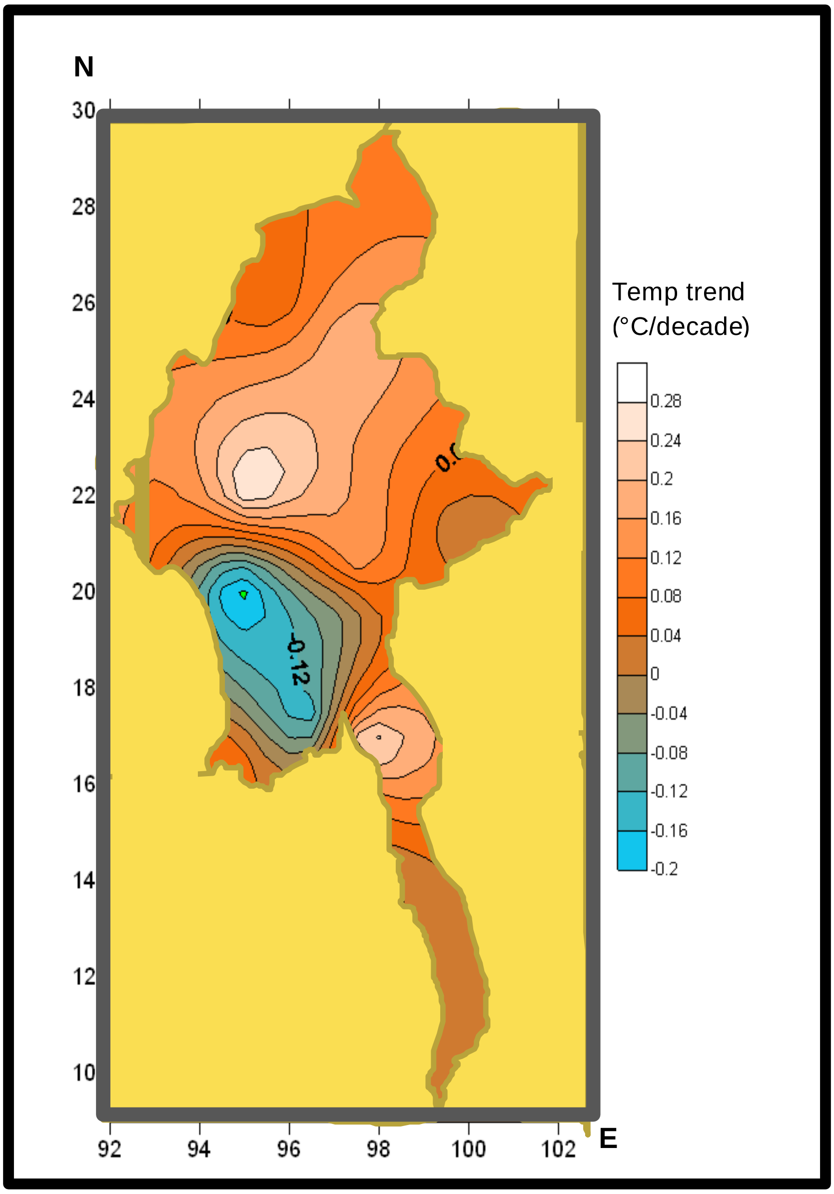


Figure 7.4: Annual mean temperature trend (contour) in various Sub-States/Regions

State and Dry Zone during the month of May. Heat waves in May and June usually last for 5 to 6 days. The longest heat wave duration was found in Yangon for 12 days from May 16 to 27, 1957. Heat waves lasting June 1 - 8 in 1958 were the second longest duration in the country, and they occurred in Kachin State. Both years were the strong El Nino years.

The heat waves rarely formed simultaneously in two different States/ Regions. Heat waves sometimes spread to the surrounding regions and often cover 25% of the country. Heat waves in May, 1967 were found to be extensively widespread covering 48% or (125,000 sq miles) 323,750 km^2 of the country. In 1998, the most extensive heat wave was found to cover 156,250 sq miles 404,688 km^2 or 60% of the country. It may be noted that the 1998 was an ENSO year where both El Nino and Southern Oscillation were active. The occurrence of heat wave (highest maximum temperature) was found to coincide with the El Nino year as shown in (Table 7.4).

As far as Myanmar is concerned, the origins of heat waves were not found outside the country. Heat waves commonly originated from Kachin , northern Shan and Rakhine States, Dry Zone, and Ayeyarwady, Bago and Tanintharyi Regions. In most occasions, heat wave is dissipated when maximum temperature is lowered and the coverage area becomes diminished when the cloudy weather prevails with or without precipitation.

Region-wise annual mean rainfalls

The lowest mean annual rainfall of 768 mm is found in the Lower Sagaing Region in the central Dry Zone. It increases eastward to about 1500 mm over Shan State, northward to about 2000 mm over Kachin State, westward to 4700 mm over Rakhine State and southward to 5400 mm over Tanintharyi Region . Increasing rainfall trends are observed at ten Sub-States/ Regions with highest rate of 215 mm per decade at Hkamti of Upper Sagaing Region. Decreasing rainfall trends are observed at four Sub-States/Regions with

Table 7.4: Highest maximum temperature records at the capitals of States and Regions

State/ Region	Station	Highest Max Tem(°C)	Date	Remark
Kachin	Myitkyina	41.5	31-5-79	El Nino year
Chin	Hakha	30.1	8-4-88	El Nino year
Upper Sagaing	Homalin	43.8	5-6-86	El Nino year
Lower Sagaing	Monywa	45	17-5-69	
Mandalay	Mandalay	44.2	1-5-95	
Northern Shan	Lashio	38.6	22-4-89	
Eastern Shan	Kengtung	40	18-4-83	El Nino year
Southern Shan	Taunggyi	33.5	23-4-95	
Magway	Magway	46	13-4-80	
Rakhine	Sittway	40	1-4-80	
Kayah	Loikaw	38	14-4-98	El Nino year
Northwest Bago	Pyay	44	24-4-73	
Northeast Bago	Taungoo	42.9	8-5-98	El Nino year
South Bago	Bago	41.7	25-4-58	El Nino year
North Ayeyarwady	Hinthada	43.6	9-5-98	El Nino year
South Ayeyarwady	Pathein	41	27-4-83	El Nino year
Yangon	Yangon (Kaba-Aye)	42	9-5-98	El Nino year
Kayin	Hpa-an	41	25-4-88	El Nino year
Mon	Mawlamyine	40.2	8-5-98	El Nino year
Tanintharyi	Dawei	38.9	6-5-98	El Nino year

highest rate of about -80 mm per decade at Bago of Bago Region in the lower part of the country. There are no appreciable changes, (i.e. less than 10 mm per decade) in the three Sub-States/Regions in the eastern and southern parts of the country as shown in (Table 7.5)and (Figures 7.5 and 7.6).

Table 7.5: Annual rainfall trend (mm/decade) of Sub-States/Regions of Myanmar till 2007

Sub State/ Region	Station	WMO annual rainfall (mm) for 1961-1990	Period till 2007		Increasing per decade (mm)
			since	Annual rainfall (mm)	
Kachin State	Myitkyina	2193	1951	2,195	64.71
Upper Sagaing Region	Hkamti	3701	1961	3,570	215.2
Lower Sagaing Region	Monywa	768	1961	785	-17.4 decrease
Mandalay Region	Mandalay	860	1951	864	13.14
Magway Region	Magway	852	1971	800	57.1
Chin State	Hakha	1,829	1981	1,742	50.5
Rakhine State	Sittway	4,723	1951	4,555	52.06
Northern Shan State	Lashio	1,341	1951	1,381	33.62
Southern Shan State	Taunggyi	1,508	1951	1,555	-5.48 *
Eastern Shan State	Kengtung	1,256	1951	1,297	-2.51 *
Bago Region	Bago	3,522	1951	3,798	-81.08 decrease
Ayeyarwady Region	Pathein	2,913	1951	2,904	36.4
Yangon Region	Kaba- Aye	2,713	1951	2,684	41.74
Kayah State	Loikaw	1,090	1951	1,089	-11.17 decrease
Kayin State	Pa-an	4,377	1961	4,346	-23.6 decrease
Mon State	Mawlamyine	4,856	1951	4,816	71.57
Tanintharyi Region	Dawei	5,419	1951	5,499	7.8 *

* No appreciable change (< 10mm /decade)

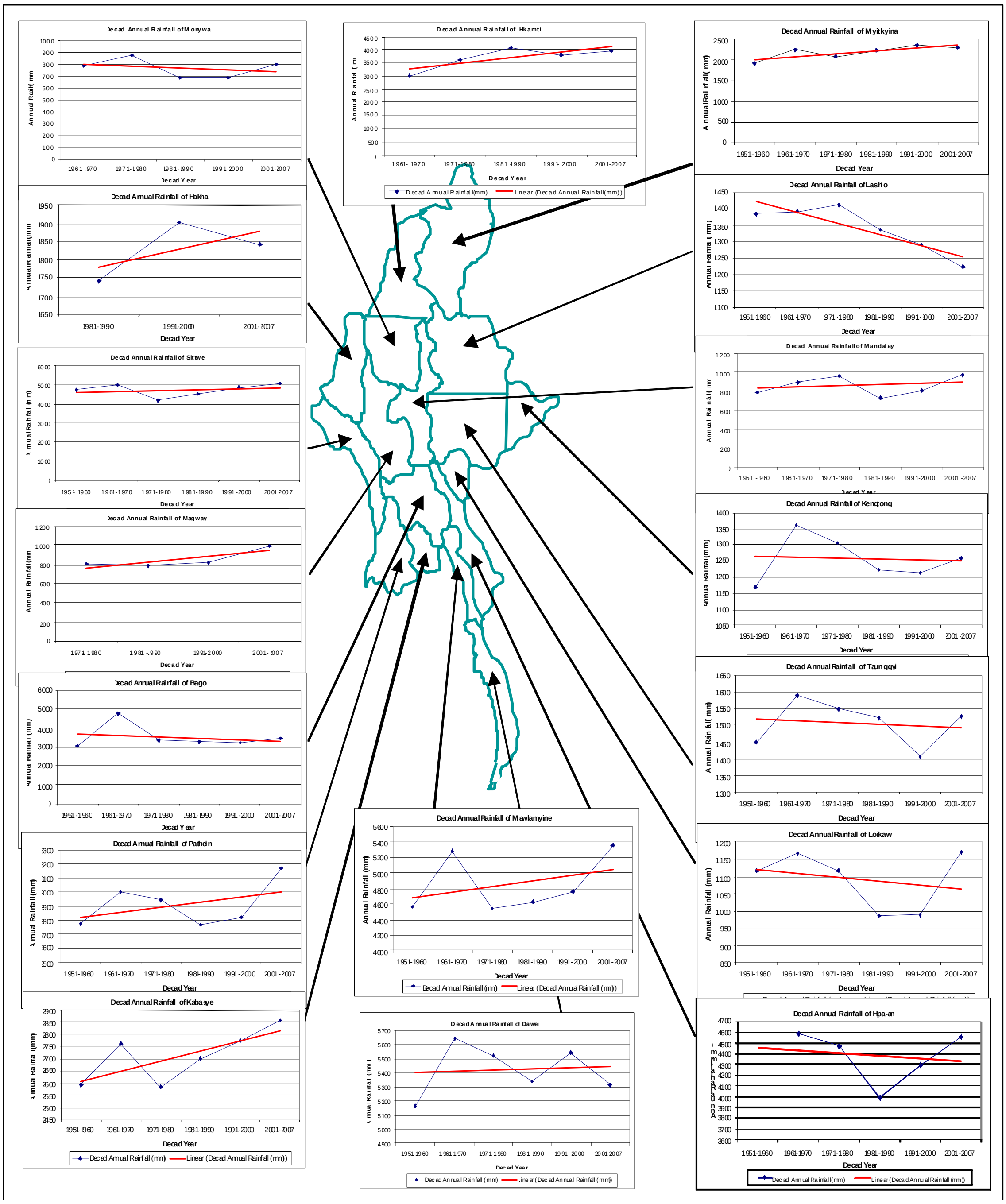


Figure 7.5: Annual precipitation trend (graph) in various Sub-States/Regions.

Extreme rainfall

Extreme rainfall is one of the meteorological hazards to the various communities and activities. It has two ends, one is "**High Extreme**" and the other is "**Low Extreme**". A marked decrease or increase of rainfall is critical to the key socio-economic sectors as they depend more or less on rain that determines water replenishment and other water related activities.

Extreme rainfall events in Myanmar during 1991 to 2004

(1) Methodology

DMH generally defines extreme rainfall when Departure From Normal (DFN) is more or less outside the range of **± 20%** during a particular period, i.e. monthly, seasonal, or annual, etc. DFN is calculated by using the following equation.

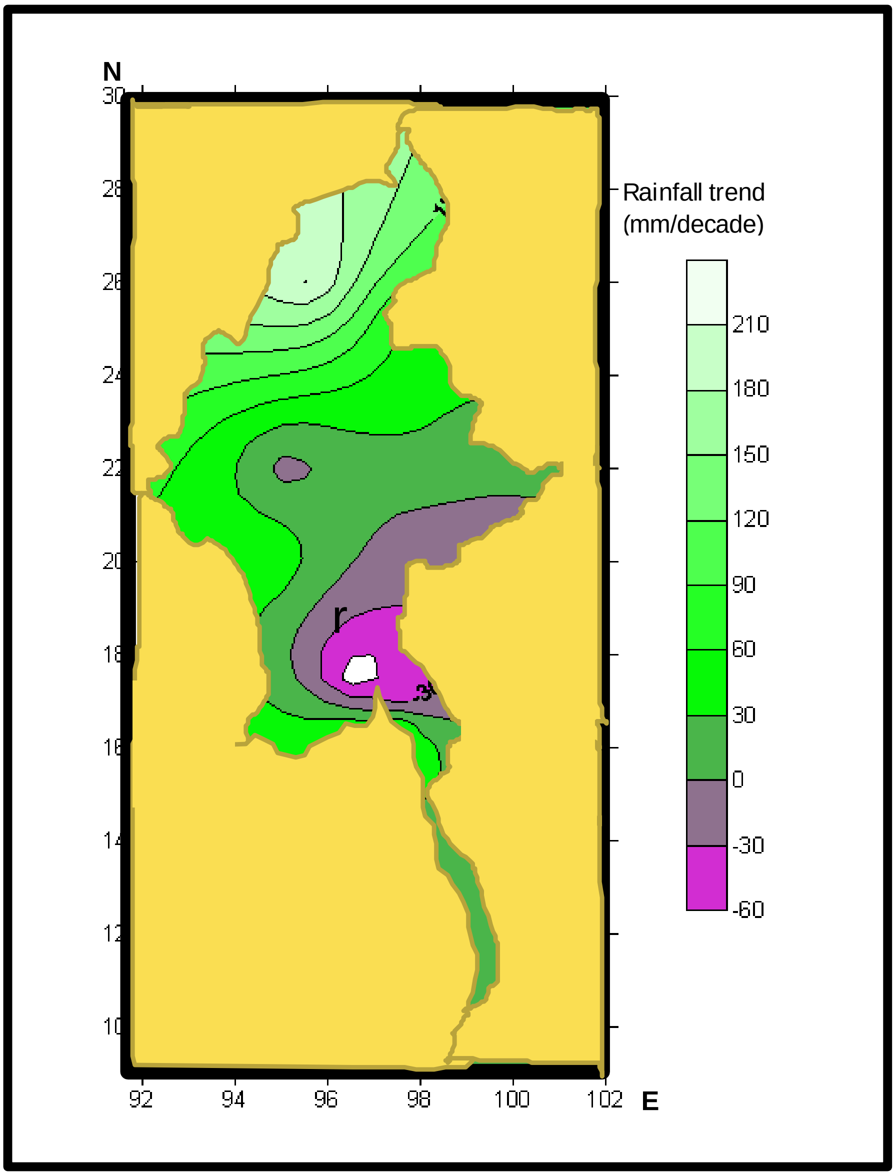


Figure 7.6: Annual precipitation trend (contour) in various Sub-States/Regions.

$$DFN = \frac{R - N}{N} \times 100\ \%$$

Where: R = Rainfall, N = Normal rainfall.

Extreme rainfall has two ends, "**High Extreme**" and "**Low Extreme**", where each of them has another one category of "**Higher Extreme**" and "**Lower Extreme**" respectively. They are specified by the DFN values as followings: -

- **Higher Extreme > + 50%**
- **+ 20% < High Extreme ≤ + 50%**
- **– 20% > Low Extreme ≥ – 50%**
- **Lower Extreme < – 50%**
- **Note: [– 20% ≤ Normal ≤ + 20%]**

(2) Results

Extreme rainfall events in Myanmar during 1991 to 2004 were studied using annual rainfalls of the 16 selected stations from the 14 States and Regions. The frequencies of "**High**" and "**Low**" extremes are shown in (Table 7.6). The maximum and minimum extremes for those 16 stations during the 14-year period are also included in the table. The following salient features can be seen clearly.

(a) **High extreme:**

- Maximum frequencies were **5** years at Nyaung Oo, and **4** years at each of the four stations of Myitkyina, Magway, Mawlamyine and Hpa-an.

- Not experienced at 3-station of Lashio, Monywa and **Sittway**.

(b) **Low extreme:**

- Maximum frequencies were **5** years at Monywa and **4** years at Mandalay.
- Not experienced at three stations of Myitkyina, **Sittway** and Yangon.

(c) **Higher extreme:**

- Only one station, Mawlamyine (+51.2% above normal in **1994**).
- Two stations were close to this category. (Nyaung-U +49.6% and Magway +47.5% above normal in 1999 and 1995 respectively)

(d) **Lower extreme:**

- Not experienced.
- Only two stations were close to this category. (Magway -48.7%, Mandalay -44.0% below normal in **1998** and **1995** respectively)

(e) **Impact of the 1998 strong El Nino year:**

- 11 out of 16 stations, 69% experienced Low Extreme.
- 10 stations, except 1-station of these 11-stations, 91% were recorded Minimum Low Extremes.

Table 7.6: Frequencies of extreme rainfall during the period 1991-2004

Sr No	Stations	High Extreme				Low Extreme			
		Maximum		Frequency		Minimum		Frequency	
		DFN (%)	Year	No.	Year(s)	DFN (%)	Year	No.	Year(s)
1	Myitkyina	28	2001	**4**	91,98,01,04	-	-	-	-
2	Falam	28.7	1991	1	91	-25.3	1992	3	92,**98**,01
3	Taungyi	21.4	2001	1	1	-35.3	**1998**	2	97, **98**
4	Lashio	-	-	-	-	-26.9	2003	2	02,03
5	Monywa	-	-	-	-	-37.6	**1998**	**5**	91,93,97,**98**
6	Mandalay	23.4	1992	1	92	**-44**	1995	**4**	93,95,00,04
7	Nyaung U	**49.6**	1999	**5**	96,99,02,03	-37.8	**1998**	2	97, **98**
8	Magway	**47.5**	1995	**4**	95,96,99,02	**-48.7**	**1998**	3	91,94, **98**
9	Sittway	-	-	-	-	-	-	-	-
10	Loikaw	24.4	2004	1	4	-28.9	**1998**	2	93, **98**
11	Bago	21.1	1997	1	97	-28	**1998**	1	**98**
12	Pathein	26.6	2002	1	2	-35.4	**1998**	2	93, **98**
13	Kaba-Aye	39.1	1999	2	99,02	-	-	-	-
14	Pa-an	29.4	1994	**4**	94,97,99,04	-37	**1998**	1	**98**
15	Mawlamyi	**51.2**	1994	**4**	94,99,02,04	-26.9	**1998**	1	**98**
16	Dawei	34.7	1999	2	97,99	-24.9	**1998**	1	**98**
Total				31		Total		29	
Mean				**1.9 (14%)**		**Mean**		**1.8 (13%)**	

Region-wise extreme daily rainfall (1961-1990)

The heaviest rainfalls in 24 hours were usually experienced during the monsoon rain period from mid-May to mid-October. They occurred41% during the "early monsoon period" of mid-May to end of June, 12% in May and 29% in June . During the "mid-monsoon" 18% of heaviest rainfalls in 24 hours occurred in July and 35% in August. In the "late monsoon" of September to mid-October, 6% occurred in October while did not experience any heaviest rainfalls September.

Extreme daily rainfalls during the period 1961-1990 are shown in (Table 7.7)below. The highest of 527 mm occurred at Hkamti, Upper Sagaing Region on 6 June 1989.The second highest of 422 mm occurred at Sittway, Rakhine State on 5 June 1979. The third, fourth and fifth highest were 367 mm on 2nd August 1979, 343 mm on 1st June 1988 and 340 mm on 2nd August 1962 which happened at Mawlamyine of Mon State, Dawei of Tanintharyi Region and Hpa-an of Kayin State respectively.

Table 7.7: Extreme rainfalls (mm) in 24-hour during the period 1961-1990

Sr. No	Sub State/ Region	Stations	Highest in 24hrs (mm)
1	Kachin State	Myitkyina	**182 [23-6-87]**
2	Upper Sagaing Region.	Hkamti	**527 [29-6-89]**
3	Lower Sagaing Region.	Monywa	**135 [3-6-84]**
4	Mandalay Region.	Mandalay	**175 [24-8-87]**
5	Magway Region.	Magway	**183 [12-8-74]**
6	Chin State	Hakha	**167 [25-5-85]**
7	Rakhine State	Sittway	**422 [5-6-80]**
8	Northern Shan State	Lashio	**168 [11-10-86]**
9	Southern Shan State	Taunggyi	**113 [14-8-90]**
10	Eastern Shan State	Kengtung	**134 [10-7-73]**
11	Bago Region.	Bago	**201 [19-7-62]**
12	Ayeyarwady Region.	Pathein	**240 [8-5-75]**
13	Yangon Region.	Kaba-Aye	**171 [11-7-88]**
14	Kayah State	Loikaw	**112 [24-8-73]**
15	Kayin State	Hpa-an	**340 [2-8-62]**
16	Mon State	Mawlamyine	**367 [27-8-79]**
17	Tanintharyi Region.	Dawei	**343 [1-6-88]**

Cyclone

Cyclone landfall frequencies

Cyclone in the Bay of Bengal is one of the climatic parameters for Myanmar and the countries around the Bay of Bengal. Increased numbers of cyclones formed in the bay will influence much on the rainfall and the monsoon of the country. At times it brings about disastrous events into the country.

During 1887-2005, there were 1248 tropical disturbances in the Bay of Bengal. Out of 1248 cyclones, 9% to 17% were formed in each month from June to November; and 3% to 7%, most of which were tropical storms, were formed in each month of April, May and December. There were less than 3% during the remaining months. Altogether 80 or 6.6% of all cyclonic disturbances in the Bay have crossed the Myanmar coast. In other words, Myanmar has a potential threat of 0.66 cyclones per year or about one cyclone every other year during the data period of 1887-2005. No cyclones from the Bay of Bengal had crossed Myanmar coast in March, July, August and September as shown in (Table 7.8).

Table 7.8: Frequency of occurrence of storms in the Bay of Bengal during 1887-2005

Month	Storms formed in the Bay of Bengal	Storms which crossed Myanmar coast
JAN	16 (1%)	**2 (2%)**
FEB	3 (0%)	**1 (1%)**
MAR	8 (1%)	---
APR	32 (3%)	**15 (19%)**
MAY	89 (7%)	**24 (30%)**
JUN	111 (9%)	**1 (1%)**
JUL	180 (15%)	---
AUG	192 (15%)	--
SEP	209 (17%)	---
OCT	190 (15%)	**14 (18%)**
NOV	141 (11%)	**14 (18%)**
DEC	77 (6%)	**9 (11%)**
Total	1248 (100%)	**80 (100%)**
Mean	10.49	**0.66**

The frequency of cyclones in the Bay of Bengal has been decreasing annually. There were six cyclones during the period 1979-2005. There had been 11 cyclones from 1950 to 1978 as shown in the (Figure7.7).

During 1947 to 2008, Myanmar was hit by 35 cyclonic storms where accompanying strong winds, heavy rains, floods and storm surges destroyed houses, infrastructure, human lives, livestock, agricultural land and forests. Ninety percent of the storms crossed Rakhine coast and the remaining ten percent crossed Ayeyarwady deltaic coast. The southern coasts which are in Mon State and Tanintharyi Region were never visited by the storms originated in the Bay of Bengal during the study period. After 2002, Myanmar coast has been crossed by cyclones every year except in 2005. In 2006, Cyclone "Mala" crossed south Rakhine coast near Gwa; in 2007, Cyclone "Akash" crossed North Rakhine coast between Cox's Bazar and Maungtaw; and recently in 2008, Cyclone "Nargis" has crossed the delta of Ayeyarwady and Yangon Regions. The cyclone "Nargis" destroyed 138,373 lives in addition to

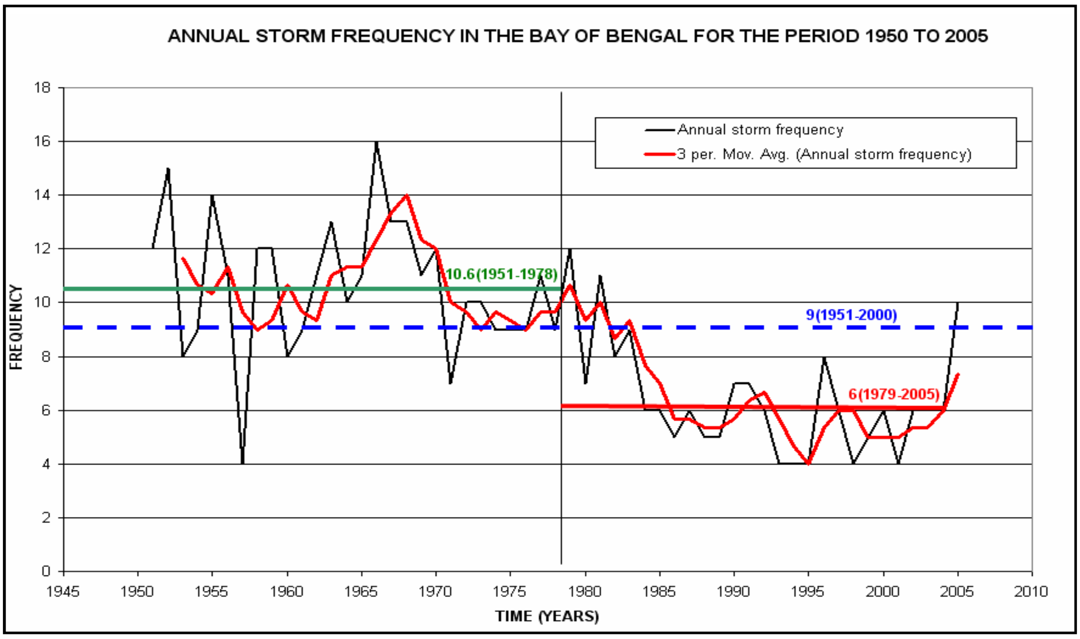


Figure 7.7: Annual storm frequency in the Bay of Bengal for the period 1950 to 2005

livestock and material damage, costing some 13 trillion Kyats. The abnormal track of the severe “Nargis” may be comparatively observed with other cyclone tracks that crossed the Myanmar coasts during the period 1967-2000. The cyclone tracks of Nargis and other cyclones are shown in (Figures 7.8 and 7.9) respectively.

Storm surge

Storm surges are the usual phenomena that accompany with the tropical storms. During 1947 to 2008, the probability of landfall was high in the northern Rakhine coast with 21 % and getting lower to the south to 3% in the Ayeyarwady deltaic coast

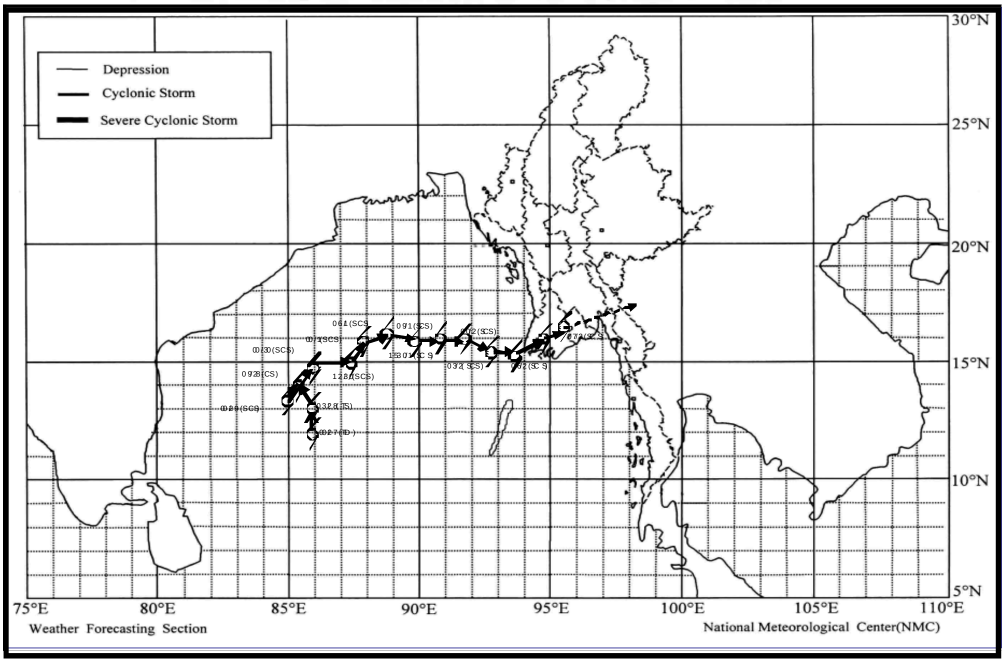


Figure 7.8: Abnormal storm track of Cyclone “Nargis”

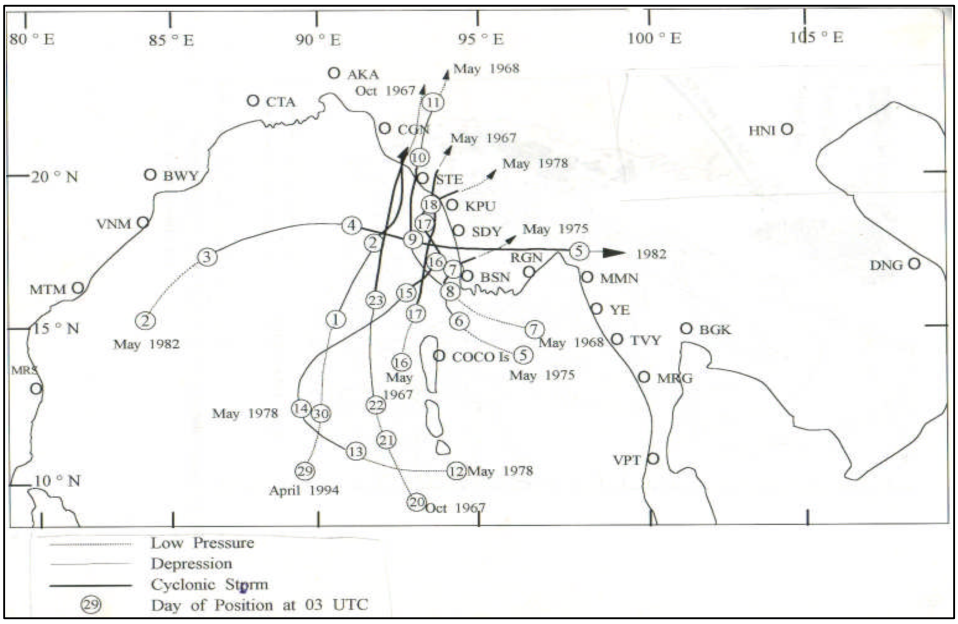


Figure 7.9: - Tropical revolving storms that crossed Myanmar coast from 1967 to 2000

as shown in (Figure 7.10). The maximum surge heights experienced at the place of landfall are shown in (Figure 7.11). The storm surge of 7.00 m caused by the Cyclone "Nargis" was unusually high. Detailed storm surge risk map for Ayeyarwady Delta due to Cyclone Nargis is shown in (Figure 7.12). Loss of lives and damage to properties due to Cyclone in Myanmar is shown in (Table 7.9).

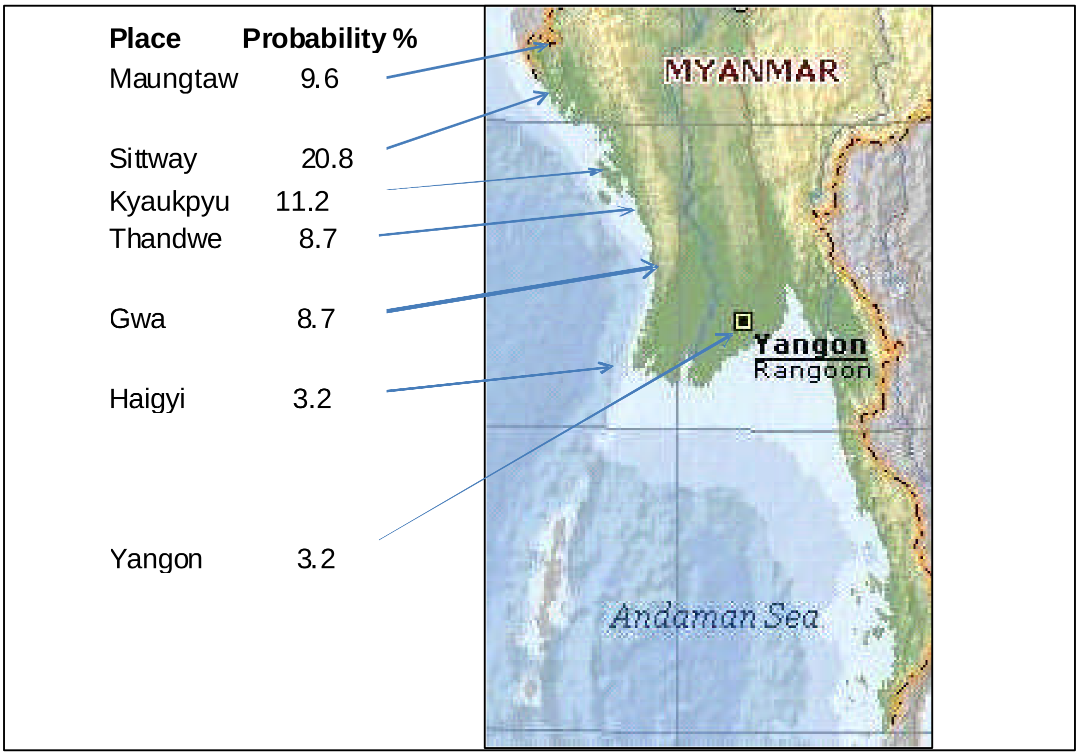


Figure 7.10: Cyclone landfall probability along Myanmar coast

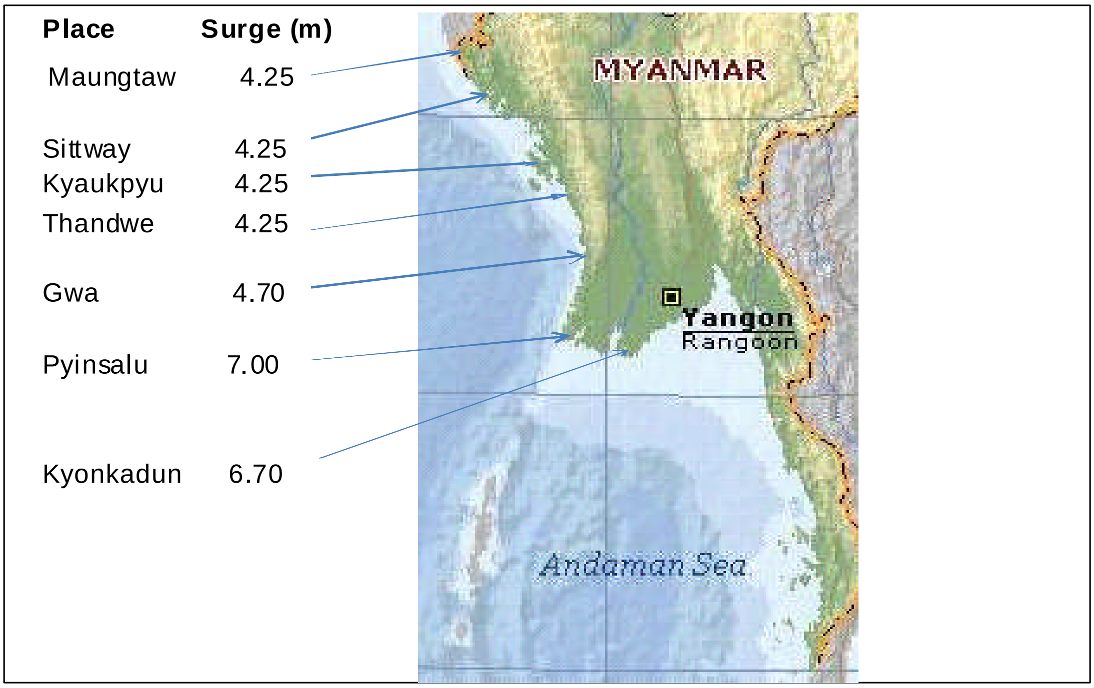


Figure 7.11: Maximum storm surge heights (m) along Myanmar coast

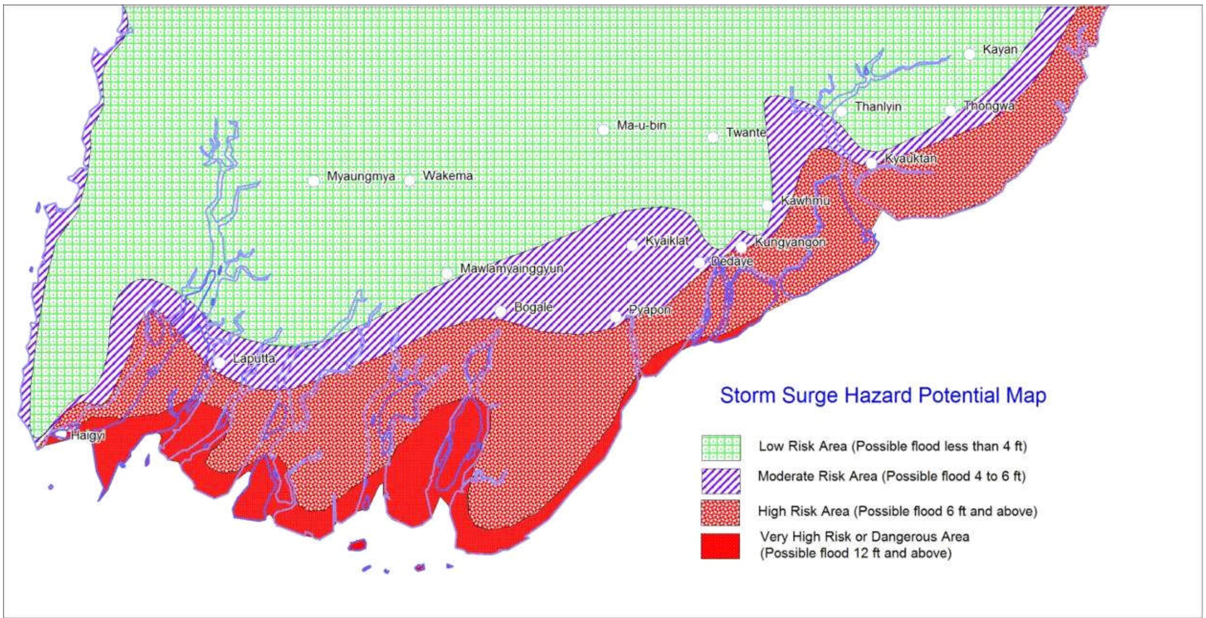


Figure 7.12: Storm surge risk (ft) map due to Cyclone "Nargis" in May 2008. (After ADPC et. al, 2009)

Table 7.9: Loss of lives and damage to properties due to cyclones in Myanmar

No	Cyclone	Date of landfall	Landfall point	Peak surge (m)	Death and loss	Damage (Kyats)
1	Sittway Cyclone	7.5.1968	Near Sittway	4.25	1037	800 Millions
2	Pathein Cyclone	7.5.1975	Near Pathein	3	304	776 Millions
3	Gwa Cyclone	4.5.1982	Near Gwa	3.7	31	38 Millions
4	Maungtaw Cyclone	2.5.1994	Near Maungtaw	3.66	10	78 Millions
5	Cyclone Mala	29.4.2006	Near Gwa	4.57	1	Not available
6	Cyclone Nargis	2-3.5.2008	Along the Ayeyarwady	7	138373	13 Trillions

(Source: DMH, 2008)

Cyclone rainfall and flood

(1) Cyclone rainfall

When there is a cyclonic disturbance in the Bay of Bengal, Myanmar experiences rain of different amounts depending on the prevailing wind and the locality within the distance of 1000 km from the Tropical Revolving Storm (TRS) centre. Superposition with other types of disturbance in the troposphere will further modify the rainfall intensity.

On 19 May 2004, a severe cyclonic storm had crossed the Myanmar coast near Sittway. The highest rainfall received at Sittway was 76 mm on the same day, but the 24 hours new record rainfall of 178 mm was set at Myitkyina on the same day, the 19th May. Myitkyina is about 750 km to the northeast of the landfall point. Mindat and Thandwe received 140 mm and 137 mm respectively on the next day. The effect of Bay cyclone continued for one to two days, particularly along the passage after the landfall. Rainfalls after two days of the landfall are not justified to be claimed as the effect of the landfall TRS. The pre-monsoon and post-monsoon five-day rainfall distributions on Myanmar coast near the landfall point of TRS are shown in (Table 7.10).

Table 7.10: Some rainfall (mm) distribution due to Sittway Cyclone landfall on 19 May 2004

Station	17-May	18-May	19 May (landfall)	20-May	21-May	Total (mm)
Myitkyina	6	35	178	5	2	226
Mindat	34	11	26	140	0	211
Maungtaw	2	4	50	77	0	133
Sittway*	11	23	76	29	0	139
Kyaukpyu	5	39	0	0	0	44
Thandwe	4	56	74	137	5	276
Gwa	20	39	82	0	8	149

There is a complex interaction between the TRS forcing, local geographical condition, troposphere disturbances and convective activity to produce rainfall in the given time period. It may be generally noted that rainfall tends to be maximum on the day of TRS passage and getting less as it is far away from the passage in time and space.

In (Figures 7.13 and 7.14), the five-day accumulated rainfall distribution due to cyclones in May 2006, May 2008, November 1988 and November 1992 are shown. Five day accumulated rainfall pattern varies according to the region and the season of landfall. When cyclone landfall is in the less mountainous portion of the south Rakhine coast or in the low lying deltaic plain of Ayeyarwady Region where moisture is abundant during the cyclone period, these situations will be another factor that support the rainfall maximum. In the case of post monsoon cyclone in November 1992, single rainfall maximum cell could be noted for the cyclone which landed in the south of Rakhine coast. The rainfall amount and area coverage are significantly greater in the pre-monsoon period than those in the post monsoon period. When cyclone landfall was in the northern Rakhine coast, rainfall maximum cells occurred separately, not necessarily near the landfall point.

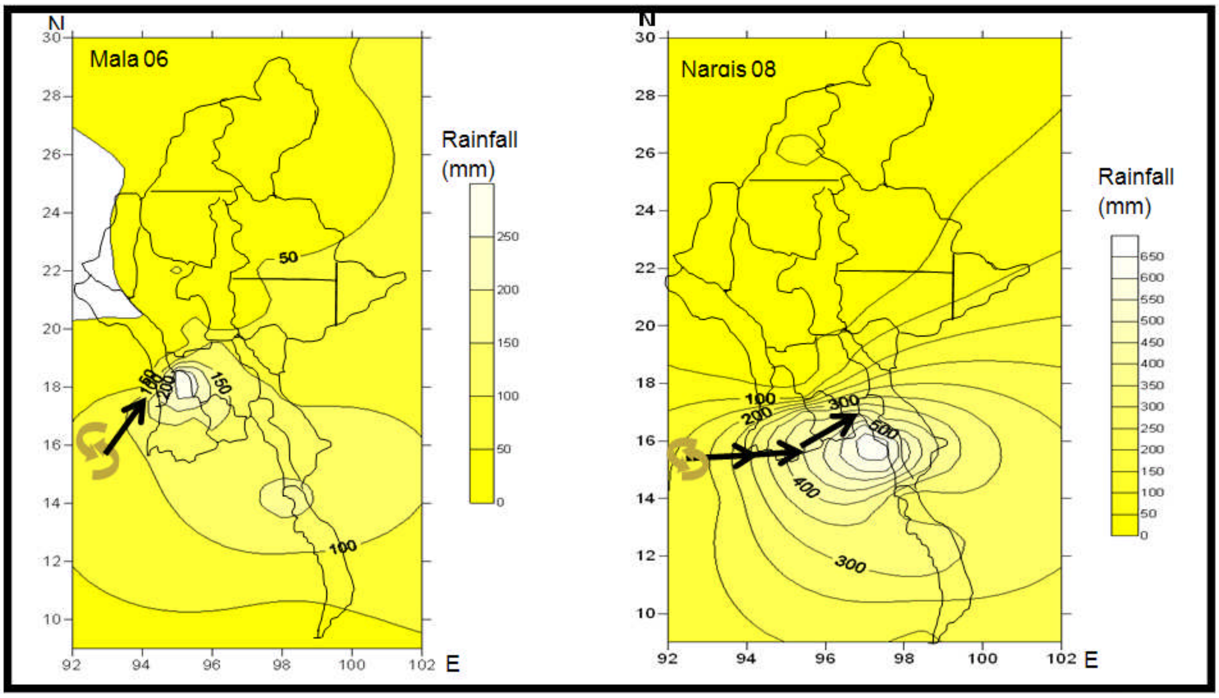


Figure 7.13: Five-day accumulated rainfall distribution (mm) due to cyclones in pre monsoon periods 2006 and 2008. Cyclone track near landfall is shown by arrow.

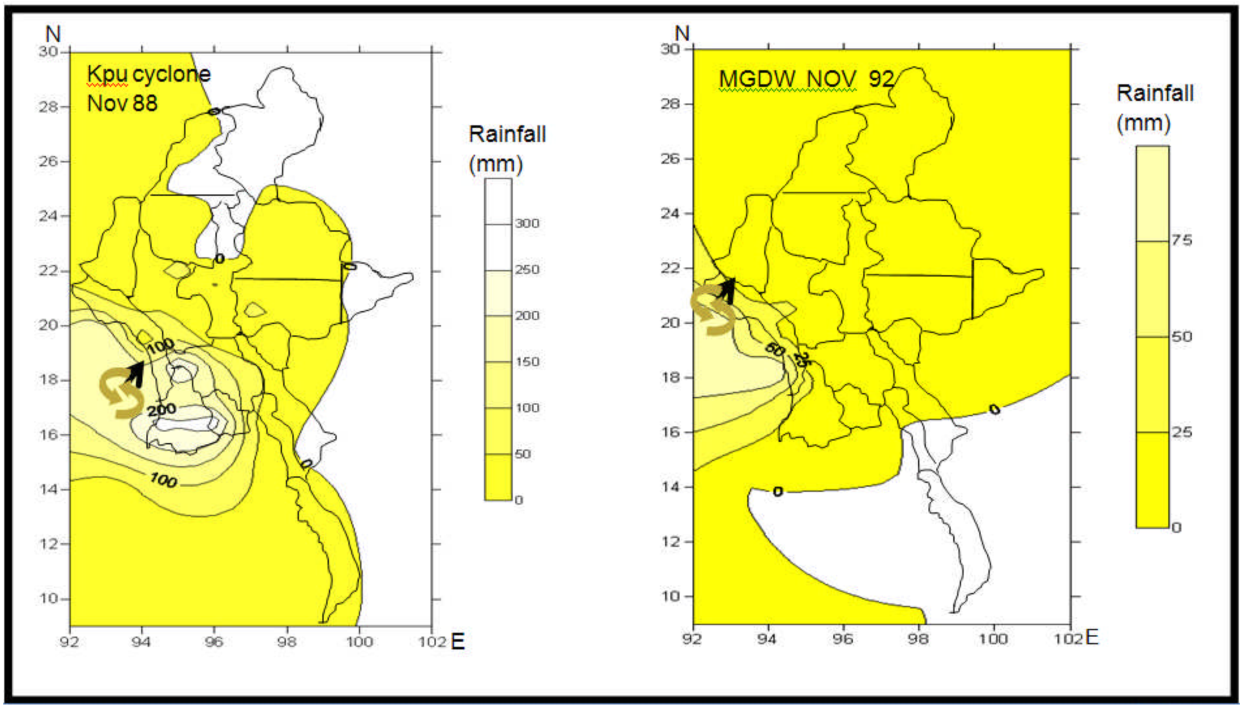


Figure 7.14: Five-day accumulated rainfall distribution (mm) due to cyclones in post-monsoon periods of November 1988 and November 1992. Cyclone track near landfall is shown by arrow.

Heavy rains occurred mostly in the proximity of the landfall points of cyclones. With Cyclone "Nargis", Kaba-Aye which was the point of landfall received the heaviest rainfall on the day of landfall. Some other stations which received maximum rainfalls were hundreds of kilometers away from the landfall point. For instance, during the 1988 November cyclone, whose landfall point was near Kyaukpyu, the station collected only 70 mm of rain. The 24 hour maximum rain was 188 mm at Hmawbi, some 250 km to the southeast of the landfall point. In May 2004, a cyclone crossed Sittway which received 76 mm of rainfall. The maximum rainfall collected on the day was 178 mm at Myitkyina, about 650 km to the northeast of the landfall point and flood was initiated. Moreover, for one cyclone in November 1992, the cyclone landfall point, Maungtaw received only 33 mm; and for Cyclone "Mala" in April 2006, its landfall point, Gwa received only 52- millimeter rainfall which is an insignificant amount for the locality. The occurrence of maximum rainfalls depends on the prevailing convergence of wind flow and favorable condition of vertical moisture transport of the locality. The five-day accumulated largest rainfall by the Cyclone "Nargis" was 653 mm at Mawlamyine in the Mon State, 100 km to the southeast of Yangon. This amount is about 20 % of the annual rainfall of Mawlamyine.

In the case of Cyclone "Mala", the 24 hour heaviest rainfall was 235 mm at Pyay, some 100 km to the northeast of the landfall point. That amount is comparable to the monthly monsoon rainfall of Pyay. The same location received the highest rainfall of 329 mm accumulated in five days due to the cyclone.

The rainfall at the landfall point on the landfall day, the maximum rainfalls on the landfall day and the five-day accumulated rains due to landfall cyclones from 1973 to 2008 are shown in (Table 7.11) Floods usually took place after each heavy rain spell.

(2) Flood

In Myanmar, low lying areas along rivers are subject to inundation for a couple of days due to normal floods during monsoon and it naturally enriches the soil. But when monsoon intensified and widespread heavy rains last long for a few days, then multiple floods occur along the rivers posing danger to the lower reaches particularly the Ayeyarwady delta. Sediment brought about by the Ayeyarwady river before entering the Andaman sea has significantly contributed to the formation of the Ayeyarwady delta. The peak monsoon season is especially vulnerable to flood disaster due to river bank erosion and embankment

Table 7.11: Maximum rainfall (mm) on the cyclone landfall day and the highest five days accumulated rainfall (mm).

Date of landfall Date	Landfall station (Cyclone)	Rainfall on the landfall day (mm)		Max. five day accumulated rainfall(mm)/ station
		At landfall station	Max. rainfall/ station	
18-Nov-73	Sittway	65	69/ Maungtaw	150/ Maungtaw
19-Nov-88	Kyaukpyu	70	188/ Hmawbi	295/ Kaba-Aye
19-May-92	Thandwe	62	122/ Kyaukpyu	245/ Kyaukpyu
21-Nov-92	Maungtaw	33	64/ Sittway	116/ Sittway
2-May-94	Maungtaw	104	113/ Mindat	264/ Maungtaw
19-May-04	Sittway	76	178/ Myitkyina	376/ Ann
29-Apr-06	Gwa (Mala)	52	235/ Pyay	329/ Pyay
5-May-07	Pathein/ Yangon	344	344/ Kaba-Aye	437/ Hpa-an
15-May-07	Maungtaw (Akash)	61	205/ Kyaukpyu	399/ Kalewa
3-May-08	Haigyi/Yangon (Nargis)	220	245/ Mingaladon	653\ Mawlamyine

failure in the deltaic area which is the rice bowl of thecountry and thickly populated. Percentage occurrence of floods along Myanmar Rivers is shown in (Table 7.12). In the Ayeyarwady River, 50 % of locations along the river bank experience floods every other year, along the Chindwin River, 80% of places experience flood every year. Near the river mouth of Thanlwin flood occurs every year which sometimes lasts for few weeks. Smaller rivers also have floods every year.

Table 7.12: Percentage of occurrence of flood along major rivers in Myanmar

Percentage of Occurrence of Flood along Major Rivers in Myanmar

No.	River Station	% of Occurrence of Flood in Months					% of Flood Occurrence Year	Flood Frequency
		Jun	Jul	Aug	Sep	Oct		
I.	AYEYARWADY							
1	Myitkyina	13	63	0	13	13	21%	1 in 5 yrs
2	Bhamo	6	59	12	18	6	33%	1 in 3 yrs
3	Katha	9	61	18	6	6	51%	1 in 2 yrs
	Upper Ayeyarwady	9	61	10	12	8		
A	Mandalay	0	37	33	15	15	17%	1 in 6 yrs
5	Sagaing	0	22	35	26	17	49%	1 in 2 yrs
6	Nuaung U	0	21	44	23	13	67%	1 in 2 yrs
7	Chauk	0	24	36	25	15	24%	1 in 4 yrs
	Middle Ayeyarwady	0	26	37	22	15		
8	Minbu	0	24	38	27	11	63%	1 in 2 yrs
9	Magwway	0	27	33	33	7	56%	1 in 2 yrs
10	Aunglan	0	24	34	27	15	18%	1 in 6 yrs
11	Pyay	0	24	37	27	12	30%	1 in 3 yrs
12	Hinthada	0	19	50	24	7	58%	1 in 2 yrs
	Lower Ayeyarwady	0	24	38	28	10		
II.	CHINDWIN							
1	Hkamti	7	53	28	12	0	70%	1 in 1 yrs
2	Homalin	6	46	29	13	6	81%	1 in 1 yrs
	Upper Chindwin	6	50	28	13	3		
3	Mawlaik	2	38	35	15	12	81%	1 in 1 yrs
4	Kalewa	2	39	36	18	7	76%	1 in 1 yrs
5	Monywa	0	30	33	27	10	67%	1 in 2 yrs
	Lower Chindwin	1	36	35	20	10		
III.	THANLWIN							
1	Hpa-an	2	23	52	21	1	88%	1 in 1 yrs
IV.	SITTOUNG							
1	Toungoo	0	12	56	26	5	70%	1 in 1 yrs
2	Madauk	0	15	65	18	1	93%	1 in 1 yrs
	Sittoung	0	14	61	22	3		
V.	SHWEGYIN							
1	Shwegyin	9	22	60	9	0	49%	1 in 2 yrs
VI.	BAGO							
1	Bago	7	33	60	0	0	27%	1 in 4 yrs
VII.	DOKHTAWADY							
1	Myitnge	0	9	45	27	19	85%	1 in 1 yrs

Some of the floods of major rivers in peak monsoon of 2004 attained the highest record for the period of the last few decades. Peak water levels due to floods in major rivers of Myanmar up to 2004 are shown in (Table 7.13). The heavy rainfalls in the northern Myanmar such as 8.20 inches in Sumprabum on 18 July 2004 was found to reinforce the high water of the Ayeyarwady River, resulting in extensive records of maximum floods along the downstream stretches of the river.

Table 7.13: Peak water levels due to floods in Myanmar major rivers till 2004

City	River	Peak water level (cm)	Date (d-m-y)	Danger level(DL) (cm)	Data since	Flood above DL (cm)	Rank
Chauk	Ayeyarwady	1532	15- 8-74	1040	1973	492	1
Hkamti	Chindwin	1771	13- 7-91	1360	1972	411	2
Mawleik	Chindwin	1608	20- 7-76	1230	1972	378	3
Kalewa	Chindwin	1920	17- 8-02	1550	1972	370	4
Minbu	Ayeyarwady	1982	15- 8-74	1700	1967	282	5
Sagaing	Ayeyarwady	927	3- 8-97	700	1965	227	6
Myitkyina	Ayeyarwady	1410	8-10-79	1200	1967	210	7
Homalin	Chindwin	3107	12/7/1968	2900	1968	207	8
Magwe	Ayeyarwady	1894	31-7-04	1700	1975	194	9
Bamaw	Ayeyarwady	1337	22-7-04	1150	1969	182	9
Aunglan	Ayeyarwady	2737	15-8-74	2550	1973	187	10
Paan	Thanlwin	936	18-8-02	750	1966	186	11
Myitnge	Dokhtawady	1048	14-10-86	870	1972	178	12
Madauk	Sittaung	1244	2-8-92	1070	1967	174	13

During the dry season, rivers are recharged by the ground water from forested watersheds and melting snow from high mountains in the north. Snow and glaciers in the north which is connected with the Himalayan mountain complex is somehow important for maintaining the flow of Ayeyarwday River during the dry season. Moreover, due to the climate variability, Dry Zone sometimes experienced wide-spread heavy rains for some continuous days which led to catastrophic flash floods in the area. The flood is so unexpected and the peak time is so quick that there is no time to respond. Due to the heavy widespread rain in the area during 27 May - 2 June 2001, there occurred a flash flood in Wundwin of Dry Zone. The total rainfall collected was 8.36 inches where the highest rainfall for the month of May was 9.97 inches in 1991 in 30-year record (DMH, 2008). At that time, DMH had no information and capacities to issue warning.

Southwest monsoon

Onset and withdrawal

In the Union of Myanmar the observations indicated that the climate change is taking place in respect of temperature, precipitation, extreme climate and severity of disasters and also in the southwest monsoon features. The southwest monsoon onset into the country is becoming late and its withdrawal from the country is advancing earlier. The southwest monsoon duration during 1988-2000 was shortened by three weeks in the northern Myanmar and one week in other regions compared to 1951-2000 average. During 1988-2000, the monsoon became less active (decreasing strong monsoon days) though the monsoon breaks which used to take place for about one week during normal peak monsoon period of July and August, were less pronounced except in 1998. There was a prolonged monsoon break due to El Nino episode.

Monsoon rain and flood

The geographical setting of Myanmar, with the north-south running mountain ranges within the country, and the low lying plains in the central region and the Shan plateau in the east, is the unique feature determining the country's annual rainfall distribution. Myanmar enjoys the southwest monsoon season. The annual rainfall is least in the central part of the country (less than 1000 mm) and it is increasing to more than 2000 mm towards the east, 2000 mm towards the north, 5000 mm towards the south and west. Major portion of the annual rainfall is due to the southwest monsoon which begins in May and ends in September. However rains may continue till November due to the influence of cyclonic disturbances especially the tropical storms from the South China Sea. Mean monthly temperature and rainfall distributions of seven selected stations in the country from 1961 to 1990 are shown in (Figure 7.15).

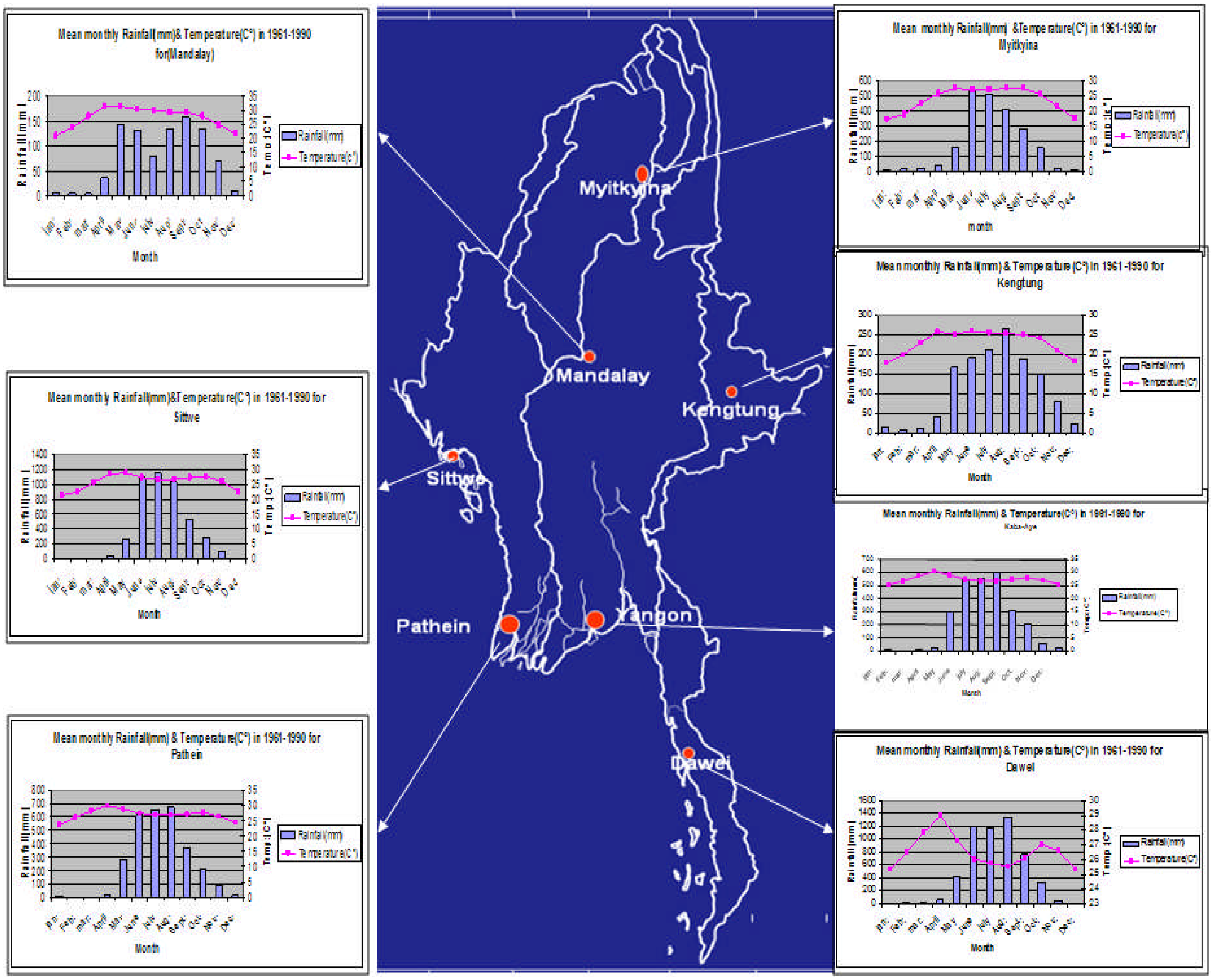


Figure 7.15: Mean monthly temperature (°C) and rainfall (mm) distribution of seven selected stations from 1961 to 1990.

Significant features are that most part of the country have the maximum rainfall during the mid monsoon period of July and August. The central Myanmar has a unique feature of double maxima, one in the early monsoon and the other in the late monsoon. Apart from the effect of annual rainfall which is less than 1000 mm, the double maxima rainfall also influences the characteristics of the Dry Zone.

Monsoon drought

The rainfall pattern during the southwest monsoon varies from time to time generally following the monsoon intensity in the Bay of Bengal. There are prolonged periods of days without rainfall, so called drought in some areas of the country. Drought is a critically important situation for many of the agricultural practices, particularly for agriculture in the Dry Zone where the normal annual rainfall is scanty.

The country which has fourteen States and Regions is also arbitrarily divided into 20 Sub-States and Sub-Regions depending upon the differential climatic conditions. For **Shan State**, there are three Sub-States, Region amely Northern Shan State, Southern Shan State and Eastern Shan State. **Rakhine State** has two Sub-States and they are the Northern Rakhine State and the Southern Rakhine State. The **Sagaing Region** has two Sub-Regions, namely the Upper Sagaing Sub-Region and the Lower Sagaing Sub-Region . The **Bago Region** has the Northwest Bago Sub-Region , the Northeast Bago Sub-Region and South Bago Sub-Region . The **Ayeyarwady Region** has the North Ayeyarwady Sub-Region and the South Ayeyarwady Sub-Region .

Dekad rainfall data of 58 selected stations for the months of May to October over the period 1950-1992 revealed the drought climatology of the 20 Sub-States and Sub-Regions (Htay Aung 1993). Drought is defined as the dekad (10 days) with below normal rainfall preceded by at least two dekads with below normal rainfall at a particular station of interest. Monsoon period in Myanmar is arbitrarily divided into three periods such as pre-monsoon period from May to June, peak monsoon period from July to August and late monsoon period from September to October. The rainfall is considered simply as normal, above normal and below normal if percentage departure is within the 20%, more than 20% and less than 20% respectively

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In Myanmar the third dekad of May and the third dekad of October are most likely to have of drought. The drought is most unlikely in the second dekad of September followed by the first and second dekads of August, the third dekad of June and the third dekad of July. The most likely areas to have drought are Chin, Northern Shan, South Rakhine and Kayah States, and Lower Sagaing and Magway Regions. The most unlikely areas for drought are the Southern Shan, Kachin and Mon States, Tanintharyi, Yangon and South Ayeyarwady Regions.

The years with minimum number of drought (wet years) have been 1959, 1960, 1968, 1973, 1975 and 1980. The years with maximum number of drought (dry years) have been 1954, 1955, 1957, 1972, 1979 and 1986. Salient feature of drought are that the agricultural produce dropped in the fiscal years 1957-58, 1965-66, 1966-67, 1972-73, 1983-84, 1988-89 and 1991-92. With the exception of 1988-89, all the years were strong or moderate El Nino years. These were also the years of maximum drought with the exception of 1965-66 and 1966-67. The factors that influence the strength of relationship between the decrease of rainfall and the drop of crop yield depend upon the proportion of crop production under irrigation, the moisture retention capacity of soil, the timeliness of rain and the adaptive behavior of farmers.

It has long been regarded that the Dry Zone potentially has the greatest chance to experience drought, and it will place significant impact on the overall economy. For central Myanmar, the years 1953, 1956, 1965, 1971, 1973, 1975 and 1985 were the drought-free years and the years 1954, 1957, 1961, 1972, 1979 and 1991 were the years, most affected by drought although time of occurrence was changing. For instance, drought occurred in peak monsoon in 1954, but it occurred in late monsoon in 1972 and 1979, and in early monsoon in 1992.

It suggests that while the climate of the world is changing due to increase in greenhouse gases, it is wise to keep an eye on the changing rainfall pattern over the whole country and monitor any trace of severe drought so as to enable to take precautionary and adaptive measures in a timely manner.

Water resources

Water resources potential (surface and ground)

The South East Asia (SEA) has 15% of the total volume of world's water resources. Demand on water resources has been increasing due to rapid urbanization and industrialization of the region. There have been indications of deterioration in water quantity and quality, low reliability of supply, high cost of water, and so on. Although SEA is the richest in water resources in the world, those resources and their potentials are being reduced at an alarming rate (Than Zaw, 2009). Among countries with rich water resources Myanmar could be classified as a country of low water stress. There are four major river systems, namely, the Ayeyarwady, the Thanlwin, the Chindwin and the Sittaung. Moreover there are some river systems in Rakhine State and Tanintharyi Region. These river systems contribute to the surface water resources of the country. Under the favorable climatic condition and physiographic features, there are eight river basins, covering about 90% of the country's territory. The amount of surface water and groundwater in Myanmar are estimated at about 828 km^3 and 495km^3 per year respectively. Details are mentioned in (Table 7.14). The drainage basin map of Myanmar is shown in (Figure 7.16).

Table 7.14: Myanmar's annual average water resources potential by river basin,

Region / River basin	Surface water (mcm /Yr)	Groundwater (mcm /Yr)
Region 1. Chindwin	104,720	57,578
Region 2. Upper Ayeyarwady	171,969	92,599
Region 3. Lower Ayeyarwady	229,873	153,249
Region 4. Sittaung	52,746	28,402
Region 5. Rakhine	83,547	41,774
Region 6. Tanintharyi	78,556	39,278
Region 7. Thanlwin	95,955	74,779
Region 8. Mekong	10,580	7,054
Total	**827,946**	**494,713**

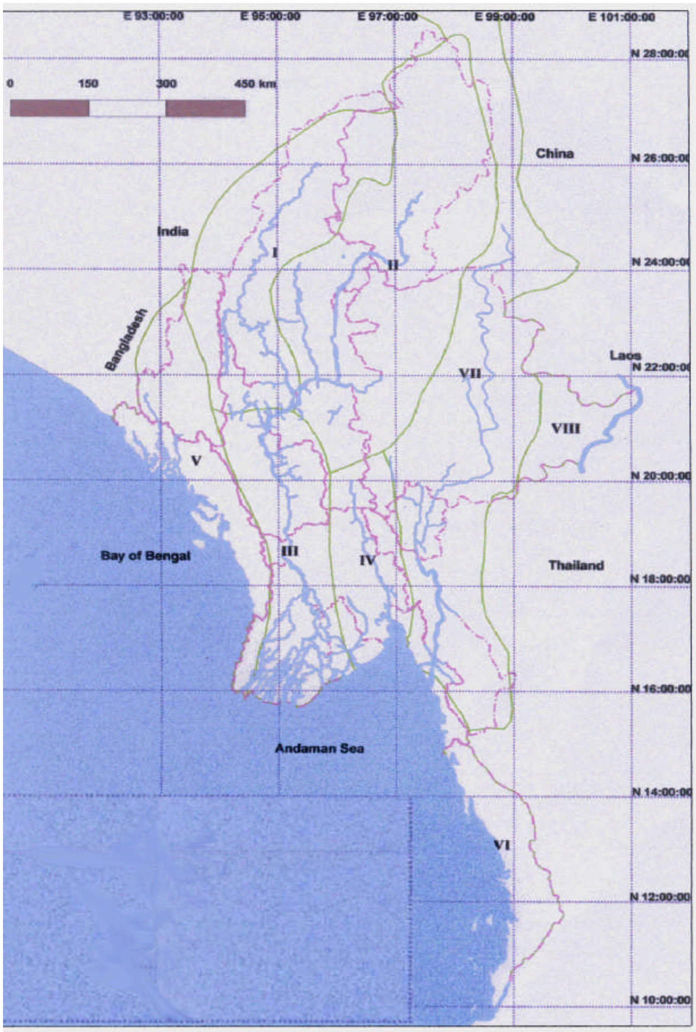


Figure 7.16: Drainage basin map of Myanmar

The assessment of water resources potentials both for surface water and groundwater is carried out on the basis of river basins. In terms of water resources, Myanmar occupies the 14th position at global level and 5th position in Asia region.

ENSO, El Nino and La Nina

The westward spread of warm sea current from south east Pacific, the off coast of Peru has some impact on global weather and climate. Myanmar is no exception. During the period 1900 to 2008, strong El Nino had occurred in 1901-02, 1913-15, 1918-20, 1972-73, 1986-88, 1991-92 and very strong El Nino in 1940-41, 1957-58, 1982-83, and 1997-98. The El Nino in 1997-98 is known to be the strongest followed by that of 1982-83.

When the El Nino is taking place simultaneously with the Southern Oscillation of the near global scale atmospheric circulation in the south Pacific and the Indian Oceans, the climate of Myanmar was more rampant and adverse extreme weather prevailed in the country. For instance, such years that Myanmar had experienced were 1982-1983 and 1997-1998.

The maximum temperature records were set in the 1998 ENSO year in Rakhine, Shan, Kayah, Kayin and Mon States, also in Mandalay, Magway, Bago, Yangon, Ayeyarwady and Tanintharyi Regions. In fact, the maximum records were observed in almost the whole country except Sagaing Region , and Kachin and Chin States.

The maximum temperature records in the 1997- 98 ENSO in Myanmar are shown in (Table 7.15). Eleven out of fourteen States and Regions experienced the ever recorded heat. In 1998, maximum record temperature of Hpa-an was 43.6°C which was 2.6°C higher than the last maximum in 1988.

Table 7.15: The highest maximum temperature records in 1998 in Myanmar

State/Region	Station	Last Record		1998 Record	
		(°C)	(d-m-y)	(°C)	(d-m)
Mandalay	Meiktila	42.4	- -5-66	43	5-Oct
	Pyinmana	42	1-5-80	43.5	9-5
Shan	Lashio	40	26-4-97	40	4-5
Rakhine	Thandwe	39	12-5-80	40.4	4-5
Magway	Minbu	45.2	17-4-73	45.8	9-5
Bago	Taungoo	42.2	10-5- 59	42.9	8-5
	Thayawady	42	14-3-63	43.6	9-5
Yangon	Mingaladon	41.7	25-4-58	42	8-5
	Kaba-Aye	41.3	27-4-83	42	8-5
Ayeyarwady	Pathein	41	27-4-83	41	8-5
	Hinthada	42.9	30-4-95	43.6	9-5
Mon	Mawlamyine	40	21-4-95	40.2	8-5
	Thaton	40	16-4-75	41	8-5
Kayah	Loikaw	37	17-4-83	38	14-4
Kayin	Hpa-an	41	25-5-88	43.6	6-5
Tanintharyi	Dawei	38.5	11-4-98	38.9	6-5
	Myeik	38	4-5-83	38	6-5
	Kawthoung	38	3-4-98	38.5	6-5

In 1998, ENSO set new lowest annual rainfall records in Shan, Kayah, Kayin and Mon States, Bago, Ayeyarwady and Tanintharyi Regions. The least annual rainfalls were also recorded in 1991 El Nino year in Shan and Kayah States, Sagaing, Mandalay and Bago Regions. The least annual rainfalls ever recorded in 1998 are shown in (Table 7.16). The most significantly lower annual rainfall of 1366 mm occurred in Taungoo of Bago Region in 1998, and it was 19% less than the former 1989 record of 1682 mm.

The data was collected from 1902 to 2003 with some years missing particularly around World Wars I and II.

Table 7.16: Least annual rainfalls (mm) recorded in 1998 ENSO year

State/Region	Station	Data Period	Old record (Year)	1998 Record
Shan	Taunggyi	1903-1941 1950-2003	1,208 (1976)	992
Magway	Magway	1971-2003	445 (1972)	442
Bago	Pyay	1903-1930 1946-2003	816 (1972)	798
	Taunggoo	1903-1937 1951-2003	1,682 (1989)	1366
	Bago	1902-1937 1961-2003	2,596 (1987)	2373
Kayah	Loikaw	1907-1937 1952-2003	770 (1993)	751

El Nino

During the El Nino years, the southwest monsoon was negatively affected on several features.

(1) Monsoon onset and withdrawal

In general, the monsoon onset dates are late and the withdrawals earlier in El Nino years compared to the normal and this pattern is particularly true for the preceding years of the episode. Thus, the rainy season have shorter durations in the El Nino years. Recently, El Nino was strong in 1991-92 and much stronger in 1997-98. The monsoon onset in the country was late by 12 days in 1991 and 16 days in 1998. Monsoon withdrawal was early by 16 days and 21 days in 1991 and 1998 respectively. The length of monsoon duration had reduced by 24 days in 1991 and by 36 days in 1998. Strong monsoon days had decreased in 1991 and 1998 by 17 days and 28 days respectively.

(2) Monsoon intensity

There is weak relationship between late monsoon intensity and the El Nino event, though there is likelihood of rather weak monsoon intensity particularly in the preceding year of the peak El Nino event. Thus the monsoon intensity as a whole is more likely to be normal during the major El Nino years, and it has the possibility of 80% based on the last six events during the period 1951 to 1998.

Though the relationship between the early monsoon intensity and the El Nino event does not perform well, below normal to normal monsoon intensities are more likely during the early monsoon periods of both the preceding and the following years of the peak El Nino events. More than 50% of the intensity of peak monsoon during El Nino events could experience failure or weakening of monsoon compared to normal condition. This is particularly true for the preceding year of the episode.

During the southwest monsoon peak season, there was a normal occurrence of inactive monsoon period commonly known as “Monsoon Break”. It was almost totally absent in most of the years through 1989 to 1997. This was particularly true in 1993 to 1996. However a very prolonged monsoon break condition returned in 1998. The 1990s marked the warmest decade of Myanmar in the 20th century.

(3) Frequency of storms

The relationship between the El Nino events and the frequency of storms in the Bay of Bengal has been controversial for long time. However the storm frequency is below normal in the preceding year and it is below normal to normal in the following year of the peak of El Nino events.

(4) Temperature and rainfall

The impacts of the El Nino were also observed (Lwin, T. 1999) upon the general climate of Myanmar during the preceding year as well as during the following year of the El Nino. 70% (Preceding Year) to 85 % (Following Year) of the El Nino events revealed that the maximum temperatures in most parts of the country were higher than normal during the dry months of April and May. Moreover, 70% (Preceding Year) to 85

% (Following Year) of the El Nino events showed that both the annual rainfall and monsoon rainfall were below normal in the country.

La Nina

During the last two decades, temperatures had been rising by day and by night in most parts of the country. However, record low minimum temperatures were observed at many stations in the cool season of 1999-2000, which was the La Nina year.The lowest minimum temperatures of somes elected stations in different States/Region , observed are shown in (Table 7.17).

Table 7.17: Lowest minimum temperatures recorded at the Capitals of States and Regions

State/ Division	Station	Lowest MinTem(°C)	Date	Remark
Kachin	Myitkyina	5	2/1/1963	La Nina
Chin	Haka	-6	30-12-91	
Upper Sagaing	Homalin	3	8/2/1980	None
Lower Sagaing	Monywa	6.7	31-1-64	La Nina
Mandalay	Mandalay	7.2	31-1-64	La Nina
Northern Shan	Lashio	-2.2	16-1-89	La Nina
Eastern Shan	Kengtung	1.7	27-1-53	El Nino
Southern Shan	Taunggyi	0.3	20-1-74	None
Magway	Magway	5	26-1-93	
Rakhine	Sittway	8.9	21-1-70	La Nina
Kayah	Loikaw	0	27-1-53	El Nino
Northwest Bago	Pyay	7.2	17-1-54	
Northeast Bago	Taungoo	8	30-12-75	
South Bago	Bago	7	11/2/1997	El Nino
North Ayeyarwady	Hinthada	7	29-12-97	El Nino
South Ayeyarwady	Pathein	10	30-12-75	La Nina
Yangon	Yangon (Kaba-Aye)	9.1	9/2/1997	El Nino
Kayin	Hpa-an	9.4	1/1/1974	None
Mon	Mawlamyine	10.8	2/1/1976	El Nino
Tanintharyi	Dawei	5.5	26-12-99	La Nina

Some of the La Nina events which occurred in the preceding year or in the following year of the El Nino episode are shown in (Table 7.18).

Table 7.18: La Nina years preceded or followed by El Nino years during 1950-1989

La Nina followed by El Nino		La Nina preceded by El Nino	
La Nina	El Nino	El Nino	La Nina
1950	1951	1953	1954
1955-56	1957-58	1963	1964
1964	1965	1969	1970
1967-68	1969	1972	1973
1970-71	1972	1982-83	1984-85
1975	1976	1987-88	1988-89

As Myanmar belongs to the non-Annex I Parties, it is in a financially and technically difficult situation to carry out various researches /studies related to climate change in Myanmar in order to understand different aspects, scopes, dimensions and extent on warming/ cooling. Similarly, country-specific information with regards to precipitation, extreme weather events, probability of cyclone landfall on coastal areas, storm surge and storm rain, southwest monsoon characters including drought and floods, and water resources potential will be disclosed through research activities. The impacts of El Nino / La Nina phenomena also need in-depth studies.

In this context, Myanmar is inviting expertise, supports and coordination from international/regional organization and institutions to acquire high quality information regarding climate and climate change aspects.

7.5. Warning Systems on Natural Disasters

Cyclone

Cyclones in the Bay of Bengal are one of the climatic parameters for Myanmar and the countries around the Bay of Bengal. Formation of more cyclones in the Bay influences much of the rainfall and the monsoon onset of the country and brings about disastrous events into the area of landfall. The cyclones, usually accompanied by spells of strong winds, heavy rainfall, floods and storm surges, can cause extensive loss of lives and damages to infrastructure and properties.

Flood

There are spells of widespread heavy rains at various places in the monsoon season and local floods are the common annual phenomena in the country. At times, floods become severe as their dimension grows in time and space, affecting the normal activities. During the dry season, rivers are fed with the groundwater from forested watersheds and melting snow from high mountains in the north, which form part of the Himalayan mountain complex. Snow and glaciers are somehow important for maintaining river flows during dry season in Myanmar. Moreover, due to the influence of climate change, dry zone occasionally experienced wide spread heavy rains for some continuous days, which led to catastrophic flash floods in the area where water supply is usually scarce.

Warnings

DMH issues hazard warnings and bulletins as required. The frequency of warning depends upon the nature, severity and imminent danger of the disaster. Warnings are disseminated to the targeted area by all means available at the DMH following the guidance of the Ministry of Transport. Relevant stations are instructed to take special observations round the clock. DMH has established five centers to watch natural disasters, particularly the tropical storms and associated weather phenomena, floods and tsunami. These centers are:

1. National Meteorological Centre (Nay Pyi Taw)
2. National Meteorological Centre (Yangon)
3. Aviation Meteorological Office (Mingaladon)
4. Multi-hazard Early Warning Centre (Nay Pyi Taw)
5. Coastal Stations

Different types of warnings and bulletins, such as flood warning, tsunami warning, earthquake warning, etc. issued by DMH are shown in (Figure 7.17). The warnings are issued with color codes where applicable particularly for the disastrous natural hazard, cyclone. The "**Yellow**" color code means there is a cyclonic disturbance in the Bay of Bengal, which is not yet threatening Myanmar coast. The "**Orange**" code

Figure 7.17: Different types of warnings and bulletins issued by DMH

means the disturbance may move towards Myanmar coast. The "**Red**" code means the cyclone may cross Myanmar coast within next 12 hours. The "**Brown**" code means the cyclone is crossing Myanmar coast. The "**Green**" color code means the cyclone has crossed Myanmar coast and weakened. For timely and efficient information exchange, provincial stations are equipped with telephones, Radiophones, Single Side Band (SSB) for direct communication. In case of communication disruption, the station may get assistance from the local general administration offices for indirect contact with the head office (National Meteorological Center) to deliver special observations and reports, and to receive / disseminate latest warning and bulletin related to tropical storm, flood, earthquake and tsunami. Myanmar is able to provide storm warning 2-3 days in advance, river floods warnings 5-7 days in advance and tsunami warning a few hours ahead with the available facilities in hand. The schematic view of the warning dissemination arrangement to the target area is shown in (Figure 7.18). In addition, monsoon

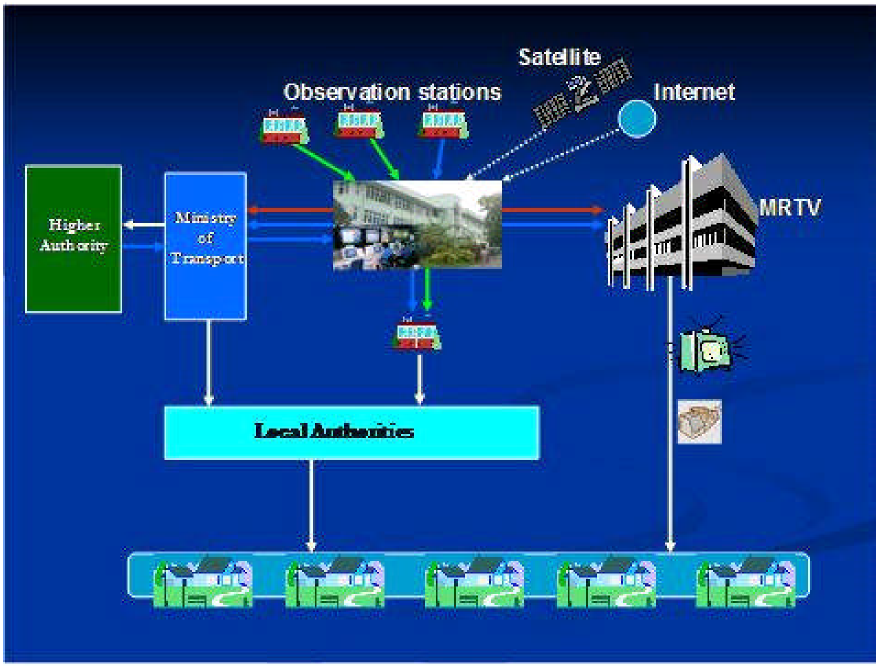


Figure 7.18: Schematic view of the warning dissemination to reach the target area.

forums are being held before and after the southwest monsoon season. It started in 2007 as a responsive initiative to deal with the climate change.

7.6. Networking

Regional/ International

In International Corporation, the Director-General of DMH is the Permanent Representative of Myanmar for WMO and he is the focal point to the Inter-governmental Panel on Climate Change (IPCC), to the United Nations Framework Convention on Climate Change (UNFCCC), to the Acid Deposition and Oxidant Research Center (ADORC) and to Acid Deposition Monitoring Network in East Asia (EANET). Myanmar is the member country to the WMO/UNESCAP Panel on Tropical Cyclones. The Director General is also working with Asian Disaster Preparedness Center (ADPC) and the Committee on Regional Integrated Multi-hazard Early Warning System (RIMES). DMH is the member to the ASEAN Subcommittee on Meteorology and Geophysics (ASCMG), and the Bay of Bengal Initiatives for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC). DMH is also closely working with China Meteorological Administration (CMA),Japan Meteorological Agency (JMA), Korea International Cooperation Agency (KOICA),Thailand International Development Cooperation Agency (TICA), Japan International

Cooperation Agency (JICA), Japan Aerospace Exploration Agency (JAXA), United Nati-ons Environment Programme (UNEP), United States Agency for International Development (USAID) and Indian Institute of Technology (IIT), etc., among others.

(1) WMO and DMH

The World Meteorological Organization (WMO) is a specialized agency of the United Nations. WMO has a membership of 189 Member States and Territories as of 4 December 2009. It was originated from the International Meteorological Organizat-ion (IMO), which was founded in 1873. Myanmar was one of the signatory countries of IMO in 1949 for establishing WMO. Established in 1950, WMO became a specialized agency of the United Nations in 1951 in the fields of meteorology (weather and climate), operational hydrology and related geophysical sciences. Myanmar had ratified the Convention in 1947 and became a member of WMO on March 23, 1951.

The DMH contributes substantially to the protection of lives and properties against natural disasters and to safeguarding the environment. Moreover, NMHS contributes either directly or indirectly to enhancing the economic and social well-being of the entire society in areas such as food security, water resources and transport.

Moreover, WMO has initiated an integrated effort by setting up or strengthening existing collaboration mechanisms among the regional bodies under Tropical Cyclone Programme (TCP), the Regional Associations and the Technical Commissions concerned. Myanmar, being a member of TCP, has been receiving WMO assistance for education and training activities through fellowship programs, relevant training courses, workshops, seminars, and the preparation of training publications. While WMO provides relevant technical advices, NMHS of Myanmar has been taking part in WMO's activities such as World Weather Watch (WWW), TCP, and World Climate Programme (WCP).

(2) UNFCCC and DMH

Myanmar ratified the United Nations Framework Convention on Climate Change (UNFCCC).

(3) JICA and DMH

Myanmar and Japan will be cooperating for the establishment of an early earthquake warning system in Myanmar by setting up seismographic network and record center. JICA's recent cooperation with DMH included "experts dispatch program" on earthquake, equipment provision program and training program. Moreover, JICA has to cooperate with DMH in future in the short-term expert dispatch program on Tropical Storm Forecasting and Warning, and Regional-focused Training Course in Acid Deposition Monitoring Network in East Asia. JICA has already provided two instruments of Ion Chromatography system and Ultra pure water production system.

(4) UNESCO/IOC and DMH

Mechanisms such as the Tsunami Warning System set up by the Intergovernmental OceanographicCommission (IOC) of the United Nations Educational, Scientific and Cultural Organization (UNESCO) could be useful in preventing and mitigating the impact of such phenomena. Myanmar is participating in the Tsunami Warning System. Of course, the two phenomena are quite distinct: tsunamis are mainly caused by submarine earthquakes; and storm surges by weather phenomena. But they have aspects in common.Global Sea Level Observing System program (GLOSS) which is an arm of the IOC has traditionally emphasized on strong training, education and mutual assistance components. Its program includes the establishment of 6 near real-time sea level station network with financial support from the UN Tsunami Regional Trust Fund.UNESCAP, in collaboration with the University of Hawaii Sea Level Center, has been administering the trust fund. It has established one station in the Philippines, two stations in Thailand, two stations in Vietnam, and soon to establish one station in Myanmar.

IOC Sub-Commission for the Western Pacific (WESTPAC) developed, within its framework of South East Asia-Global Ocean Observing System (SEAGOOS), one pilot project entitled "Monsoon Onset Monitoring and Its Social & Ecosystem Impacts" (MOMSEI). This pilot project aims to improve the understanding and forecasting of Asia monsoon and its multi-scale variability. The project will enhance the capability for monitoring the monsoon onset in the Andaman Sea. It is also in synergy with the on-going efforts of Indian Ocean Observing System(IndOOS). There are six member states of IOC /WESTPAC suffering from Asian monsoons, including China, Indonesia, Malaysia, Myanmar, Philippine and Thailand. DMH of Myanmar is actively cooperating with other member countries by sharing Myanmar Monsoon Climatology and its changes.

India and Myanmar have jointly undertaken the expedition in the Andaman Sea. UNESCO/IOC/ ADPC prepared to install new advanced tide-gauges in Myanmar coast. The National Institute of Ocean Technology (NIOT) of India, DMH and Myanmar Port Authority (MPA) had already implemented two acoustic tide gauges in Yangon and Pathein. Another two advanced tide gauges are to be installed in the near future by the GLOSS-UNESCO/IOC/ADPC program. The advanced tide gauges, currently under preparation, will have real-time data transmission facility.

The operations for storm-surge prediction and warnings are being coordinated through the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM). It is an example of the long standing cooperation among WMO and IOC. The JCOMM guide for 'storm-surge forecasting' is being finalized by the Commission and will contribute to the enhancement of storm-surge forecasting capability at the regional and national level.

(5) RIMES (ADPC) and DMH

The Regional Integrated Multi-hazard Early Warning System (RIMES) is a regional cooperation among Bangladesh, Bhutan, Cambodia, China, Comoros, India, Lao PDR, Maldives, Mauritius, Mongolia, Myanmar, Nepal, the Philippines, Sri Lanka, Thailand, Vietnam and Yemen. RIMES will focus on the early warning of tsunami and hydro-meteorological hazards within the framework of UNESCO/IOC and WMO. RIMES is now in force and is looking forward to working in the area of capacity building for the regional countries which are in need of assistance on weather and climate forecasting, storm and storm surge forecasting, and issuance of tsunami warnings.

Under the arrangement of ADPC, DMH supported to hold a national forum for early warning in April 2007. It was intended to hold national forums in pre-monsoon and post-monsoon months on a regular basis. The forum was named "Monsoon Forum". It constitutes a platform for open dialogue and inter-agency coordination as the representatives from forecast providers, user agencies, non-government organizations and selected communities would be among the forum participants. Since 2007, the Monsoon Forum has been organized twice a year in pre-monsoon and post-monsoon months. It is now nationally and regionally recognized as the key platform for understanding of risks from current variability, extremes, and long-term climate change. Forums have been able to identify the needs and gaps, and helped find ways and means to narrow the gaps with the technical guidance and support of ADPC, and also by the cooperative efforts of stakeholders from various sector.

National Consultation Workshops on Coastal Community Resilience (CCR) and Incident Command System (ICS) were held separately in Nay Pyi Taw, Myanmar. DMH brought together representatives from various government and non-government organizations concerned with coastal resource management. The workshops were organized to update on the current status of disaster risk reduction in coastal areas and to explore how the CCR initiative can assist in building institutional capacities. The participating agencies were aware of the importance of ICS, which brought together personnel, policies, procedures, facilities and equipment in an integrated structure designed to improve emergency response operations of all types. .

Workshop on Tsunami Alert Rapid Notification System (TARNS) and Concept of Operations (CONOPS) was held in Myanmar on 21-22 November2007,with the participation of representati-ves from government organizations. Generation and dissemination of tsunami warni-ng based on the CONOPS and TARNS initiatives had been the workshop output. It was briefed by the participants at the workshop and an implementation plan was prepared. National Tsunami Warning Centers (NTWCs) were assisted by CONOPS for mapping the operational flow of hazard and non-hazard information between organizations, for defining the intra-department reporting relationships within the NTWCs, and for developing a robust decision-making process for the generation of tsunami warnings. TARNS is a set of protocols and procedures for quick and accurate dissemination of tsunami-related advices or warnings from the NTWCs to all relevant national and local officials and the public.

(6) WMO/ESCAP PANEL ON TROPICAL CYCLONES

WMO has initiated an integrated effort by setting up or strengthening the existing collaboration mechanisms among the TCP regional bodies, the Regional Associations and the Technical Commissions concerned. There are eight Members in the Panel on Tropical Cyclones (PTC), namely, Bangladesh, India, Maldives, Myanmar, Oman, Pakistan, Sri Lanka and Thailand. The TCP is designed to assist the countries in areas vulnerable to tropical cyclones with the primary objective of minimizing the destruction and loss of life through improved forecasting warning systems and disaster preparedness measures. The Panel noted that training events and workshops are to be organized for the benefit of DMH of Myanmar. The Panel had benefited from WMO's education and training activities through the provision of fellowships, relevant training courses, workshops, seminars and the preparation assistance to prepare training publications.WMO also provided technical advices to the Panel. Assistance to Myanmar includes "Attachment of Storm Surge Experts from Myanmar and Sri Lanka to the Indian Institute of Technology". The Panel also noted that WMO fellowships for long-term and short-term trainings will continue to grant to the Member countries of the Panel under the various WMO programs.

(7) UNESCAP and DMH

UNESCAP will also help Myanmar develop an early warning system for tsunami and other natural disasters. The UNESCAP's decision to fund Myanmar for setting up the warning facilities is based on the fact that the region around Bangladesh and western Myanmar's Rakhine coastal area is susceptible to storm, earthquake and tsunami. A network of 4 real-time broadband seismic stations was established with financial support from the UN Tsunami Regional Trust Fund being administered by UNESCAP. One station was established in Myanmar, one in the Philippines and two in Vietnam.

(8) EANET and DMH

Acid Deposition Monitoring Network in East Asia (EANET) has been established as an important initiative for regional cooperation among the East Asian countries since 1998 in order to create common understanding on the state of acid deposition problems and for providing useful inputs to policy makers at various levels. Myanmar has attended EANET meetings as an observer since 1999. By the encouragement of officials from Secretariat and Network Center-ADORC of EANET, Myanmar became a member country of EANET in 2005. After becoming a member, DMH was designated as the National Center of EANET. DMH then carried out wet deposition monitoring. ADORC had already provided two sets of HORIBA pH meter and wet sampler. JICA provided two instruments for ion chromatography system and ultra pure water production system. With the support of Japan Government through JICA, the Myanmar National Center for EANET has been able to fulfill the requirement of EANET wet deposition monitoring. Myanmar could have provided reliable data of ion content.

National

Establishment of research network for the assessment of the impact of climate change in Myanmar

In the higher education sub-sector of Myanmar, there are many universities, degree colleges, colleges and vocational institutions. These are not only under the ministry of education but also under the various ministries. The research network concerning with climate change should be established among these institutions. The main objectives of the networking activities are:

- ❖ To provide the technical guidance in the conduct of research,
- ❖ To use the research outcomes in the preparation of the draft development plans.

- To promote the public awareness on climate change and its impacts on social and economic sectors of the country.
- To understand the potential impacts of climate change on different sectors of the economy, their vulnerabilities and the possible adaptation options to reduce such impacts.
- To encourage climate-related research works, in the Higher Education sub-sector and to include climate change and ti
- To share knowledge and experience among the institutions.

Fields of research and implementation activity

In the Higher Education sub-sector, universities perform various research activities. The research activities in agriculture, forestry, urban, coastal and marine, tourism, water and soil resources etc., should cover research on climate, particularly to climate change impact to the respective sectors, in addition to conventional research works. See (Table 7.19)

Table 7.19: Some tasks to be undertaken for promoting climate-related research projects

No.	Description of tasks
1	Study on syllabus of the universities related to the environment and climate change
2	Database construction of research activities for universities and related departments
3	Inviting the research proposal for the assessment of climate change impacts on the various fields of study.
4	Performing workshops and seminars on climate change impacts
5	Establishing Web Site for research networks
6	Publication of research papers

Myanmar Higher Education Institutions will also collaborate with the International Educational Institutions in the research network. These international institutions may participate in the Myanmar University Research Network on climate change. Successful research activities need various relevant supports.

7.7. Needs and Recommendation

The meteorological/hydrological observa-ntories are usually equipped with conven-tional instruments, and data handling and assessments are carried out manually. The observed data are sent to the National Data Collection Centre at Kaba-Aye by voice message using telephones, single side band transceivers and telegrams, which need further confirmation by monthly registers sent by mail. Data are archived in paper copies which decay easily due to the tropical moist climate. Staff are busy with the manual operation and handling of data, analysis and issuance of warnings and bulletins. Progress in the field of climate change related assessments is insufficient and slow to obtain up-to-date situation in many aspects. There is an inadequate analysis of existing data by local expertise, such as climate variation due to ENSO. Capacity building of DMH staff, university students and personnel from related institutions is also another area of gap in the country. Myanmar is truly interested in sharing climatic information to relevant agencies and willing to involve in global efforts to deal with the climate change.

Myanmar needs to replace the existing conventional instruments with automatic/ digital ones which will significantly reduce manual operations. The use of control buttons is to be promoted to improve data assessment for efficient transmission to target points. Human capacity development needs to be simultaneously enhanced so that dissemination of WMO/ IPCC standard information may become much more facilitated. Climate change information network should be strengthened nationally, regionally and internationally. This may be achieved phase by phase. National strategic plans on Research and Systematic Observation with special focus on climate change, tropical storm and drought are shown as follows.

National strategy

- The area of research relevant to climate change must be promoted strategically with specific directions and goals.
- The research programs should also aim to maintain and develop international links that ensure collaboration in research activities and transfer and dissemination of advanced environmentally sound technologies.
- The observational instruments must be replaced with automatic or computerized facilities to control the data quality and to provide quality information to regional and global climatic centres.
- The technology enhancement must be promoted through the use of numerical models.
- Workshop/Forum must be organized frequently to raise awareness on climate change, to develop response strategies, and to open up opportunities to researchers.

Table 7.20 : The strategic research topics on climate variability

No	Topics
1	Early signs of late monsoon onset over Myanmar.
2	Precursory signs of early monsoon withdrawal from Myanmar.
3	Variability of annual rain in Dry Zone of Myanmar.
4	Tropospheric patterns associated with deficit monsoon monthly rainfalls in Dry Zone of Myanmar.
5	Tropospheric patterns associated with deficit monsoon monthly rainfalls in Lower Myanmar.
6	Tropospheric patterns associated with deficit monsoon monthly rainfalls in Upper Myanmar.
7	Tropospheric patterns associated with excessive monsoon monthly rainfalls in Lower Myanmar.
8	Extreme rainfalls in central Myanmar.

Table 7.21: The strategic research topics on climate change

No	Topics
1	Climate change aspects of SW monsoon onset/withdrawal over Myanmar.
2	Monthly rainfall trends of states and divisions in Myanmar.
3	Significant excessive monthly rainfalls in Dry Zone of Myanmar.
4	Significant dry spells in Dry Zone of Myanmar.
5	Trend of post-monsoon rains in Myanmar.
6	Trend of pre-monsoon rain in Myanmar.
7	Monthly rainfall assessment of Myanmar. .
8	Extreme day temperature patterns in Myanmar.
9	Extreme night temperature patterns in Myanmar.

Table 7.22: The strategic research topics on tropical storms

No	Topics
1	Landfall frequency distribution of tropical storms and depressions along Myanmar coast.
2	Vulnerability of tropical storms along Myanmar coast.
3	Excessive rainfalls in Myanmar associated with cyclonic storms.
4	Attempt to quantitative forecasting of storm surge in Myanmar.
5	Forecasting of cyclonic storm rain.
6	Study on the influence of the sea surface temperature pattern upon the cyclogenesis in the Bay of Bengal and the Andaman sea.
7	Tropospheric circulations responsible for the abnormal movements of cyclones in the Bay of Bengal.
8	Regeneration of cyclones in the Bay of Bengal due to typhoon remnants of the South China Sea.
9	Storm surge prediction along an estuary.
10	Scenarios of different abnormal cyclone tracks and their potential storm surges.

Table 7.23:The strategic research topics on drought and precipitation

No	Topics
1	Frequency distribution of drought in Myanmar.
2	Severe droughts and monsoon situation in Myanmar.
3	Tropospheric circulations that influenced the severe droughts in Myanmar.
4	Precursory regional situations responsible for the severe drought of Myanmar.
5	Synoptic situations responsible for the widespread drought in Myanmar.
6	Synoptic situations responsible for the prolong droughts duration in Dry Zone of Myanmar.
7	Hydrological features during droughts in central Myanmar.
8	Vulnerability to impact of severe drought in central Myanmar.
9	Potential impact of severe drought in Dry Zone upon the domestic water supply.
10	Dry season drought potentials in Myanmar.

Table 7.24: The strategic research topics on extreme climates in relation to El Nino

No	Topics
1	Early signs of climate impact due to El Nino.
2	Impact of El Nino upon the extreme heavy rainfalls of different States and Divisions in Myanmar.
3	Impact of El Nino upon the extremely warm spell duration of different States and Divisions in Myanmar.
4	Warming pattern in Myanmar in the early stage of El Nino.
5	Rainfall pattern in Myanmar in the early stage of El Nino.
6	Drought characteristics during the period of El Nino.
7	Significant climate pattern in Myanmar in the wake of El Nino.
8	Significant intensity/track of cyclones in the Bay of Bengal during El Nino.
9	Flood frequency and duration along the Ayeyawady River system due to impact of El Nino.
10	Abnormally low water level in rivers during dry season due to impact of El Nino.

Research works will have to focus on ENSO, tropical storms and their associated hazards and droughts, etc. in Myanmar. To enhance the systematic observation and research activities, technical, financial and technological supports are to be sought for from various organizations both international and regional. In order to enable to conduct research on cross-cutting climate change issues among key socio-economic sectors, human resource development should be given priority.

7.8. Conclusion

In the Union of Myanmar, observations indicated that climate change is taking place in the fields of temperature, precipitation and extreme climate. Occurrence of disasters is getting more frequent and severe, and the southwest monsoon features are also changing. The southwest monsoon onset dates into the country were becoming late and its withdrawal dates from the country were advancing earlier. During 1988-2000, the southwest monsoon duration was shortened by three weeks in northern Myanmar and one week in other parts compared to 1951-2000 average. The monsoon became less active (decreasing strong monsoon days). Monsoon break which used to take place for about one week during normal peak monsoon period of July and August became less pronounced except in 1998 during which there was a prolonged break monsoon due to El Nino event.

Climate change imprints are found in the meteorological elements such as temperature (generally rising trend), rainfall (generally falling trend) and cyclone frequency of landfall on Myanmar coast (rising trend). Myanmar is highly vulnerable to disasters due to extreme climate impacts induced by global warming. Research and systematic observations are the paramount important basic measures that Myanmar has to undertake. To effectively support the Global Climate Observation System, Myanmar urgently needs to update the existing conventional measuring instruments, to provide data, information and reports following the WMO standard. Data collection should be upgraded and replaced by stand-alone communication devices. Observation stations are to be equipped with desk top/ lap top computers to ensure data quality and improve archiving operation.

Myanmar has a dozen of stations with more than a century-long rainfall data, a few dozen of stations with more than five decades of meteorological observations and about 100 stations, taking meteorological and hydrological observations up to about five decades. Much of the data are in the pocket registers and forms. DMH has to upgrade a data archive system so as not to lose the valuable data. DMH needs not only data archive centre but also capacity building, the facility upgrading and expertise to run the centre.

Data are needed to be analyzed in the formats recommended by WMO, UNFCCC, UNEP, IPCC etc. with the help of relevant software. Where ready-made software is not available, staff has to develop own software to analyze the data. Capacities building of trainers should be strengthened through relevant trainings from time to time. Ways and means should be sought for to train new generations of climatologists andmeteorologists, agrometeorologists, hydrologists, environment-alists, biologists etc., to monitor the climate change and its potential impacts. New elements and process of changes in nature may need to be observed systematically and it is essential to open up a new domain of research on climate change impacts on human, animals, foods and plants.

Past climates and current climates of Myanmar should be analyzed and the results should be informed to the authorities and relevant agencies for necessary measures and preparedness. Development of climate scenarios in the immediate future is another area challenging Myanmar.

The observation stations are not evenly distributed in the country and they are scarce in remote areas where more observations are needed for early warning systems and for activities related to agriculture, forestry, fishery, livestock and water resources as well. Fairly uniform distribution of stations should be given priority.

Various country-specific climate change information and the climate-related publications issued by UNFCCC, WMO, IPCC, UNEP and other institutions should be made available to all environment-related agencies of the country. Myanmar participation in the regional and international training workshops, seminars, forums, meetings, conferences and cooperative endeavors should be further encouraged so as to enhance the national capacity for undertaking effective research and systematic observations. Capacity building of the staff assigned at the stations is another important matter to help develop effective systematic observation system within the region. At the same time public awareness campaigns on climate change and adaptation strategies should be launched from time to time. To this end, adequate funds should be made available to responsible departments and agencies of the government and non-governmental organizations as well.

Myanmar needs increased technical, financial and logical support from UNFCCC, UNEP, IPCC and other related institutions. Those supports will enable Myanmar significantly contribute to the global efforts of adaptation to climate change.


Chapter 8 Education, Training and Public Awareness on Climate

8.1 Introduction
8.2 Education and Training Activity
8.3 Public awareness activity
8.4 Way forward

Chapter 8

Education, Training and Public Awareness on Climate Change

8.1. Introduction

In compliance with the Article 6 of UNFCCC, Myanmar has paid special attention to enhance education and awareness of the public on climate change through trainings and various means. Since National Commission for Environmental Affairs (NCEA) was formed in 1990, attempt has been made to promote the education and public awareness on environmental conservation.

In Myanmar Agenda 21, there are 6 integrated programs formulated by government agencies and approved by Cabinet for the pursuit of environmental education and public awareness activities. These are namely (1) formation of national advisory and coordination body for environmental education and training, (2) improvement of environmental education in school, (3) improvement of environmental education and research at the tertiary and professional level, (4) building the capacities of business, industry, academic and private sectors for proper code of conduct in environmental conservation, (5) launching public education and awareness campaign, and (6) developing partnership with other national and international stakeholders. In this context, World Environment Day and nation-wide Tree Planting Campaigns are annually implemented by concerned government agencies. Mass media, radio and national television programs also widely cover the issues of environmental public health, soil and water conservation, energy saving and forest conservation. In line with these existing programs, education, training and public awareness on climate change (ETPA) are intensified for its effectiveness on maximum coverage of climate change communication nation-wide. This section of the report highlights progress made so far in implementation of ETPA activities on climate change during the period of 2008 to 2010.

8.2. Education and Training Activity

Under this activity, three sub activities are implemented to increase the local capacity for addressing the issue of climate change in Myanmar. These includes –

1. Development of Information, Education and Communication Materials
2. Training of government officials
3. Training on environmental journalism and climate change communication

Development of Information, education and communication materials (IEC)

Apparently, information, education and communication materials (IEC) are important for effective communication in order to enhance public awareness on climate change related issues. The project for national communication on climate change under United Nations Framework Convention on Climate Change (UNFCCC) has developed the following IEC materials that are useful for ETPA activities.

1. *A reference book for student and families: Introduction of Climate Change*: A manual of World Health Organization on climate change for student and families was translated into Myanmar language with additional information about climate change in Myanmar. It is to introduce the climate change subject to the public in simple expression.
2. *A toolkit of climate change communication for field extension agent*: For field extension workers, illustration on mitigation and adaptation of climate change is essential to be used in their field level education programs and public awareness raising activities. Containing the facts about cause and effect of climate change in Myanmar, a communication toolkit was developed and pre-tested for effective climate change communication.
3. *Development of climate change video (Myanmar Version of " An Inconvenient Truth")* – For training purpose, documentary

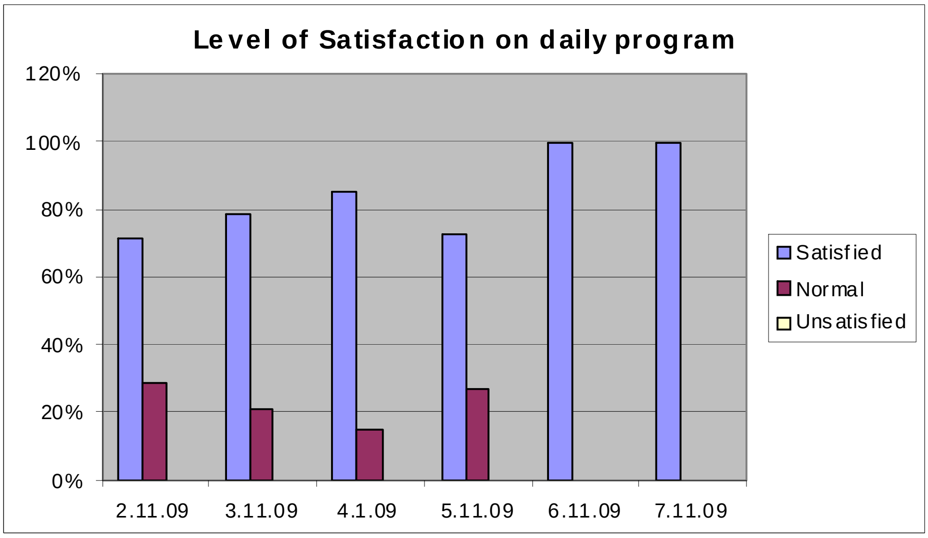
video is crucial to visualize the content of climate change subject. For this purpose, an internationally well-known climate change documentary video; namely "An Inconvenient Truth" was translated into Myanmar version.

4. *Information sheet for calculating ecological footprint*: Volunteer participation by all citizens in environmental conservation is an important first step for building capacity on mitigation and adaptation to Climate Change. To nurture the process of environmental ethical consideration and action by conscientious individuals, the concept of ecological footprint is introduced and the procedure for self assessment of one's own knowledge about the foot print is developed.

Training of government officials on climate change

The training was conducted for twenty nine officials of various government departments and organizations from nine States and Regions to enhance their understanding on climate change and related issues. The training was focused on strengthening the capacity of the trainees to enable them to communicate well with the public on climate change and required mitigation and adaptation measures. Participatory training method was employed in delivering training. As part of the training, the trainees prepared post-training programs to raise public awareness on climate change issues in the areas where they were working. Primarily, most of the trainees developed programs which included awareness survey, seminar for departmental heads and local authorities, and trainings for trainers. Small grants were given to the trainees to implement their programs.

Figure 8.1: % of Trainees responding to satisfaction on training



An important outcome of the training has been the dissemination of the information on climate change across the country through government officials who had attended the training resulting in increased interests of local authorities and local communities in climate change issues.

Training on environmental journalism and climate change communication

Training on environmental journalism and climate change communication was conducted during the month of November, 2009. The purpose of the training was to increase the capacities of journalists from local media for effective communication in the matters of climate change and environmental conservation. Training is not only focused on subject matter of climate change but also covered the aspect of fundamental in investigated journalism. A total of 12 participants from 11 local media groups attended the training and training assessment showed that their level of understanding on climate change issues had considerably increased. After the training, ETPA team

Table 8.1: Participating organizations in the training on climate change

No.	Department	Participant			Area/Location
		Male	Female	Total	
1	National Commission for Environmental Affairs	-	2	2	Nay Pyi Taw
2	Department of Planning & Statistics	1	1	2	Nay Pyi Taw
3	Forest Department	3	1	4	Nay Pyi Taw, Mandalay, Rakhine
4	Dry Zone Greening Department	1	1	2	Mandalay
5	Education Department	1	2	3	Magway, Bago, Ayeyarwady
6	Myanmar Fishery Department	1	-	1	Ayeyarwady
7	General Administration Department	2	2	4	Magway, Bago, Kachin, Chin
8	Department of Water Resources & Rivers Development	1	1	2	Sagaing
9	Ministry of Electric Power No. (I)	-	1	1	Mandalay
10	Red Cross Association, Myitkyina University	-	1	1	Kachin
11	Department of Meteorology and Hydrology	1	1	2	Kachin
12	Village Peace and Development Council	1	-	1	Shan
13	Department of Development Affairs	1	1	2	Rakhine
14	Social Welfare Department	1	-	1	Chin
15	Irrigation Department	1	-	1	Ayeyarwady
	Total	**15**	**14**	**29**	

met with the journalists and shared information about the climate change and environmental conservation in Myanmar. All of these trained journalists wrote articles about environmental situation in Myanmar based on the information provided by ETPA team and Climate Information Center. These articles were regularly appeared in local weekly journals promoting public awareness on climate change.

Figure 8.2: Government official training on climate change

8.3. Public Awareness Activity

As mentioned above, capacity building program for the government officials and environmental journalists was also designed to assist public awareness raising activity nation-wide. In addition, a couple of programs were designed and launched to reinforce the actions to raise public awareness on climate change effectively.

Figure 8.3: The percent understanding on training subject

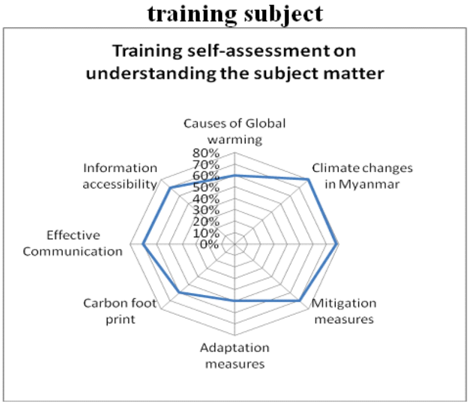
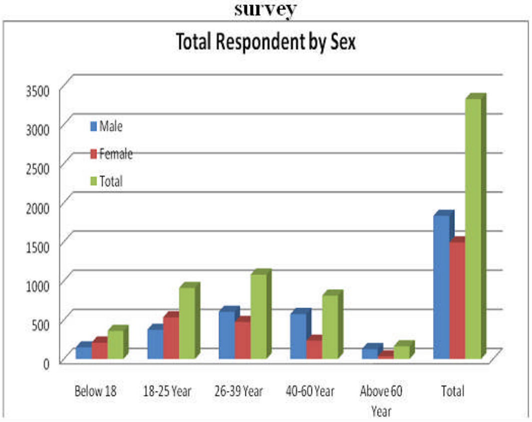


Figure 8.4: The respondent by gender participated in survey



Public awareness survey

Public awareness survey was conducted during the period from June to October, 2009 in order to examine the level of citizens' awareness on climate change issues. One page self-administered questionnaire was developed and circulated to the public through local media and non-governmental organizations throughout the country. People living in Yangon city, Central Dry Zone, Ayeyarwaddy delta, Mon and Kachin State actively participated in answering the questions of the survey and returned their answers back to ETPA team. A total of 3,328 respondents included 1,834 males and 1,494 females.

Box 1: Highlights of public awareness survey

ARE PEOPLE AWARE OF GLOBAL WARMING?

Public awareness survey enquires about people's awareness on global warming in general. Data show that 85% of respondent were aware of the global warming. So it is to say, almost all respondents heard about it. But Casual laborers, dependents and farmers were less aware of the climate change concerns. When further detail was asked about the cause of global warming, the chosen correct answers were varied and only above 80% of respondents correctly answered that deforestation was one of the reasons for global warming. To some extent, it was also found that people were aware of the causal linkage of industrialization, increased use of energy and vehicles. It was also notable that people were mostly able to differentiate the fact that global warming was due to human factor, not by natural phenomenon. Confusion was found among the respondents when it was examined about the relationship between green house gases and global warming.

IS EXTREME WEATHER SERIOUS?

Global warming and extreme weather were intertwined and awareness and experiences of the respondents on extreme weather were examined during the public awareness survey. The result showed that the most experienced extreme weathers were extreme heat, strong wind and storm. Respondents from Yangon, other urban areas and rural areas shared the same view on it, though the percent of respondent expressing their experiences of these extreme weathers were varied. Obviously, the devastating effects of the cyclone Nargis in 2008 reflected their experiences and suffering of extreme weather. From their expression, what is notable is the impact from these extreme weathers. Reportedly, loss of households and family members under these circumstances accounted for 10% in Yangon, 16% in other urban area and 23% in rural area. The effect of extreme weather on household economy was 42%, 48% and 60% in Yangon, other urban and rural area respectively. More than one half of the respondents from rural area, 44% in other urban area and 24% in the vicinity of Yangon complained about their health problem after extreme weather. Therefore, it is evident that the extreme weather is already adversely impacting on the lives and the economies of the people.

DO PEOPLE THINK THE CLIMATE HAS CHANGED IN MYANMAR?

Then, the people were asked whether they thought that the climate in Myanmar has already changed or not. Above 80% of the respondents from all over the country believed that climate change has been happening in Myanmar. It is significant that the percentage of the respondents who felt the impacts of climate change was highest among those respondents who were less aware of global warming (dependents, casual laborers and farmers). With regard to mitigating climate change, two thirds of the respondents thought that efforts could be made to improve the climatic conditions. Especially, the respondents working in NGOs, international organizations, government services and military were more optimistic in this respect. The respondents were also asked to express their perceptions on the potential impacts of climate change on their livelihoods. Those living in Yangon were concerned more about the negative impacts of climate change on environmental stability and public health. Other urban and rural people were equally concerned with the negative impacts on food production, public health and environmental stability. Concerns over water supply, income generation and loss of property were less apparent in all areas.

ARE PEOPLE AWARE OF CLIMATE INITIATIVES IN MYANMAR?

Regarding climate initiatives in Myanmar, a simple question was asked in the questionnaire if the respondent was aware of either the National Commission for Environmental Affairs (NCEA) or the United Nations Framework Convention on Climate Change (UNFCCC). The responses showed that 23% of the respondents were aware of NCEA and 40% UNFCCC. Retired government servants, military personnel, current government and media staff know about the two organizations relatively better. Interestingly, the respondents working in NGOs and international organizations were less aware of them than those working in the business companies.

In terms of age classes, 32 percent of the respondents belonged to age class 25 to 39, 27 percent to age class 18 to 24, 24 percent to age class 40 to 60 years. More than half of them were university graduates. High school and middle school graduates constituted 17% and 11% respectively.

Majority of the respondents were students and farmers accounting for 18% and 15% of the total respectively.

Occupations also varied. Company employees made 9%, employees at NGOs and international agencies 11% and government employees 6% of all respondents. All of these accounts sum up that the majority of respondents are mature and fairly educated with quite diverse employment backgrounds.

The major findings were highlighted in Box 1 and the salient points of the findings are-

a) People were aware of the global warming in general to some extent; however, the causes of global warming except for deforestation were less well known;

b) Higher temperatures, stronger winds and storms were reportedly the extreme weathers people had felt. Reflecting the experiences of Cyclone Nargis that hit lower part of Myanmar in 2008, higher casualties and loss of lives than officially recorded were reported by the respondents, casualties ranging from 10 to 23% of the total. Extreme weather also severely impacted on household economic condition and health of household members.

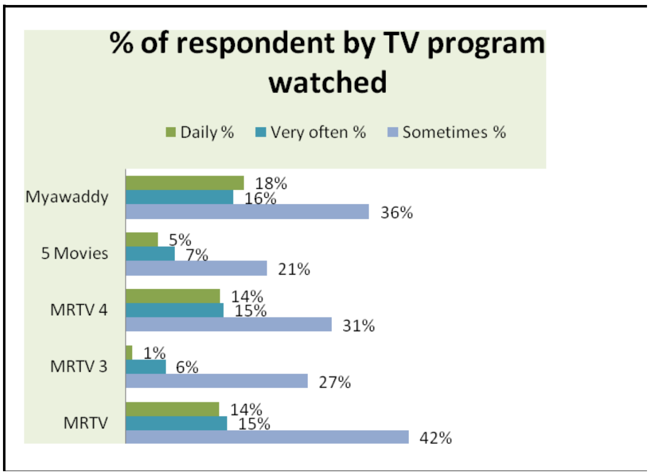
c) On the average, 80% of the respondents perceived that Climate Change has already occurred in Myanmar. With regard to the sectors vulnerable to climate change, perception was varied depending on the background of the respondent. Respondents from Yangon City were concerned about environmental sustainability and public health, while respondents from other urban and rural areas felt that food security was the most concerned followed by public health and environmental sustainability.

d) MOECAF is a national focal point of UNFCCC and the most responsible institution in Myanmar so far as inter-agency cooperation and coordination for environmental conservation and climate change initiative are concerned. However, people's awareness on MOECAF and UNFCCC was not so high that it needs to be improved for enhancing their participation in MOECAF's initiatives.

e) As part of the public survey, the effective media channel for conveying message to wider audience of the public was assessed. By TV, the maximum coverage was less than 40% of total respondents whereas it was 25% for the radio program. For printed media, 7 day- weekly journal and the government newspapers were the most read by respondents. However, the readership intensity in which the minimum and maximum values ranged from 0 to 1 was even less than 0.5 for those media the most people read. It means that the effectiveness of the printed media was modest in passing the message across the country. Therefore, it is to take a note that the maximum number of public that can be reached by TV, radio and printed media for disseminating the information and message is around 30 to 40% of total population meaning that 60 to 70 % still remain to be reached by the media. For effective climate change information communication, it is thus important to establish social networks with an emphasis on the enhancement of public awareness and education.

f) As far as public awareness is concerned, it was found that the level of awareness was lowest among the farmers, wage laborers and the dependents. Therefore, special attention needs to be paid to these social groups and appropriate communication channel should be selected for sending message to them.

Figure 8.5: Effectiveness of TV program reaching to public



Stakeholder awareness raising workshop

Enhancing the level of stakeholder's awareness on climate change is important to facilitate the process of public awareness and education on climate change matter. For this reason, attempt was made to raise the awareness of private business sector and civil society. In collaboration with Myanmar Fishery Federation, a technical seminar workshop and expert panel discussion were organized for businessmen, manufacturers and investors of Myanmar Chamber of Commerce and Industry Association in order to raise their awareness on climate change in Myanmar and measures that need to be taken. Similarly, collaboration was made with Food Security Working Group which was a larger network of non-governmental organizations in Myanmar in order to hold a consultative workshop on climate change matter. A total of 41 local and international NGOs participated in the workshop and explored the possibility of inter-agency collaboration and cooperation for building the community adaptive capacity to climate change. As these organizations are operating varieties of community development activities nationwide such as water supply and sanitation, primary health care, community based natural resource management and sustainable agriculture, the stakeholder workshop opened up the scope and space for mainstreaming climate change adaptation into existing development programs run by civil societies. Consultative dialogue has continued bilaterally among the civil societies for cooperation in climate change adaptation. International donor agencies such as United Nations Development Program (UNDP) and Department For International Development of the United Kingdom (DFID) stepped up in organizing further events to continue consultative process in exploring the possibility of action toward climate change adaptation. These consultative stakeholder workshops contributed to the process of forming a tri-partite steering committee by UNDP for setting up a small grant scheme for NGO and Community Based Organization (CBO) in order to carry out community based climate change adaptive program at grassroots level.

Nation-wide public awareness raising campaign

In the course of implementing the project for national communication on climate change under UNFCCC, public awareness raising campaigns were organized nationwide, particularly in the critical areas which were feasible. The audiences of these campaigns were key stakeholders within the area such as local authorities, government officials, non-state actors and community leaders. The messages given in these campaigns were causes and effects of global warming, the climate scenarios in Myanmar and their potential impacts, and the potential measures for mitigation and adaptation to climate change. To date, the following regional level public awareness raising campaigns have been conducted.

Awareness raising campaigns completed to date

1. District level awareness campaign, Moe Nyin District, Kachin State
2. Moe Kaung township level awareness campaign, Kachin State
3. Pharkant township level awareness campaign, Kachin State
4. Putao township level awareness campaign, Kachin State
5. Wai Maw township level awareness campaign, Kachin State
6. Inter-departmental awareness campaign in Monywar Township, Sagaing Region
7. Inter-departmental awareness campaign in Mindut Township, Chin State

8. District level departmental awareness raising campaign in Kyaukphyu Township, Rakhine State
9. Regional level awareness raising training and township level inter-departmental awareness raising campaign, Bago Region

In addition, there are also a few on-going awareness campaigns as stated below -

1. Stakeholder awareness campaign, Southern Shan State
2. District level and township level awareness campaigns, Pyar Pon District, Ayeyarwady Delta
3. State level awareness raising campaign, Myitkyina, Kachin State
4. Awareness raising campaign for community based organizations in Magwe, Minbu, Pwint Phyu and Pakkoku Townships of Dry zone, Magway Region

During each awareness campaign, one session was included for participatory group discussion and participatory tool was introduced to analyze the status of emitting greenhouse gases and the incidence of extreme weather in given administrative areas. This mobilized the participants to deeply think of and undertake necessary measures that could reduce the vulnerability due to climate change. Such an activity like community forestry or introducing energy efficient cooking stove appeared to be the immediate action for addressing the climate change issue in the locality as a follow-up to the awareness campaign.

Climate information center

For the preparation of the Initial National Communication Report on climate change under UNFCCC, documents related to climate change were widely collected. Nearly 500 information materials have been collected covering technical, educational, legal, financial and institutional aspects in environmental conservation and climate change. Thus, the Climate Information Center (CIC) was established at the office of the Academy of Forestry Science in Yangon in order to make accessible the collected information to the public, especially to those stakeholders such as post-graduate researchers, government officials, journalists, and business entrepreneurs and development practitioners. At present, the journalists trained by ETPA are the major users of CIC and monthly forums are organized to update them and ensure dissemination of up-to-date information on climate change to the public through their articles published in the local media. An information assistant has been attached to the center by ETPA team to take care of the visitors on matters concerning climate change.

8.4. Way Forward

The project for Initial National Communication on climate change under UNFCCC has opened up opportunities for civil societies to improve education, training and public awareness on climate change issues in the context of Myanmar. It enlarges the scope of improving the citizens' access to climate change information in order to enhance their participation in mitigation and adaptation measures against climate change. The activities described in this section should be continued in the future to upkeep the momentum created by this initiative. To maximize the benefits to the entire nation, it will require institutionalizing the process of uplifting education, training and public awareness by forming inter-agency coordination body to enable the development of national level ETPA scheme and its implementation nationwide with increased inputs of human and financial resources.

In this respect, international cooperation is also critical to enhance information sharing and learning mechanism so that informed, healthier and better decisions could be made through ETPA process. This action will effectively bridge national level intervention with local initiative in building community adaptive capacity to face climate change reality in Myanmar.

Chapter 9 Integration of Climate Change Concerns into Development Plans and Programmes

9.1 Introduction
9.2 Climate Change in Myanmar
9.3 Integration of CCCs into Development Plans and Programmes
9.4 Programme sectors

Chapter 9

Integration of Climate Change Concerns into Development Plans and Programs

9.1. Introduction

Integration of Climate Change Concerns (CCCs) into development plans and programs is of vital importance to Myanmar in view of further enhancing its low-carbon economy and reducing its vulnerability to climate change challenge. Both GHG emission mitigation and adaptation to climate change are indispensable and complementary.

Reductions in GHG emissions will delay and reduce damages caused by climate change, and thus reduce the investment that will be needed for adaptation. However, it is worth noting that while mitigation of climate change is crucial to limit long-term impacts, climate change is already happening, and is bound to continue simply because of the atmospheric GHGs that have already accumulated.

According to the GHG inventory undertaken for the preparation of Initial National Communication (INC) for the year 2000, Myanmar has proved more than being a net carbon sink nation, with a CO_2 net removal of (-) 67,863 Gg CO_2e (or) 67.8 million tons of CO_2. Land use change and forestry is the only sector in the country to absorb CO_2 with an amount of 142, 221 Gg. Myanmar had emitted a total of 74, 358 Gg CO_2e emissions in year 2000. It thus demonstrates that Myanmar has been implementing low carbon economy, significantly contributing to the global efforts of stabilizing atmospheric CO_2 concentration below dangerous levels.

Myanmar has been experiencing considerable increase in per capita incomes. The per capita incomes in 1990 of 1,232 Kyats increased to 2,000 Kyats in year 2000 at 1985/86 constant producers' prices (CSO 2004, CSO 2006, and Ministry of Information 2009). In line with the growing GDP, GHG emissions from Energy and Industrial Processes sectors had increased from 6 086 Gg CO_2e and 180 Gg CO_2e in 1990 to 7 863 Gg CO_2e and 463 Gg CO_2e respectively in year 2000. Along this trend, it is sensible that the total GHG emissions could increase with the increased consumption of energy to sustain the growing national economy in the decades to come.

Especially since late 1970s Myanmar has been experiencing negative impacts of climate-related natural disasters to which its geographical setting is attributable. Myanmar, being located on the eastern coastline of Bay of Bengal and Andaman Sea, has a coastline of some 2,832 km while climate is influenced by southwest monsoon. The country is featured with three parallel chains of forest-clad mountain ranges and north-south running long river systems in-between. In addition, there exists rain-shadowed dry zone in its central part influenced by orographic effect of western mountain range. Such a geographical setting exposes Myanmar to a number of climate-related natural disasters. The tropical depressions due to low atmospheric sea-level pressure formed in the Bay of Bengal could hit Delta region and other coastal areas. Myanmar was hardest hit by the Cyclone Nargis in May 2008.

Integration of CCCs into development plans and programs and implementation of the recommended actions are therefore considered vital to sustain Myanmar's economic development in harmony with social and environmental integrity.

9.2. Climate Change in Myanmar

During the period from 1961 to 1990 the lowest mean annual temperature of Myanmar was 15.8°C in the Chin State of the northwest mountainous region while the highest temperature was above 40°C in Magway Region. Mean annual rainfall was lowest about 500 mm in the Lower Sagaing Region and highest with 5,000 mm in the Tanintharyi Region of southern strip of Myanmar (DMH, 2009).

Observed changes

Temperature

Over the period from 1951 to 2007, annual mean temperatures generally increased in Chin, Kachin, Kayin, Mon, Rakhine, and northern and southern parts of Shan State, and in lower Sagaing and Mandalay Regions. The temperature increase per decade was highest with 0.32°C in Hpa-an of Kayin State and Monywa of Sagaing Region. The cooling trend with -0.23°C and -0.16°C per decade was observed in Magwe and Bago respectively. During 1951 to 2000, annual mean frequencies of heat wave occurrence numbered five in Kachin State, two each in Northern Shan State, Magwe, Mandalay and Lower Sagaing Regions, and one each in Bago Region and Mon State. The longest heat wave duration of 12 days was recorded in Yangon. The El Nino episodes have occurred in Myanmar in the years 1957, 1958, 1983, 1986, 1988, 1998 and 2009.

Precipitation

During 1991 and 2004, high extreme rainfall events occurred five times at Nyaung-U and four times at Myitkyina, Magway, Mawlamyine and Hpa-an. Of the 4 high extreme events at Mawlamyine, one was found to be of higher extreme with 51.2% departure from normal (DFN) that happened in 1994. Low extreme rainfall events occurred five times in Monywa, four times in Mandalay and three times in Falam and Magway, and two times each in Taungyi, Lashio, Nyaung-U, Loikaw and Pathein. The year, 1998 was a strong El Nino year that delivered low extremes to much of Myanmar except Rakhine, Kachin and Northern Shan State and Upper Sagaing Region.

Cyclones

During the period 1887 to 2005, out of 1,248 tropical cyclones which originated in the Bay of Bengal, 80 cyclonic disturbances had crossed Myanmar coast. It means Myanmar did not receive cyclones every year. During 1947 and 2008, both inclusive, Myanmar was hit by 35 cyclonic storms, which were usually accompanied by strong winds, storm surges, heavy rains and floods.

Imprints of climate change in Myanmar

Impacts of climate change have been recorded since 1978 according to the observations of Department of Meteorology and Hydrology (DMH). Myanmar has been experiencing a general warming trend, especially since 1979 (Htay Aung, 1998). The average temperature has increased by 0.7°C over the last two decades, and the rise is in line with both the global and Southeast Asia trends (Tun Lwin 2002). In general, there have been late onsets and early withdrawals of monsoon since 1978; duration of the monsoon is becoming shorter than normal. Prior to 1977, the average number of rainy days per annum used to be around 144, but it reduced to 103 in 1997. In the period from 1988 to 2000, the monsoon duration was shortened by about three weeks in the northern part and by one week in other parts of Myanmar compared to the 1951 - 2000 average.

While the years 1979 and 1980 were characterized by prolonged warm and dry periods, the years 1983, 1986, 1988, 1989, 1995, 1998, 2000, 2005, 2007 and 2009 had temperatures higher than normal.

The year 2009 was an El Nino year with decreased annual rainfall, with heavy rains in some areas and with droughts in others. Some off-season rains occurred in coastal areas of Ayeyarwady Region in the last week of March 2009, causing widespread damage to salt industries.The year 2010 started with widespread cold waves crossing over parts of the country including Mandalay, Magway and Yangon Regions. Moreover, there were also unusual rains at Nay Pyi Taw Pyinmana, Western Bago Region, Southern Shan State and Ayeyarwady Region on January 26, 2010 due to tropical depressions in South China Sea. There were also high temperature extremes during summer months (March through May), leading to the occurrence of severe heat and water stresses virtually all over the country.

9.3. Integration of CCCs into Development Plans and Programs

Sustainable Development has been defined by the World Commission on Environment and Development (1987) as the development that meets the needs of the present without compromising the ability of the future generations to meet their own needs. It is the pursuit of economic development in parallel with environmental protection (Myanmar Agenda 21). The Sustainable Development needs a harmonious integration of economic, social and environmental dimensions.

In Myanmar different ministries and organizations used to undertake development measures within their mandates to achieve their set targets very often in isolation. The coordinated efforts between the ministries have been insufficient to put the country in the right track towards sustainable development.

As the National Environmental Policy stipulates, the development activities must integrate environmental considerations in order to achieve harmony and balance between national wealth, national cultural heritage and natural resources. In this context, line ministries and all other related organizations must cooperate with one another and work hand in hand closely so that national economic targets are met in harmony with environment, culture and natural resource development. This calls for a strong mechanism that could create and ensure inter-ministerial cooperation and coordination.

Regarding environment, the National Commission for Environmental Affairs (NCEA) was established in 1990 to act as a central body to coordinate and cooperate environmental affairs. It was set up at the Ministry of Foreign Affairs, chaired by minister for Foreign Affairs. NCEA operates directly under the guidance of the Cabinet and comprises a chairman, a secretary, and a joint-secretary. It has the following four committees:

1. Committee on Pollution Control,
2. Committee on Natural Resources Conservation,
3. Committee on Training, Research & Education, and
4. Committee on International Relations.

NCEA had developed National Environmental Policy which was adopted in December 1994, formulated Myanmar Agenda 21 (MA21) in 1997 and drafted the National Environmental Protection Law (NEPL) in 2000. The Environmental Conservation Committee (ECC) was formed in 2004 to effectively and systematically carry out environmental conservation activities within the country.

In 2005, NCEA was transferred to the Ministry of Forestry to be chaired by the minister for Forestry.The chairman of the NCEA also chairs ECC. In addition, the National Environmental Conservation Committee (NECC) has been reformed in 2011 as a full flash focal organization for the environment sector throughout the country and the NCEA was abolished. Moreover, to speed up its environmental protection measures the Ministry of Forestry was renamed to Ministry of Environmental Conservation and Forestry (MOECAF) in 2012.

The National Environment Policy underlines the Government's commitment to establish sound policies in the utilization of water, land, forests, minerals, marine and other natural resources in order to conserve the environment and prevent its degradation (MA21).

A specific aim of MA21 is to facilitate the in corporation of environmental and sustainable development policy considerations into the decision-making and policy formulation processes of the government in the economic and social sectors (MA 21).

The current process of national development and planning in Myanmar does not provide a systematic means for the integration of environmental dimensions (MA 21).Climate change is one of the hottest environmental issues today and MOECAF was established to undertake the task of coordinating line ministries and ensuring the integration of climate change concerns into the national and sectoral development plans and programs.

However, MOECAF does not have the capacity and authority for integrating environment and development at all levels and to ensure coordination and cooperation among different ministries and agencies. NCEA should be strengthened to this end. It should have an extensive network of administrative branches throughout the country to ensure that the integration of environment and development takes place at the state and regional levels, and in townships, wards and villages (MA 21).

In this connection, Environmental Impact Assessment (EIA) is an effective and vital tool for integrating environment and development. The environmental issues identified during EIA process can improve economic planning to achieve harmony and balance between environment and development. EIA rules and regulations should be enacted for every big project to be implemented only after the analysis of its costs and benefits.

All of the Government's national economic and social development plans should be reviewed in order to comprehensively integrate environmental concerns with particular focus on climate change. NECC should be empowered to ensure the integration and monitor the implementation at all levels and in all localities.

[MA21 has outlined very comprehensively the process of integration of environment and development in decision-making in Chapter 18. This should be taken as the guideline for "Integrating climate change concerns into sustainable development plans and programs"].

Since the economic, social development and industrialization processes are rapidly taking momentum, the population increasing and the natural resources dwindling, it is critically urgent that the climate change concerns are integrated into all future national and sectoral development plans and programs to bring about economic development in social harmony and ecological integrity.

9.4. Program Sectors

To integrate environment and development, the particular emphasis has been placed on key economic sectors for which GHG inventory was undertaken for the preparation of Myanmar's first Initial National Communication. These economic sectors are

1. Energy,
2. Industrial processes,
3. Agriculture including livestock,
4. Land use change and forestry, and
5. Waste.

Energy sector

Energy is a major component of economies, both as a sector in itself and as a factor input to all other economic activities. Agenda 21 identified two program areas concerning energy –

1. Develop a system of comprehensive energy planning, development and management, and
2. Improve energy efficiency and energy conservation.

In the fourth Short-Term Five-Year Plan (2006/2007 to 2010/2011) of the national 30-year development plan for the energy sector, it has been mentioned that environmental conservation should be paid attention while making concerted efforts to produce more crude oil and natural gas to meet domestic requirements and for export while boosting production of mining sector.

The energy policy has defined the following objectives-

- to sustain energy independence,
- to develop the use of new and renewable sources of energy,
- to enhance energy efficiency and conservation, and
- to promote alternative fuels for household use.

Myanmar has both non-renewable energies such as crude oil, natural gas and coal, and renewable energies such as hydro energy, geothermal energy, solar energy, wind energy and biomass energy.

The government has been working with multinational companies for exploration and development of gas fields in both on-shore and off-shore areas. The government has also been implementing medium and large scale hydropower projects.

Transportation involves fuel consumption, usually associated with CO_2 emission. All transport means – road, rail, water and air are being improved and extended with a view to facilitating and promoting efficiency of the flow of goods and services across the country. The government has encouraged and involved private companies to undertake the construction and maintenance of important segments of union highways.

In Myanmar, road transport is mostly used although waterway and railway transport modes are cheaper with lower rate of fuel consumption.

The followings are some of the important energy-related measures undertaken by the government between 1989 and 2008 (Ministry of Information, 2009).

- ❖ A total of 4,418 new hydro-power plants (large, medium and small) had been constructed to date.
- ❖ Another 13 hydro-power plants are under construction with foreign investments and more than 21,000 MW will be generated upon their completion.
- ❖ Production of natural gas now reached 364,578 million cubic feet.
- ❖ 44 CNG filling stations have been constructed.
- ❖ 100,428 and 81 power plants using biogas, biomass and solar energy respectively have been installed by the private business enterprises.
- ❖ About 50 million Jatropha (*Jetropha curcas*) have been raised on cultivable wastelands in the past couple of years and the project will continue to produce bio-fuel as much as possible.
- ❖ 600 CNG buses had been imported for public transport so far, and more than 25,000 motor vehicles have been changed from petrol/diesel to CNG up to September, 2009.

Two GHG inventories had been conducted in Myanmar. The first inventory was based on 1990 and the second on 2000 data. A comparison of GHG emissions in the energy sector in the two inventories is presented in (Table 9.1).

Table 9.1: GHG emissions in energy sector in years 1990 and 2000, in Gg

Base year	CO_2	CH_4	N_2O	NO_x	CO	CO_2 equivalent
1990	3,311.81	119.79	0.83	71.01	1095.49	6,086.14 (1)
2000	7,658.65	5.62	0.28	0	0	7,863.47 (2)

Note: (1) includes 2,591.71 Gg CO_2 equivalent.
(2) excludes 28,297.82 Gg CO_2 equivalent.

Source: (1) Asian Least Cost GHG Abatement Strategy (ALGAS) Project 1997.
(2) National GHG Inventory for Myanmar INC 2000.

Total GHG emissions from traditional biomass burned for energy amounting to 28,297.82 Gg CO_2 equivalents in 2000 estimated in 2000 GHG inventory were not included in both the sectoral and national totals. In 1990 it was only 2,591.71 Gg CO_2e and included in the totals. It had been an extremely big increase in GHG emission from traditional biomass burned during ten years from 1990 to 2000, being 25,706.11 Gg CO_2e. Because it mainly consisted of GHG emissions from fuel-wood consumed for domestic home cooking, wood fuel substitutes are urgently needed to ensure the sustainability of forests and carbon sinks. GHG emission from other sources had increased by 4,369 Gg CO_2e.

In the total GHG emissions of 7,863.47 Gg CO_2e, those from fossil fuel conversion alone have been estimated at 7,755.11 Gg CO_2e constituting 98.6% of the total.

Use of energy will increase with the growing population and economy which will be accompanied by increasing GHG emissions. In order to mitigate the GHG emissions and adapt to the increased warming, the following policy measures have been identified for integration into the national and sectoral development plans and programs (Table 9.2).

Table 9.2 : Policy measures to addressing rising GHG emissions in energy sector for integration into national and sectoral development plans and programs

Policies, Strategies and Actions:
Policies:
1.Enhance energy conservation, efficiency and production and ensure energy security. 2.Promote efficiency of national transportation system and regulate imports of second-hand motor vehicles.
Strategies:
1.Perform energy audit. 2.Tap all potential power sources including renewable energy for increased power generation and utilization. 3.Improve traffic demand management. 4.Establish national ambient air quality standards.
Actions:
Mitigation Measures: 1.Set energy efficiency standards and label efficiency grades on products. 2.Provide advices, inspection, incentives for energy conservation and efficiency. 3.Capture fugitive gaseous emissions; 4.Develop voluntary agreements for increased use of energy efficient products. 5.Invest more for and promote the use of cleaner and zero-emission energies. 6.Construct more hydropower facilities where EIA permits. 7.Upgrade existing power-generation and transmission systems. 8.Extract coal-bed methane. 9.Promote bio-energy production from available sources without compromising food security and viability of forests and soils. 10.Further promote and expand CNG-used vehicles, CNG pipelines and stations. 11.Improve all transport modes and traffic demand management, including cycling and containerized freight transport. 12.Install more light-emitting diodes for traffic lighting. Adaptation Measures: 1.Adopt environmental standards for energy efficiency. 2.Construct buildings with designs to increase cross ventilation, prevent direct sunlight in the afternoon and reduce heat gains with shade covers. 3.Increase the use of fuel-efficient motor vehicles. 4.Make all public transports more attractive and affordable. 5.Raise public awareness on GHG emission reduction and energy conservation. 6.Build institutional capacity to monitor ambient air quality.

Industrial Sector

Regarding industrial sector, Myanmar Agenda 21 identified one program area, entitled "Promote Sustainable Industrial Development and Cleaner Production".

In the industrial sector, there are two ministries: Ministry of Industry No.(1) and Ministry of Industry No.(2).

The Ministry of Industry No.(1) covers textile industries, foodstuff industries, pharmaceutical industries, ceramic industries, general and maintenance industries and paper and chemical industries.

Under the Ministry of Industry No.(2), there are nine major factories and four Industrial Training Schools. The factories under the Ministry of Industry No.(2) produce various kinds of tires and tubes, trucks, light vehicles, bicycles, pumping machines, hand-tractors, tractors, threshers, hoes, bulbs, florescent tubes, dry cells, transformers, electric metres and household electrical equipments. The Ministry has some joint ventures with foreign companies to promote foreign investment and technology transfer. Between 1995-96 and 2005-2006, 18 industrial zones have been established in 9 States and Regions. By the end of September 2006, the number of factories and mills operating in them totalled 9,849. Although the government reduced its direct involvement in economic activities by privatizing selected industries, the position of state-owned enterprises is still large. But, the share of private mills and factories in the industrial sector is now rising.

In parallel with the initiation of the market-oriented economic system after 1988, new laws such as the Foreign Investment Law, the State-Owned Enterprises Law and the Private Industrial Enterprises Law were promulgated. This has created a significant increase in industrial investment and production. But, the contribution of Myanmar's industrial sector to the total national GDP had been merely 10 to 15 per cent for many years, and it is the lowest in the South East Asian region. The vision of Myanmar regarding industrial development is to contribute 25 percent to the national GDP.

In addition to other laws and regulations for environmental cleaning, Chemical Safety Law has been drafted recently and will be promulgated this year. It is the government's drive to force brewery plants to install waste water treatment facilities so as to avoid soil and water contamination.

A comparison of GHG emissions from the sector between 1990 and 2000 is provided in table (Table 9.3).

Table 9.3: GHG emissions in industrial processes sector in 1990 and 2000

Year	CO_2 (Gg)	Other gases(NMVOC, ODS & SF6(Gg CO_2e)	Total Gg CO_2e
1990	180.44	Not estimated	180.44
2000	248.59	214.7	463.29

Source: (1) Asian Least Cost GHG Abatement Strategy (ALGAS) Project 1997.
(2) National GHG Inventory for Myanmar INC 2000.

In 1990, CO_2 emission only was estimated which amounted to 180.44 Gg. In 2000, CO_2 as well as emissions of other gasses like NMVOC, ODS and SF6 were also estimated. The total amount of CO_2 emitted in the latter year was 248.59 Gg.

Therefore there had been an increase of 68.15 Gg CO_2 during the decade from 1990 to 2000. Since industrialization processes are stepping up, the increase in the emissions of GHGs in the sector could very well follow a steep upward trend unless mitigation measures are undertaken in time.

To this end, the following policy measures have been identified to be incorporated in the national and sectoral development plans and programs (see Table 9.4).

Table 9.4 : Policy measures addressing GHG emissions in the industrial processes sector for integration into national and sectoral development plans and programs

Policies, Strategies and Actions:
Policies:
1.Adopt energy efficiency standards and labelling system. 2.Prohibit manufacture and import of GHG inefficient products. 3.Promote energy efficiency and emission control technologies.
Strategies:
1.Practice Green Certification System. 2.Introduce clean and green technologies. 3.Promote cleaner production.
Actions:
Mitigation Measures:
1.Set high energy efficiency and environmental standards. 2.Conduct at each industry Efficiency Audit and provide green labels and tax benefits to the industry and product that meet the set standards. 3.Further promote the use of CNG, LPG and renewable energies by providing incentives.
Adaptation Measures:
1.Encourage the use of more energy-efficient boilers, motors, furnaces and electrical equipment 2.Introduce energy-saving, process-specific technologies. 3.Initiate the development of carbon capture and storage for energy-intensive plants. 4.Implement energy-saving regulations and improved energy management systems. 5.Provide energy efficiency-related information services. 6.Conduct advocacy extensively on conservation of energy and utilization of cleaner energy.

Agriculture sector including livestock

Agriculture is the mainstay of Myanmar's economy, currently with a net sown area of over 11 million hectares under about 60 cultivated crops. For agricultural sector, Myanmar Agenda 21 has identified two program areas, namely,

1. *Promote Sustainable Agriculture, Livestock and Fisheries Development; and*
2. *Enhance Food Security.*

In 2006-07 agricultural sector accounted for 37% of the country's Gross Domestic Product (GDP) and 13.3% of total export earnings (Myanmar Agriculture in Brief, Ministry of Agriculture and Irrigation, 2009). The Government has been continuously constructing dams and reservoirs throughout the country by utilizing large capital investment, machineries and expertise. As a result, irrigation facilities now exist in some localized zones throughout the country. Up to September 2006, there are 664 irrigation facilities (MNPED 2006b).

At present, only about 6% of the total water resources of about 1,073 km^3 are being utilized annually. Since 1988 the Government has intensified construction of dams and reservoirs throughout the country to provide irrigation especially to the paddy fields. The successfully completed irrigation projects during 1988 to 2000 reached a total of 116. Irrigation coverage had increased from 12.5% in 1987-88 to 18.0% of the total sown area in 1998-99. In the year 2000, the irrigated rice fields covering 6,302,306 ha constituted 29.4% of the total rice land in the country. Rice is the principal agricultural crop and Myanmar is a rice-surplus country. Efforts are being made to expand rice cultivation and area under rice cultivation increased from 6.3 million ha in 2000-2001 to 8.09 million ha in 2007-2008.Summer rice cultivation, which has been introduced since 1992, shared 1.1 million hectares in 2000-2001. Rice production increased from 21 million tons in 2000-2001 to over 31 million tons in 2007-2008 (Department of Agricultural Planning, Ministry of Agriculture and Irrigation, 2009).

Livestock are used for many purposes. Myanmar relies heavily on draught cattle to promote agricultural expansion. Almost all the land cultivation is done by draught cattle and buffaloes. Draught cattle are also very useful as a mean of transport in the rural areas. Dairy cattle are bred to produce dairy products for domestic consumption, and beef cattle for export. Buffaloes, pigs, ducks, sheep and goats are also raised for domestic consumption. There were about 10.98 million cattle, 2.44 million buffaloes, 1.8 million sheep and goats, and about 3.97 million pigs in Myanmar in 2001 (Daing, T., 2009). In general, cattle and buffaloes are part of Myanmar farming system. However, feed resources are scarce and of poor quality especially during the dry season, resulting in low productivity.

Although Myanmar's agriculture has been developing as planned, it is the sector most vulnerable to cyclone and strong winds, flood and storm surge, intense rain, extreme temperatures (day and night), drought, sea level rise and salt water intrusion, which are identified as climate-related natural hazards in Myanmar. Accordingly, the potential threats of climate change include prolonged and more frequent droughts, changes in rainfall distribution, more storms and other extreme weather events, rising sea levels and salt intrusion, increased and changing pest loads, increased risk of heat and water stresses in cropping and livestock farming.

A comparison of GHG emissions from the sector in 1990 and 2000 is presented in table (Table 9.5).

The table shows about 45.5% decrease in methane production during the observed period from 1990 to 2000. The total CO_2 net emissions have also dropped by about 16,402.46 Gg CO_2e (41.8%).

Table 9.5: GHG emissions from agriculture, inclusive of livestock, sector in years 1990 and 2000

Year	CH_4 (Gg)	N_2O (Gg)	NO_x (Gg)	CO (Gg)	CO_2 equivalent total emission (Gg)	CO_2 e total net emission (Gg)
1990	1767.4	6.71	0.45	24.19	39,202.92	39,202.92
2000	963.58	9.01	0.02	0.81	22,800.46	22,800.46

Source: (1) Asian Least Cost GHG Abatement Strategy (ALGAS) Project 1997.
(2) National GHG Inventory for Myanmar INC 2000.

On the other hand, flooded rice fields and ruminant animals are a major source of methane. The increasing extent of rice fields and net sown areas with more fertilizer inputs, and increasing population of livestock, are likely to uplift the trend of methane and nitrous oxide emissions.

In order to mitigate further emissions of GHGs and adapt to global warming in the sector, the policy measures to be integrated into the national and sectoral development plans and programs have been identified and presented in the table (Table 9.6).

Table 9.6: Policy measures to addressing GHG emissions in the agriculture and livestock sector for integration into national and sectoral development plans and programs

Policies, Strategies and Actions:
Policies:
1.Follow CGAP (Code of Good Agricultural Practice) to implement sustainable agriculture. 2.Ensure increased food production in the climate friendly and resilient manner. 3.Improve livestock and livestock feed.
Strategies:
1.Improve water management and nutrient management practices for mitigation of CH_4 and N_2O emissions) from rice fields 2.Promote organic farming (system). 3. Encourage research and development on crop varieties adaptable to climate change. Promote breeding programs of genetically improved strains of animals and regulate their population. Improve animal feed with quality forage and mineral supplements.
Actions:
Mitigation Measures:
FOR AGRICULTURE 1.Reduce tillage and practice intermittent irrigation technique, proper selection of rice varieties and crop rotation in rice fields. 2.Promote "Conservation Agriculture", "Sloping Agricultural Land Technology" and other climate friendly advanced technologies. 3.Encourage the system of rice intensification (SRI) method with alternative wet and dry condition. 4.Improve water, crop and crop residue management. 5.Promote Integrated use of organic manure and bio-fertilizers together with synthetic nitrogen fertilizer. 6.Apply phosphor-gypsum with urea to reduce CH_4 emission. 7.Apply herbicides and slow release fertilizer to reduce N_2O emission. 8. Apply integrated pest management (IPM). **FOR LIVESTOCK** 1.Improve and expand pastures, grasslands and forage and its quality. 2.Improve the use and management of animal waste to harvest producer gas and to use gasification effluent as bio-fertilizer. 3.Supplement poor quality roughage with minerals, urea molasses, legume or other agricultural by-products? to reduce feeding amount.
Adaptation Measures:
FOR AGRICULTURE 1.Adjust cropping patterns, improve farm management measures including post-harvest treatment, processing and storage improved management practices, including post harvest technology. 2.Use high-quality, stress-resistant plant varieties and ensure climate-resilient agriculture. 3.Encourage more efficient water use and soil and water conservation. 4.Expand water impoundment systems through clusters of smaller dams, ponds, lakes and rain water collection. 5.Promote organic farming and use of bio-fertilizers. 6.Popularize dry-land agricultural technologies, preserve soil moisture, foster soil fertility and further increase river water pumping and ground water harvesting, particularly for dry zone agriculture. 7.Furtherstrengthen weather forecasting and early warning system. 8.Make more investment to implement climate risk reduction measures. **FOR LIVESTOCK** 1.Protect grasslands and pasture against fires, over-grazing and soil and water erosion. 2.Add fermentation-control medicine, fermentation stabilizers and micro-organism repressors to animal diets. 3.Protect livestock against heat stress and strong winds.

Land use change and forestry

Myanmar Agenda 21 has identified the following program areas in the forestry sector:

- ❖ Accelerate sustainable development of forest resources.
- ❖ Develop the forestry sector to meet basic needs.
- ❖ Promote efficiency in the production of forestry goods and services.
- ❖ Strengthen forestry policies, legislation and institutions.
- ❖ Enhance people's participation in forestry development and management.

Myanmar is still rich in forest resources with 52.5% of the land area being covered by forests (FAO,2003). The total permanent forest estate (PFE) in 2003 amounted to 22.4% of the country's total land area against the 30% target set in the 1995 Forest Policy. The PFE comprising of Forest Reserve and Protected Public Forest is the area where forests are intended to be managed on a permanent and sustainable basis.

Unfortunately, the previous few decades had witnessed forest depletion and degradation. The main causes have been land use change and forest exploitation. Agricultural land expansion and fuel wood cuttings, most probably, have accounted for the biggest share of this context. The periodic forest-cover assessments made by the FD had revealed that natural forests were lost at the rate of approximately 107,910 ha per annum during the period from 1975 to 1989, and at 466,420 ha annually during the period from 1989 to 1998 (Tint, K.,2008)

In order to check and reverse this trend of forest depletion and degradation, FD has strengthened its structural and legal capacities. Forest Law was updated in 1992, the National Forest Policy adopted in 1995, and the participatory forest management boosted through promulgation of the 1995 Community Forestry Instructions (MOF,1995). To ensure forest and environmental restoration and prevent desertification in the central dry zone, the Dry Zone Greening Department was formed in 1997. Afforestation and reforestation have been speeded up. Permitting forest lands to the private sector to establish teak and other forest plantations by the Government in 2005 has been a breakthrough in the history of forest management in Myanmar. Private companies and individuals have now been very actively undertaking forestry activities.

From the climate change perspective, it is vital to improve and sustain forests as they are the sources and the sinks of CO_2. Both GHG inventories conducted in 1990 and 2000 had testified that Myanmar was a net sequester in terms of CO_2 emissions.

GHG emissions and removals in the land-use change and forestry sector as estimated by the two inventories are presented in (Table 9.7).

Table 9.7: GHG emissions and removals in the land-use change and forestry sector as estimated by the two inventories are presented in

Year	CO_2 emissions (Gg)	CO_2 removal (Gg)	Net CO_2 emission (Gg)	CO emission (Gg)	CH_4 emission (Gg)	N_2O emission (Gg)	NOx emission (Gg)	CO_2e total emission (Gg)	CO_2e total net emission (Gg)
1990	63,586	72,988	-9402	-	118.67	0.82	-	66,332	-6,656
2000	33,656.51	142,221.19	108,564.68	2,215.37	144.85	4.26	34.08	40,404.86	-101,816

Source: (1) Asian Least Cost GHG Abatement Strategy (ALGAS) Project 1997
(2) National GHG Inventory for Myanmar INC 2000

Table 9.8: Policy measures addressing forestry issues for integration into national and sectoral development plans and programs

Policies, Strategies and Actions:
Policies:
1.Promote carbon sequestration through sustainable forest ecosystem development. 2.Change of land use to be preceded by EIA in accord with broad National Land Use Plan. Strategies: 1.Introduce private forestry. 2.Manage state and non-state forest ecosystems in a sustainable manner. 3.Intensify re-afforestation programs. 4.Promote community forestry and urban tree planting. 5.Encourage manufacture of long lasting value added forest products. 6.Develop national land use plan; Let EIA precede any major land use change.
Actions:
<u>Mitigation Measures:</u>
1.Protect existing forests effectively. 2.Expand forest extent, increase forest density and growth. 3.Maintain structural diversity of forest and species mixture. 4.Restore depleted and degraded forests by planting and natural regeneration. 5.Conserve biological diversity and productivity with emphasis on genetic diversity. 6.Expand Protected Areas System. 7.Recover and conserve endangered species, and protect habitat loss and deterioration . 8.Avoid clear felling of forest in timber harvest, practice reduced impact logging and restore harvested areas. 9.Increase advocacy and educate public on Community Forestry (CF). 10.Apply systems such as agro-forestry or aqua-forestry to establish CFs to ensure early incomes for the users and thus, attract their participation. 11.Continue the annual free distribution of tree seedlings for roadside and urban greening and consider incentives to ensure the survival of the planted trees. 12.Meet forest-related human needs. 13.Develop technologies for manufacturing superior quality end-use forest products for extended use. 14.Encourage the increased use of wood in place of fossil-fuel intensive construction materials. 15.Strive for development and implementation of national land use plan to sustain permanent forest estate. 16.Conduct EIA and thorough cost-benefit analysis prior to deciding any major land use change.
<u>Adaptation Measures:</u>
1.Enrich and sustain biodiversity. 2.Develop climate-resilient genetic strains. 3.Practice multi-culture and structurally complex forest ecosystems management. 4.Intensify mangrove re-afforestation in coastal zones. 5.Establish an efficient fire fighting mechanism. 6.Promote private and community forestry. 7.Enhance public awareness and participation in forest protection, conservation and development. 8.Educate public on climate change concerns.

In both inventories the forestry sector was found to absorb CO_2, amounting to 72,988 Gg in 1990 and 142, 221 Gg in 2000.

If the current annual deforestation rate estimated at about 400,000 ha cannot be controlled, the sequestration effect detected in the year 2000 will disappear in the not very distant future.

In this context, the policy measures presented in Table 9.8 have been identified for integration into the national and sectoral development plans and programs. The vision is sustainable forest ecosystem management to be realized with understanding, cooperation and coordination of all related ministries and organizations and through public participation.

Waste sector

Context

Since the inception of the market-oriented economic system in 1988, urbanization has accelerated in big cities due mainly to enlarging employment opportunities in the private sector. The population of Yangon City increased from 2.5 million in 1983 to 4.1 million in 2003-04, and in Mandalay from 532,949 in 1993 to 856,264 in 2003. To accommodate the increasing urban population and to relocate urban squatters, the Government created many satellite towns throughout the country. The increasing population, improved economy and rapid industrialization have been causing increased waste generation especially in big cities.

A wide range of chemicals, metals, fuels and other materials used in industrial processes will generate hazardous wastes. If not properly disposed and treated they will pollute environment and cause health hazards. Serious environmental pollution can occur due to the discharge of waste and effluent particularly by chemical plants.

Waste collection and disposal are the responsibility of the local municipal authorities in Myanmar. "In Nay Pyi Taw, Yangon and Mandalay, autonomous City Development Committees and their Pollution Control and Cleansing Departments (PCCDs) with a network of branches and sub-units are tasked with solid waste management within their municipal areas. In other parts of the country Township Development Committees under the Department for Development Affairs (DDA), Ministry of Progress of Border Area Development and National Races and Development Affairs (MPBND), manage municipal waste collection and disposal. This makes DDA responsible for 323 out of 325 townships in Myanmar" (Draft EPA Report, March 2006).

In spite of the rising GDP in the country, the per capita waste generation had decreased during the period from 1983 to 2004 probably due to the waste collection fees charged by waste volume. Daily per capita solid waste generation in Yangon had decreased from 0.405 kg in 1983 to 0.287 kg in 2006/2007, while it is constant at 0.53 kg in Mandalay. The volume of waste generated in other cities in the country remains to be investigated.

A study conducted by YCDC in 2003 has found that solid waste contained 77% food refuse, 7% paper and textile, 13% plastics and 3% other substances. Daily waste generation in Yangon increased three folds from 564 tons in 1990 to 1,324 tons in 2007. YCDC still needs to control and investigate the effects of liquid waste disposed from 26 chemical factories located along water courses on the quality of river and stream waters.

To date all wastes collected by the municipality were dumped at the designated dumping sites. Although solid waste collection and disposal have improved considerably particularly in Yangon and Mandalay, waste treatment and recycling has been very negligible.

Table 9.9: CH_4 emissions in the waste sector in years 1990 and 2000

Source	1990	2000
Solid waste (Gg)	108.92	133.31
Domestic and commercial waste water (Gg)	0.978	1.198
Sludge (Gg)	0.0482	0.059
Total CH_4 emission (Gg)	109.95	134.57
Total CO_2e emission (Gg)	2,308.95	2,825.97

Source: (1) Asian Least Cost GHG Abatement Strategy (ALGAS) Project 1997
(2) National GHG Inventory for Myanmar INC 2000

Although Myanmar does not have a specific policy target on solid waste management, the country, through its Pollution Control and Cleansing Department has developed by-laws giving considerable focus to waste management YCDC.

A comparison of GHG emissions in the waste sector as estimated by the 1990 and 2000 inventories is presented in (Table 9.9). Both inventories estimated CH_4 emissions only.

As seen in the above table CH_4 emission from waste has increased by about 140 GgCO_2e in the ten years from 1990 to 2000. The emission will certainly assume an upward trend with the improving economy coupled with increasing industrialization.

In order to address the issue of potentially rising GHG emissions in the sector, the policy measures have been identified and presented in (Table 9.10). They should be integrated into the national and sectoral development plans and programs.

Table 9.10: Policy measures to address rising GHG emissions in the waste sector

Policies, Strategies and Actions:
Policies:
Strengthen "Green and Clean Country" campaign to make the country green and clean reducing GHG emissions and environmental pollution.
Strategies:
1.Minimize per capita waste generation 2.Recycle waste 3.Generate heat and electricity from waste 4.Advocate self-cleanliness and public hygiene, and 5.Enforce "Polluter Pay System"
Actions:
<u>Mitigation Measures:</u> 1.Reduce the volume of waste per capita; 2.Categorize waste and dispose it properly at designated landfills; 3.Collect fees for waste disposal (polluter pay system); 4.Fine heavily those who throw wastes recklessly; 5.Eliminate the use of polyethylene bags; 6.Expand waste treatment facilities, i.e. for landfill, compost and burning; 7.Produce biogas for electricity generation at sewage treatment facilities; 8.Encourage waste recycle and waste reuse; 9.Promote market opportunities for recycled waste products; 10.Enforce regulations and standards for waste management to ensure environment free from pollution

Chapter 10 Information and Networking

10.1 Introduction

10.2 Assessment and enhancement of information communication technologies

10.3 Establishment of information networks

Chapter 10
Information and Networking

10.1. Introduction

The availability and dissemination of appropriate and up to date information on climate change are essential for promoting public awareness on the climate change issues and for taking effective actions to address the problems. In most of the developing countries, only a few people and organizations have access to climate change information technology and communication facilities. There is limited capacity to disseminate the information that is available. There is also a lack of coordination and net working among the various stakeholders. Coordination and networking among the government departments concerned are also weak. Climate change problems cannot be tackled by a few stakeholders or by a few government departments. Climate change mitigation and adaptation measures call for effective cooperation, coordination and networking among all the stakeholders.

10.2. Assessment and Enhancement of Information Communication Technologies

Information communication technologies (ICT), such as internet, website and email is essential to ensure efficient exchange and sharing of information both within and outside the country. Some of the gaps that are usually found in this respect include inadequate quantity of computers, difficult access to internet and inadequate information networking.

The ICT assessment survey conducted by the INC project indicated the following:
Although there is a considerable number of desktop computers, there are only a few laptops in most of the government departments. Some organizations have only one or two laptop computers. With respect to communication facilities, some have internets but not all the departments have websites. Email is used to a considerable extent.
There are some restrictions in the use of internet and website. The existing ICT facilities are not adequate and there are only a few experts in ICT in most of the government departments and organizations. ICT related trainings are given locally; but it is necessary to provide further trainings on a regular basis to update and upgrade the local ICT experts. Most organizations need more computers, laptops, scanners, color printers, plotters, climate change related software programs, access to internets, and trainings.

It should be noted that in recent years there is a considerable progress in the use of ICT in both private and the government sectors. Computers, e-mails and internets are being increasingly used by private companies and organizations as well as by many individuals. Schools, colleges, universities are also promoting the use of computers. Computers and software companies and ICT related businesses such as internet café have been gradually expanding in the cities especially in Yangon. Promotion of ICT has been undertaken jointly by the private computer associations and the government.

However, there still remain many gaps and drawbacks in the development of ICT. Infrastructures and administrative capacities also need to be strengthened.

Thus, there is a great need to address these problems to enhance ICT in Myanmar. Institutional strengthening, including human resource development related with ICT is needed in almost all the government organizations.

10.3. Establishment of Information Networks

Climate change information network is essential as it could promote the exchange of important information on climate change and enhance cooperation and coordination among the stakeholders in addressing climate change issues.

In order to promote networking among the INC project team members, the internet facilities have been provided to the project teams under the project.

One of the important activities under the INC project is the establishment of a climate change information network. The climate change information network has been officially established by the MOECAF with twenty five network members including focal points nominated by various government departments such as Meteorology and Hydrology, Forestry, Agriculture, Irrigation, Fisheries, Energy, Electrical Power, Industry, Livestock Breeding and Veterinary, Education, Health, etc.

NGOs are also included in the network. The network members relay information relating to climate change mitigation, adaptation and disaster preparedness programs and activities undertaken by their respective organizations.

The MOECAF has also established a website under this project. Training relating to the use of website had been conducted for the officers and staff of the MOECAF by a local company.

Exchange and sharing of information with international, regional and sub-regional information networks would be useful for Myanmar in developing appropriate policy, plans and programs related with climate change.

As approved by the government, the present INC report as well as several other thematic reports prepared by the project teams under the INC project will be uploaded to the project website www.myanmar-unfccc-nc.net.

It has been mentioned earlier that there are several drawbacks in the use of internets and websites. Restrictions in the use of these facilities, frequent power failures and difficulties in accessing internets could hinder effective and meaningful participation in and contribution to sub-regional, regional and international climate change information networks.

Nevertheless, it should be noted that essential foundations have been laid under the INC project which would enable Myanmar to enhance climate change information sharing and networking both inside and outside the country.

Chapter 11 Capacity Building

11.1 Capacity-building needs assessment

11.2 Capacity-building Strategy

11.3 Enhancement of international negotiation skills

Chapter 11

Capacity Building

Capacity building with respect to climate change is considered to be a process seeking to build, develop, strengthen, enhance and improve existing scientific and technical skills, capabilities and institutions to prevent, mitigate and adapt to climate change and its impacts. According to the decision 2/CP. 7, capacity building is a continuous and progressive process, the implementation of which should be based on the priorities of the developing countries.

The developing countries are aware of the fact that all Parties to the UNFCCC have common but differentiated responsibilities to address climate change. But, the developing countries, particularly the least developed countries have limited capacities in terms of finance, technology, man-power and institution to undertake the enormous task of mitigating climate change and adapting to its impacts. Moreover, there are numerous capacity gaps, constraints and needs in meeting their obligations and commitments to the UNFCCC including the preparation of national communications.

In order to meet their commitments to the Convention and to address the climate change and its impacts, the developing countries need capacity building for which they have to secure cooperation and support of the international organizations and the developed countries especially the Annex II countries stated in the UNFCCC.

11.1. Capacity Building Needs Assessment

Being a least developed country, mitigating climate change and adapting to its impacts are no easy tasks for Myanmar. Capacity building is greatly needed at every level and in all aspects of addressing climate change. Human resources and scientific, technical and institutional capacities must all be developed and strengthened.

A capacity building needs assessment survey was carried out under the present INC project with a view to identifying areas that are in critical need of capacity building. The survey could not cover all the areas identified in the " Marrakesh Accords" such as institutional capacity building; capacity building under the CDM; development of human resources; technology transfer; national communication; adaptation; public awareness; coordination and cooperation; and decision making improvement. However, the needs assessments covered human resources/manpower development training, technology enhancement training, environmental protection training and other trainings addressing climate change issues.

The assessment survey was made by means of "Capacity building needs assessment" questionnaires distributed to various government ministries and departments, and local NGOs. The information provided by that survey has been summarized in Table 11.1.

Table 11.1 : Capacity building needs assessment

S.N.	Ministries and Organizations	Man-power training needs (Human resources development) Fellowship & scholarship for long term, short term and informal training		Technology capacity building needs
		Specialized training	General training	(Needs for technology transfer)
1	Ministry of Industry (1)	Trainings on : - Cleaner production of cement; Sustainability of bamboo for pulp and paper making; Reducing GHG emission in textile manufacturing; Pollution control in food processing	Trainings on : - Industrial safety; Environment conservation; Climate change Issues; EST; Carbon trading	Water, steam and energy saving technologies related with the use of boilers; Eco cement production technology; Low energy cement production technology
2	Ministry of Industry (2)	Trainings on : - New and Renewable energy and emission control; Energy efficiency; Ozone Depleting Substance (ODS)management; Industrial waste water treatment	Trainings on : - Environmental management; Industrial Standards and pollution control; **Environmental Impact Assessment (EIA)** for industry; Carbon trading; Negotiation skills; EST; Disaster management (Local training)	Process control technology/ Automation; Ozone Depleting Substances (ODS) substitutes technology; Post harvest technology; CNG and Dual fuel engine technology; Precision Cleaning
3	Ministry of Science and Technology	Trainings on : - Large scale bio energy production from algae **(Algenol)**; Fuel Cell; GIS and Flood mapping; Self cleaning concrete	Trainings on : - Environmental Monitoring techniques; EIA	Algae Taxonomy; Fuel Cell Technology; Self cleaning concrete technology/ Nano technology
4	Ministry of Electrical Power (1)	Trainings on : - Disaster proof design of hydropower projects; Installation and maintenance of power plants using coal	Trainings on : - Global Warming and Climate Change issues	Technology for designing environmentally friendly hydropower project/ especially flushing facilities, fish and aquatic migration ladder, energy dissipation technologies; Technology for
5	Ministry of Electrical Power (2)	Trainings on : - Combined cycle power plant; Efficiency in electricity use	-	Combined Cycle technology

6	Ministry of Mines	Trainings on : - Recycling of minerals and metals; Treatment of mining wastes; Biomass energy; post mining and land use management; Reducing harmful gases in the environment; Extraction of minerals from ore; Treatment of acid drainage rocks in the mining sector	Trainings on : - Environmental management; Environmental pollution monitoring	Technology for analysis of toxic waste; Technology for extraction of metals from mineral wastes; Technology for control blasting and Dust control system
7	Ministry of Environmental Conservation and Forestry	Trainings on : - Estimation of forest carbon by forest inventory and satellite data	Trainings on : - Climate change; EST; carbon trading; Negotiation skills; Environmentally friendly method of teak extraction	Remote sensing and image classification Equipments for biomass measuring (inventory) and carbon detection
8	Ministry of Energy	Trainings on : - Preventing desertification in the Dry Zone (Local training); Euro Asian research and training in climate change management (CLIMA); **Chlorofluorocarbon** (CFC) recovery	Trainings on : - Climate Change issues; Negotiation skills; Sustainable agriculture	Galileo TP for CFC recovery
9	Ministry of Cooperatives	Trainings on : - Climate change & its impacts on rural livelihood; Market-based instruments for environmental management	Trainings on : - Climate change issues	Recycling technology for biological wastes such as plant residues, food scraps and paper products;
10	Ministry of Livestock and Fisheries	Trainings on : - Methane gas reduction from livestock sector	Trainings on : - Environmental science; Waste treatment; CDM; Negotiation skills; EST	Methane gas reduction technology, Solid waste and waste water treatment technology
11	Ministry of Health	Training on : - Environmental health risk assessment; Air quality monitoring		Technology for air quality monitoring; Technology for measuring GHG gases

Table 11.1 : Capacity building needs assessment

12	Yezin Agricultural University	Trainings on : - Formulation of National Least Cost GHG Abatement Strategy; GHG inventory and mitigation options analysis; Development and Transfer of Environmentally Sound Technologies (ESTs) in Agriculture; Climate change mitigation through sustainable agriculture; Climate change impacts on agriculture sector	Trainings on : - Climate change issues; CDM & carbon trading; EST training	Technology for measuring methane flux in flooded rice fields; Nutrient management technology; Technology for minimizing potential harmful N_2O emission in different agro-ecosystems; Technology for producing Bio-energy from biomass
13	Myanmar engineering Society(MES)	Training on:- Emission reduction; Cleaner production; ISO 14000 series	Training on :- EIA : EMS ; Waste management; Laboratory analysis and instrumentation	Technology for wastewater treatment
14	Myanmar Academy of Agricultural, Forestry, Livestock & Fishery Sciences	Training on:- Upland farming system ; Dry land farming system ; Assessment of Biodiversity crop residue and its effects on environment; Planting techniques to adapt to climate change	Carbon trading ; Greenhouse gases ; Clean environment; Project formulation, implementation on Afforestation and Reforestation under CDM (ARCDM)	Technology for monitoring changes in Fauna and Flora due to climate change; Selection of plant species that can adapt to climate change; Technology for Upland farming system; Technology for dry land farming system; Technology for Bioenergy production and utilization; Technology for animal
15	BANCA (Biodiversity and Nature Conservation Association)	Training on: - Reduction of Emission on Deforestation and Degradation (REDD)	Negotiation skills	Technologies related with REDD
16	Forest Resource, Environment Development & Conservation Association (FREDA)	All trainings related with climate change		

The capacity building needs assessment high-lighted the needs of the institutions and organizations in terms of man-power training, technology capacity building, and institutional capacity building etc.

With regard to the development of human resources, a large number of organizations are interested to have general trainings on climate change issues in order to promote awareness on climate change matters and their impacts. Such trainings would draw greater public attention on climate change and could organize people and institutions to take necessary measures to prevent and mitigate global warming and climate change and adapt to their impacts. The trainings that the majority of organizations proposed include: global warming and climate change issues and their impacts; environmental management including waste management; environmentally sound technologies (ESTs); clean development mechanism (CDM) and carbon trading.

A large number of organizations are interested in solar power technology and its related trainings. At the same time, bio-energy and bio-fuel technologies and the related trainings are also requested.

There is an urgency to introduce cleaner boiler technology and related trainings. Information and trainings on environmentally sound technologies are also essential.

Capacity building in terms of developing ICT and R&D would also greatly facilitate in addressing climate change. Capacity building and trainings related with GHG inventory, Technology Needs Assessment (TNA) and Vulnerability and Adaptation Needs Assessment (V&A assessment) have also been requested by several organizations and institutions.

The capacity building needs assessment has found that there are different kinds of specific capacity building needs from different organizations and industries. For example, the Ministry of Industry (1) needs technologies as well as trainings related with cleaner production of cement; efficient and cleaner boilers; reduction of GHG emission in textile manufacturing etc. The Ministry of Livestock and Fisheries stated that it needs technologies and trainings on methane gas reduction from livestock sector. The Ministry of Health requires technologies and trainings o air quality monitoring. The Biodiversity and Nature Conservation Association (BANCA) needs technologies and trainings related with Reduction of Emission on Deforestation and Degradation (REDD).

According to the capacity building needs assessment, it is found that there is a requirement for most of the ministries to improve the understanding and awareness on their specific capacity building needs. It is important that the capacity building program in Myanmar aptly addresses the gaps and needs of the country. Moreover, the capacity building needs assessment should be made periodically.

11.2. Capacity Building Strategy

The following approach or strategy has been identified for initiating capacity building process in Myanmar. The strategy involves three steps. These are –

Step1. Capacity building needs assessment
Step2. Identification and formulation of priority capacity building projects
Step3. Mobilization of funds and other resources for implementing the Capacity building projects

The capacity building needs assessment should include: institutional capacity building; capacity building under the CDM; development of human resources; technology transfer; national communication; adaptation; public awareness; coordination and cooperation; and improvement in decision- making.

The capacity building needs assessment would indicate various kinds of capacity-building needs. In prioritizing and identifying the capacity-building projects the following factors may be considered;

❖ Needs that are common or similar: Capacity building needs assessment will show that there may be high, medium or low demand / needs for certain kinds of capacity- building. It will also show the kinds of capacity- building needs that the majority of organizations require. It is important to select and address those capacity building needs that the majority of organizations prefer.

- ❖ Needs that are technically and financially feasible: The capacity building needs that the majority preferred may not always be technically or financially feasible. For example, high-tech solar power or high-tech air pollution monitoring stations. In this respect, priority should be given to address those needs that are appropriate technically as well as financially.
- ❖ Needs that are urgent: Urgency of needs is another important factor to be considered in prioritizing capacity-building projects. For example, there are many industries in Myanmar with old boilers that are not only polluting but with very low safety standards also. Therefore, there is an urgency to introduce cleaner boiler technology and related trainings.
- ❖ Formulation of pilot /demonstration projects: Once the most appropriate and feasible capacity building projects have been identified and selected, formulation of these projects can be done. Here, it is important that the project proposals clearly describe the capacity build-ing needs; technology needs and related trainings; funding needs; expertise; and the expected tangible results. It is crucial that the capacity-building projects provide an essential foundation and support upon which necessary measures and actions can be developed to address climate change.

Mobilization of resources including funding and technical support is an important part of the capacity-building strategy. The Global Environment Facility (GEF) provides financial support through GEF Trust Fund and the Special Climate Change Fund (SCCF). The Least Developed Countries Fund (LDCF) provides funding support for the urgent and immediate needs of the least developed countries. The SCCF, the LDCF and the GEF Trust Fund's Strategy Priority for Adaptation (SPA) provide funding under the "capacity building, coordination and policy" category.

Projects can be proposed through one of the ten GEF agencies. These are the UNDP, the UNEP, the World Bank, the African Development Bank, the Asian Development Bank, the European Bank for Reconstruction and Development, the Inter-American Development Bank, the FAO, the IFAD and the UNIDO. The UNEP mainly provides technical support for the projects. Funding can also be sought under various Kyoto Protocol mechanisms such as CDM, Joint Implementation (JI) and also through emissions trading.

Mobilization of technical resources/ support is also essential. Consultancy, expert services and trainings are the main components of the capacity-building projects.

The Capacity building Strategy can be applied on a national scale or on a sector-wise basis. As new and better technologies are constantly being developed, climate change related capacity building should be carried out on a continuous basis in order to effectively address global warming and climate change threats.

11.3. Enhancement of International Negotiation Skills

The developing countries especially the LDCs have limited skills with respect to international climate change negotiation. These countries have been attending the international climate change conferences such as the Conference of the Parties (COP), regional and sub-regional climate change conferences, seminars, forums and workshops. However, they have been unable to contribute much to the international climate change negotiations. It could be mainly due to the lack of experience in negotiations, lack of expertise on climate change, limited knowledge on climate change issues and language barriers. In order to be able to actively participate in the climate change negotiation conferences and to express their problems and needs for addressing climate change and adapting to the climate change impacts, capacity-buildings in these areas are greatly needed. This could greatly benefit the developing countries, particularly the CLMV countries (Cambodia, Laos PDR, Myanmar, Vietnam) in the ASEAN region.

A seminar on international negotiation skills was held in Yangon to enhance negotiation skills of the departmental personnel concerned with climate change matters. A retired ambassador from the Ministry of Foreign Affairs with wide experience and knowledge in international negotiation skills conducted the seminar. Such seminars and workshops strengthen the technical capacity of the participants, and as such they should be convened frequently.

All personnel working in the field of climate protection and resource conservation are needed to participate actively in the international climate change negotiation conferences.


Chapter 12 Other information considered relevant to the achievement of the objective of the Convention

12.1 Introduction
12.2 Programs and activities undertaken under various UN environmental conventions that are relevant to the achievement of the UNFCCC
12.3 Additional information considered relevant to the achievement of the objectives of the UNFCCC

Chapter 12

Other information considered relevant to the achievement of the objective of the Convention

12.1. Introduction

Apart from the programs and activities that are required by the UNFCCC to be undertaken by a party to the Convention, there are several other environmental protection and conservation activities carried out in Myanmar which could directly or indirectly contribute towards addressing climate change and achieving the objective of the Convention. It may be useful to mention some of the important activities being undertaken in Myanmar, especially those that are being implemented under some of the UN environmental conventions to which Myanmar is a party. Additionally, there are other programs and activities that are also relevant to the objective of the UNFCCC. These include organizational improvements such as emergence of an environmental committee and local non-governmental environmental organizations; international environmental cooperation including the conduct of air quality surveys supported by UNEP and participation in many of the UNFCCC Conferences of the Parties (COP); and natural disaster preparedness programs. These activities are in many ways complementary and supportive to those programs that are essential for achieving the objective of the Convention.

12.2. Programs and Activities Undertaken under Various UN environmental conventions that are Relevant to the Achievement of the UNFCCC

United Nations Convention to Combat Desertification (UNCCD) related programs and activities

In Myanmar, land degradation occurs in several areas and this is due to various causes. Land degradation in the central Myanmar known as the Dry Zone is mainly caused by low rainfall, water shortage, deforestation, improper method of cultivation and over-grazing among others.

Myanmar acceded to the UNCCD in January 1997. Even before acceding to the UNCCD, Myanmar has been implementing several projects to combat desertification and drought in the country especially in the semi-arid areas of central Myanmar. In 1994, the Forest Department implemented a special greening project for the nine districts which have been affected by drought, water shortages, and land degradation. During the 3-year project period, 7,280 ha of forest plantations were established in the degraded forests, on denuded lands and in the vicinity of the villages to stabilize environment, restore forest cover and meet basic needs of the local communities. The project area was extended to 13 districts in three Regions, namely Mandalay, Sagaing and Magway, with the formation of a new Dry Zone Greening Department in 1997.

The Dry Zone Greening Department plays a key role in combating desertification in Central Myanmar with special mandates to undertake intensive re-afforestation, to protect, conserve and improve the residual natural forests, to develop water resources, and to develop and encourage use of wood fuel substitutes. Forest plantations have been established in the deforested and degraded areas. The total area planted during the period 1994-1995 to 2005-2006 has reached 117,414 hectares. Currently, there are 140 dams constructed in the Dry Zone with watershed areas of 4.5 million hectares.

The Forest Department has also been taking measures to upgrade the social and economic status of the local people by promoting the practice of community forestry, agro-forestry, and proper grazing, and by providing water supply and creating income generation opportunities. Use of wood fuel substitutes has been encouraged through distribution of briquettes and energy efficient cook stoves.

Rehabilitation and reforestation of mangroves are also being carried out in the Ayeyarwady delta where large areas of mangrove forests have disappeared due to over-exploitation. These activities have been intensified in the wake of the Cyclone Nargis not only by the Forest Department but also by the local NGOs together with the cooperation and contributions from the international NGOs.

A 30-year comprehensive Master Plan for the period from 2001-2002 to 2030-2031 is being implemented. At its end the following tasks will be accomplished in the Dry Zone:

- Forest plantations for village firewood supply, watershed protection, research and other purposes will have been established on 0.42 million hectares (1.05 million acres);
- The remaining degraded forests on 0.73 million hectares (1.8 million acres) will have been rehabilitated and conserved;
- 1.5 million energy efficient stoves, about 400 million briquettes, and 210 tons of agricultural residues as substitutes for firewood will have been distributed; and
- 6,400 ponds, 150 artisan wells, and 150 water pumping stations will have been constructed.

Myanmar has also formulated the National Action Program (NAP) to combat desertification. Five projects have been proposed in the NAP to be implemented to combat desertification in the country, particularly in the Dry Zone. They are -

1/ Mitigation of land degradation project,
2/ Drought mitigation project,
3/ Capacity building project,
4/ Rural development project, and
5/ Land use planning project.

It is evident that environmental issues and problems are all related and thus interactive. Deforestation, desertification, local or global warming, local or global climate change are inter-related. Thus, in addressing global warming and climate change, coordination and synergy of activities of various environmental conventions are essential. In case of Myanmar, both deforestation and desertification problems are handled mainly by the Ministry of Forestry, but to successfully combat them it needs close cooperation and coordination of the related line ministries.

The Dry Zone has now started to benefit from the greening activities with improved vegetation, improved water supply, improved soil and better climatic conditions. Thus, the project activities undertaken under the UNCCD have greatly supported and complemented the efforts to achieve the objective of the UNFCCC.

Vienna Convention and Montreal protocol related programs and activities

Myanmar acceded to the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol in November 1993.

The preparation of a Country Program was completed during 1998 and 1999. The Country Program was supported by the UNEP and coordinated by the National Commission for Environmental Affairs (NCEA). Now by MOECAF).

The program contains an analysis of the current situation with regard to the production and consumption of Ozone Depleting Substances (ODS), together with a strategy and a plan of action to be undertaken by the government. The approval of the Country Program is a precondition for financial assistance from the Multilateral Fund for investment projects and Institutional Strengthening projects. The Program was approved in November 1999 and funding was made available to Myanmar for the Institutional Strengthening project. Due to some delays the project could start only in September 2004. The project implementation was due to be completed in 2008. However, it was extended to 2010. The Institutional Strengthening project Phase 2 will begin in 2010 when its Phase 1 terminates.

Refrigeration Management Plan (RMP) was formulated in 2002 and approved by the Multilateral Fund in 2005. The RMP is to provide support to Myanmar to phase out ODS in the refrigeration and air conditioning sector. The RMP is composed of three components: (a) Preparation of ozone regulations for control of ODS; (b) Monitoring implementation of RMP activities; and (c) Establishing conversion practice of domestic refrigeration. A Memorandum of Understanding (MOU) on the Preparation on ozone regulations for the control of ODS, and Monitoring implementation of the RMP was signed in 2008. The MOU on provision of services and data collection for the formulation of the Hydrochlorofluorocarbons (HCFCs) Phase out Management Plan (HPMP) has also been signed.

Today, Myanmar has successfully phased out CFC consumption in all sectors. Awareness promotion activities on protection of the ozone layer, training programs for refrigeration and air conditioning service technicians, and training programs for enforcement officers have also been conducted.

Measures taken by Myanmar to implement the Vienna Convention and the Montreal Protocol are important activities that will help reduce the emissions of ODS , save the ozone layer and at the same time make positive contribution towards addressing global warming and climate change.

Convention on Biological Diversity (CBD) related programs and activities

All over the world, there is an increasing loss of biological diversity due to increasing social and economic pressures. Today, climate change is also posing threats to the biological resources. Conservation of biological diversity has therefore become a big challenge for all nations around the globe. The CBD can play an important role in addressing the loss of biodiversity.

The efforts to conserve biological diversity have positive impacts on addressing climate change. For example, establishment of protected areas, forest reserves and natural parks to protect wildlife and habitats help conserve forests which constitute sinks and reservoirs of carbon dioxide.

Myanmar's efforts for the conservation of biological diversity are summarized as follows:

The "Protection of Wildlife and Wild plants and Conservation of Natural Areas Law" was promulgated in 1994 in order to protect endangered species of wild flora and fauna and their habitats.

Myanmar Forest Policy (1995) was formulated mainly for safeguarding soil, water catchments, ecosystems, biodiversity, and plant and animal genetic resources, scenic reserves and natural heritage sites.
Myanmar ratified the CBD in November 1994.

Myanmar acceded to the Convention on International Trade in Endangered Species of wild flora and fauna (CITES) in 1997.

Myanmar's first national report was prepared in accordance with the CBD guidelines for the third national report and was submitted to the CBD secretariat in 2005. Its second national report was submitted in 2009. It was prepared in line with the CBD guidelines for the fourth national report.

Myanmar ratified the Cartagena Protocol on Biosafety in 2008. National Biosafety Framework is now being drafted.
Within the Bali Strategic Plan for Capacity Building and Technical Support, the NCEA is now initiating the development of National Biodiversity Strategy and Action Plan (NBSAP) with technical support from UNEP Regional Office for Asia and the Pacific (UNEP-ROAP).

Conservation of biodiversity calls for protection of the habitats mainly forests, so that by implementing the CBD, forests are being protected and conserved.

In Myanmar, the protected areas have increased rapidly since becoming a party to the CBD. By the year 2009, about 4.35% of the country area has been notified as protected areas against its 2010 target of 5% . To date, 34 protected areas, 3 zoological gardens, 1 botanical garden and a national herbal park have been established across the country.

Forests play an important role in carbon sequestration and climate stabilization. Thus, it is clear that the implementation of CBD is supportive to achieving the objective of the UNFCCC.

12.3 Additional Information Considered Relevement of the Achievement of the Objective of the UNFCCC

Organizational improvement

Additional to NCEA which was formed in 1990 as a main policy body for environmental protection, to coordinate environmental matters in the country to act as the national focal point for environmental relations with other countries and international organizations, the Environmental Conservation Committee (ECC) was formed in 2004 to effectively and systematically carry out environmental conservation activities within the country.

The chairman of the NCEA also chairs ECC. Deputy Ministers from seven related ministries act as the committee members and as heads of the seven working committees responsible for seven States and seven Regions. These working committees make assessments of the environmental situations in their respective regions and take necessary measures to address environmental problems.The National Environmental Conservation Committee (NECC) has been reformed in 2011 as a full flash focal organization for the environment sector throughout the country and the NCEA was abolished. Moreover, to speed up its environmental protection measures the Ministry of Forestry was renamed to Ministry of Environmental Conservation and Forestry (MOECAF) in 2011.

In recent years, there has been a substantial development of the non-governmental environmental organizations such as Forest Resources Environment Development and Conservation Association (FREDA), Biodiversity and Nature Conservation Association (BANCA), Ecosystem Conservation and Community Development Initiative (ECCDI), Economically Progressive and Ecological Development (ECODEV) and Renewable Energy Association Myanmar (REAM), Wildlife Conservation Society (WCS) (country program) and several others. These NGOs have been rehabilitating forests and conserving the environment and are actively involved in the climate change mitigation and adaptation activities.

FREDA was set up in 1996 with the aim of conserving forest resources, environment and promoting sustainable development in the country. These activities are being promoted through community development and participation of the local people. FREDA is now actively promoting mangrove rehabilitation in the Ayeyarwady delta area.

BANCA was founded in 2004 to conserve the nature, primarily biological diversity though actions based on research and survey, advocacy, partnership, network building, education, people's participation and public awareness.

ECCDI was established in 2006 with the main objective for ensuring sustained environment through enrichment of biodiversity by conserving and improving natural ecosystem. ECCDI is now actively engaged in environmental restoration and community development activities for securing food, water and sanitation as well as village electrification from solar power and biogas.

ECODEV was set up in 1999 with the objective of promoting environmental governance through improving community access to environmental information and building local capacity for community forestry management. ECODEV has also involved in the implementation of the INC project, particularly in promoting education, training and public awareness raising on climate change.

REAM was founded in 1993. It is actively engaged in promoting alternative energy in several rural areas across the country. At present, REAM is undertaking a project for installing solar pumping system and other community development activities in delta area.

WCS local program started in 1996. The main activities include promotion of the protected areas and conservation of keystone species such as tiger and elephant in Myanmar.

International cooperation for addressing climate change

After signing the UNFCCC in 1992, Myanmar ratified the convention in 1994. Myanmar was one of the 12 participating countries in the Asia Least Cost Greenhouse Gas Abatement Strategy (ALGAS) project supported by UNDP/GEF and executed by the ADB from 1995 to 2000. The project made an assessment of GHG sources and sinks in the energy, forestry and land use change, and agriculture sectors setting 1990 as the base year. Myanmar ratified the Kyoto Protocol in 2003.

Regarding CDM projects, there has been cooperation between Myanmar and Japan mainly in the form of feasibility studies and demonstration projects to be undertaken under the CDM program. The Designated National Authority (DNA) of Myanmar was established in 2006 for approving proposed CDM projects and to provide information on CDM projects.

With support from UNEP, MOECAF carried out air quality surveys in Yangon and Mandalay in 2007 and

2008 respectively. These surveys were carried out in cooperation with the Ministry of Health and City Development Committees of Yangon and Mandalay.

Myanmar participated regularly in the Conferences of the Parties of the UNFCCC and in the meetings of its subsidiary bodies. COPs and all climate change related meetings had been attended mainly by representatives from MOECAF, Ministry of Foreign Affairs, Department of Meteorology and Hydrology, and from some other related ministries.

In order to make Myanmar safer and more resilient to natural hazards after the country had suffered from a disastrous cyclone Nargis in 2008 which claimed more than 138,000 lives and affected 2.4 million people, the National Disaster Preparedness Central Committee (NDPCC) was formed in the same year The Committee is chaired by the Prime Minister and has 38 members. It is the highest body for disaster management in Myanmar.

Myanmar Action Plan on Disaster Risk Reduction (MAPDRR) 2009-2015 has been prepared. It was prepared by an inter-ministerial task force comprising thirteen government ministries, Myanmar Red Cross Society (MRCS), UNDP, UNOCHA, ASEAN, and Asian Disaster Preparedness Center (ADPC). The Plan has identified projects and activities which are necessary to meet the Hyogo Framework for Action (HFA) and ASEAN Agreement on Disaster Management and Emergency Response Commitments.

As the impacts of global warming and climate change are being increasingly felt in the country, and public awareness on climate change is growing rapidly in recent years, there is no doubt that there will be more programs and activities in Myanmar for addressing climate change in the years to come.

Chapter 13 Constraints and Gaps, and Related Financial, Technical and Capacity Needs

13.1 Introduction

13.2 Development of national greenhouse gases inventory

13.3 Financial Needs

13.4 Technical Needs: Mitigation & Adaptation

13.5 Needs for capacity building

13.6 Activities for overcoming gaps

Chapter 13

Constraints and Gaps, and Related Financial, Technical and Capacity Needs

13.1. Introduction

Myanmar has several variant climate zones ranging from the temperate region of the north to the dry zone in the central part and the monsoonal belts in the northwest, west and south. As it is located mainly in the tropical region, Myanmar has a tropical monsoon climate with three seasons: the hot, the monsoon or rainy and the cool.

The country's topography has an important effect on the climate. The mountains to the north and east shield Myanmar from the much colder climate that prevails in Tibet and western China. Elsewhere the Northern and Western Hills cause heavy rainfall along their western slopes. On the eastern slopes, there is far less rainfall. Temperature records from 1901 to 1996 indicate a general warming trend, especially since 1979 and in the coastal areas, though the northeastern part of the country may have a tendency for cooling. The average temperature is 0.7 °C higher than the average recorded temperature over the last two decades in most towns and cities of Myanmar.

Myanmar lies in a climate zone, which is frequently subjected to cyclones and river flooding. Flooding, sometimes caused by cyclones, but more often by excessive precipitation in mountainous watersheds, is a regular feature of Myanmar's extensive riverine plains. Much of Upper Myanmar lies on a tectonically active zone. In most parts of the country, earthquakes are common and occasionally devastating.

13.2. Development of National GHG Inventory

Present efforts in national greenhouse gases inventory

Apart from the preliminary greenhouse gases (GHG) inventory and mitigation options assessment undertaken in the ALGAS-study based on some limited 1990 data, very limited activities on climate change have been undertaken in Myanmar. Myanmar was one of the 12 participatory countries in the ALGAS project implemented by UNDP/ GEF and executed by ADB from 1995 to 2000. The project aimed at improving the understanding and the estimates of the sources and sinks of GHG emissions, and to better assess the cost-effective mitigation options based on common and verifiable methodologies.

The ALGAS project undertook a national GHG-inventory for carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) for the base year 1990 in five source categories, namely:

(1) Energy i.e. fuel combustion, energy industries; transport: commercial institution only (residential was not considered), and others,

(2) Industrial Processes,

(3) Agriculture (i.e., enteric fermentation from domestic livestock); manure management and rice cultivation (CH_4 emission only): agricultural soils (N_2O emission only), prescribed burning of savannas and field burning of agricultural residues (CH_4 and N_2O emissions only).

(4) Land use changes and Forestry i.e., changes in forest and other woody biomass stock; forest and grassland conversion; abandonment of managed lands; and on-site burning of forest (CH_4 and N_2O emissions only) and

(5) Waste, CH_4 emission only for solid waste disposal on land; waste water treatment; others, using the IPCC- methodologies (both Reference Approach and Detailed or Bottom-Up Approach).

Based on this inventory, projections of national GHG-emissions to 2020 had been made, and the options for mitigation of GHG-emissions identified for the energy, land use change and forestry, and agriculture sectors.

Myanmar is preparing to receive some proposed projects for the financial assistance and technical support from the developed world as well as from the United Nations and international donor agencies.

Under the INC project, national GHG Inventory for direct greenhouse gases namely carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) and for indirect greenhouse gases namely carbon monoxide (CO), nitrogen oxides (NO_x) and non-methane volatile organic compounds (NMVOC), as well as sulphur dioxide (SO_2), was undertaken for the year 2000. While the database for CO_2, CH_4 and N_2O of the ALGAS project was updated, a new database for NO_x, CO, NMVOC, SO_2, HFCs, PFCs, SF_6 (where available) was established.

Relevant global and/or regional circulation models may be used to generate climate change scenarios for the region that includes Myanmar. Detailed climate scenarios for Myanmar up to the year 2100 based on "downscaling" of the outputs provided by these models will be developed to assess the vulnerability of the key socio-economic sectors to climate change. In collaboration with relevant university research groups, it is proposed to undertake the following research activities:

(a) Assessment of the effects of climate variability, as well as the impacts of increased probability of extreme weather events (flood, drought, typhoon) associated with climate change on the key socio-economic sectors;
(b) Trend analysis on precipitation patterns in Myanmar based on the best available data;
(c) Assessment of existing water resources, including underground water resources, and its implications for socio-economic development;
(d) The trends of El Nino and its impacts in Myanmar;
(e) There seems to be a decreasing trend of the frequency of storms and depressions that formed annually in the Bay of Bengal and Andaman Sea since the late 1960s. Further analysis on this aspect is needed;
(f) Assessment of the impacts of climate change on oceanographic processes and ocean productivity;
(g) Assessment of the marine ecosystems; i.e., the reef systems, for better management of reef resources which are one of the main sources of protein (food security);
(h) Development and construction of vulnerability maps for key socio-economic sectors and in key areas which are most vulnerable under various climatic scenarios;
(i) Climate change and sustainable development in Myanmar.

Cooperative efforts of the United Nations organizations, such as IPCC, UNEP, INGOs and LNGOs are important to address the climate change issues and research activities. Public awareness and education on climate change issues have to be enhanced from the very basic levels.

Information and technology of climate change related issues have to be translated into Myanmar language and disseminated to schools, universities, public libraries and government agencies. Posters, banners, leaflets and other information materials should be distributed on special occasions or events. Broadcasting of climate change information on Myanma Radio and Television Programs will be effective for public awareness. Workshops, seminars, public education and essay contests, as well as public participation programs on environment and climate change issues will be necessary to develop adaptation measures.

Climate change could have significant effects on sustainable development. Climate change will adversely affect Myanmar agriculture and fishery sectors, which are vital for food security and income generation. Public health will also be threatened by climate change. It is predicted that the incidence of malaria, dengue fever and diarrhea will increase. Performance can be assessed against national objectives and international commitments such as the United Nations Framework Convention on Climate Change (UNFCCC).

Environmental pollution and environmental hazards arise from industrialization and increased urbanization. GHG inventory and mitigation option analysis team (GHG study team), established under this INC project in January 2008, has successfully accomplished national GHG inventories for the year

2000 in energy, industrial processes and product use, agriculture, forestry and other land use, and waste sectors. GHG inventory in different sectors would be a particular initiative in the context of improving and updating the reliable data on GHG emission/ absorption in Myanmar.

Data availability constraints

Identification and removal of barriers to the application of ESTs are still needed. Accessibility of user-friendly database on ESTs, including endogenous technologies is an example of such constraints. Improvement of climate data bank should be enhanced. Climate change related papers are very few. Data and case studies have some gaps, and data on climate fluctuation and frequency of extreme anomalies are not fully available. There are no forecasts of ENSO (El Nino - Southern Oscillation) events in Myanmar. One major barrier for water resource planning is the unavailability of sufficient information and data on watershed resources. The methods used for the development of vulnerability indices and maps need to be elaborated. Information supports from various sectors are still required.

Needs for GHG inventory on a continuous basis

Report the desired data on a continuous basis. Institutional networking and coordination play a critical role to establish new data frameworks and report formats in various sectors.

Energy and industrial processes sectors constraints and needs

The energy sector is usually the most important sector in greenhouse gas emission inventories. In energy sector, GHGs are emitted from combustion of fuel and fugitive emission from fossil fuel production. During combustion, the carbon and hydrogen of the fossil fuels are converted mainly into carbon dioxide (CO_2) and water (H_2O), releasing the chemical energy in the fuel as heat. Greenhouse gas inventory for energy sector includes carbon dioxide and nitrous oxide emissions from fossil fuel combustions, methane emissions from fugitive coal mining and post-mining activities, fugitive oil and natural gas system, NMVOC from fuel combustion.

Since there are insufficient country-specific emission factors in Myanmar for emission assessment, default values suggested by IPCC guidelines are used either in net calorific value estimation or in CO_2 emission studies or in fractions of carbon oxidization. Emissions from the use of fossil fuels from international bunkers are excluded in the current national GHG estimations. Therefore, CO_2 emissions from aviation and maritime fuel burning are not accounted for in the National Inventory.

A wide variety of industrial activities produces greenhouse gases. GHG emissions from industrial processes are related to chemical and physical transformations of materials. During these processes, many different greenhouse gases, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6), can be produced as by-products of many non-energy related activities and use of greenhouse gases in products.

Key emission sources of carbon dioxide include the production processes of cement, lime, urea, iron and steel, and calcium carbide used in acetylene production. These are the major sources of greenhouse gas emissions from industrial processes in Myanmar. The total CO_2 emissions from the industrial processes in Myanmar were estimated at 248.59 Gg in 2000.

The rest of the emissions arose from glass production, urea production and carbide used for acetylene production. CO_2 emissions from cement production had a dominant share at 82 percent, the production of lime, iron & steel and production of glass and others contributed 12 percent, 2 percent, 1 percent, 3 percent, respectively.

Agriculture sector constraints and needs

Chemical-based, conventional systems of agricultural production have created many sources of pollution that can contribute to degradation of the environment and destruction of natural resource base. The misuses and excessive use of chemical fertilizers and pesticides have often adversely affected the environment and created many problems associated with (a) food security and quality and (b) human and animal health. Furthermore, the production of methane from paddy fields and ruminant animals and of CO_2 from the burning of fossils fuels, land clearing and organic matter decomposition have been linked to global warming as 'GHG' (e.g., CH_4, N_2O, and CO_2).

The major challenge is to promote a balanced and efficient use of plant nutrients from both organic and inorganic sources at farm and community levels to intensify agriculture in sustainable manner.

Livestock sector constraints and needs

Among domesticated livestock, ruminant animals are the major emitters of methane because of their unique digestive system. Ruminant animals possess a rumen or large fore-stomach in which bacteria reside and enteric fermentation occurs. As part of this fermentation, the microbes break down the feed into volatile fatty acids and other products that the ruminant animals can absorb and use to maintain body function and grow. This process enables ruminants to digest coarse plant materials that non-ruminants including humans, cannot digest. Because of this rumen fermentation, ruminant animals have the highest methane emissions among all animal types.

Based on data availability and the importance of the emission sources, methods were determined for calculating methane and nitrous oxide emissions from animal manure management systems. IPCC-tier 1 method was adopted for swine, cattle, goat/sheep, and chicken. IPCC-tier 2 method was used for the other emission sources. For the emissions inventory from the livestock sector, the Tier 1 method of 2006 IPCC guidelines was used for the calculation of emissions from cattle, buffalo and swine. Since there were no emissions factors developed in Myanmar, the default emission factors of the 2006-IPCC guidelines were applied.

Waste sector constraints and needs

GHG inventory for the waste sector mainly includes methane emissions from Municipal Solid Waste (MSW) and domestic & industrial wastewater. In rural areas and small towns, there is no systematic collection of waste and it is unexpected (haphazard). As anaerobic conditions do not develop, no methane is generated in these areas. However, in urban towns, solid waste is disposed by land filling in low-lying areas located in sub-urban areas. Due to filling of waste over the years, anaerobic conditions develop and hence these dumping sites generate large amount of methane.

In most developing countries , industrial waste is included in MSW stream, it is difficult to obtain data of the industrial wastes separately. Only a small number of countries has comprehensive waste data covering all waste types and treatment techniques . Also very few countries have data on historical waste disposal late several decades. In Myanmar , such data cannot be achieved and so default data has to be used.

Land use, land use change and forestry sector constraints and needs

Extensive environmental damages resulting mainly from both over-logging and land use change have been frequently observed in Myanmar, and virtually very few forested hilltops remain in the region. Deforestation on hilltops causes severe soil erosion, which again, makes the siltation and sedimentation happen in the lowland areas, e.g. in the reservoirs, dams and delta regions, through downstream flow. Improper land uses, such as cultivation on steep slopes, shifting cultivation without proper fallow periods and overgrazing have led to the degradation of forests. Besides, commercial oil palm and rubber plantations are one of the main causes of deforestation in some parts of Myanmar.

In situations in which population pressure leads to reduce fallow period cycles, shifting cultivation can become a major cause of forest depletion and degradation threatening the sustainability of the forest estate and forest resources. The changes in land use take place in response to various underlying factors, including population growth, economic development and poverty. The deforestation problem arises partly from the expansion of human activities in forested areas and partly from land use mismanagement. Firewood collection contributes much to the depletion of tree cover, especially in localities, which are lightly wooded. According to FAO/UNEP-estimation (1981), fuel wood, including wood for charcoal, accounts for 88% of the round wood removal in tropical Asia.

Table 13.1: Carbon emissions from forest and grassland conversion during 1990

Source/Sink	ktC
Quantity of biomass burned on site and off site (Total)	
on site	7,916
off site	7,416
Carbon released from decay of above ground biomass	1,184
Carbon released from soil	8,240
Total annual carbon release from the forest and grassland conversion	**17,340**

Overgrazing is another important factor in the degradation of forests, mainly of open forests. The problem is particularly acute in areas where forests are often the only places where livestock can find vegetation for grazing. In addition to the damage done to the vegetation cover, trampling by livestock hardens the soils, prevents wood regeneration and promotes soil erosion.

Shifting cultivation practice, in which original forests are cut and burnt, emits carbon into the atmosphere.

Myanmar Selection System offers a great advantage in reducing carbon emission because it limits minimum girths for teak and hardwood for harvest preventing severe destruction and losses of existing primary forests that serve as natural carbon sink.

Countrywide, annual deforestation has been estimated approximately at 0.3%, only slightly above the global average. Forest losses are greatest in the mangrove forests of the Ayeyarwady delta, where as much as 20% of mangrove forests disappeared in only 10 years. Agricultural expansion is driven by human population growth, and its effects on natural habitats are exacerbated by the lack of comprehensive land use policies and planning. The most important types of changes in land use to record are in the balance between forest, dry land agriculture, and irrigated agriculture. Rain-fed agriculture, grazing and degraded lands are likely to have larger levels of rainfall runoff than irrigated land, which generally has inward-sloping terraces that accumulate water. Likewise, well-managed forests reduce peak flows at the micro- and lower meso-scale.

The expansion of agriculture, forest exploitation and population growth are causing much environmental degradation. Within upland watersheds and below, landslides and floods inflict much loss of life and damage to property and infrastructure. Dam construction can inundate riverine habitats up-stream, and alter seasonal flow regimes and natural sedimentation processes downstream. Mining for gold, gems and other minerals is another major source of pollution in Myanmar.

Very few studies on carbon absorption capacity of natural forest have been conducted. Species-specific and ecological zone-specific data are still lacking. There are some reliable data of carbon absorption capacity of forest plantations in Myanmar. Most conventional inventory data emphasized on the commercial volume of the timber species (dbh>20cm). Thus, the dry matter (biomass)-based inventories for planted species should be carried out.

Substantial area of deforestation was encountered in Myanmar but the deforested area by different causes and land use change pattern cannot be traced. Inventory activities with new approaches to address the deforestation, its causes and land use changes should be conducted. Forest fires are common in dry season of Myanmar. However, most are surface fires and the litter (leaves and small twigs) are consumed during forest fires. Actual biomass burning takes place during land use change (shifting cultivation, land clearing, etc.). Reliable data on types of fire, actual area burnt annually and emission of greenhouse gases are still lacking.

Satellite images and related skills are essential for inventories. Different sectors and stakeholders (Forestry, Agriculture, Mining) have been conducting many inventory activities, but information sharing between different sectors is crucial to make the national GHG inventory comprehensive and coordinated.

13.3. Financial Needs

Financial resources for climate change outreach programs and activities are needed in Myanmar at present. As a developing country, Myanmar needs adequate and continuous financial assistance from the developed nations for long-term research projects on climate change. Myanmar's contribution to the mitigation of and adaptation to global climate change certainly depends to a great extent on transfer of technologies and capacity building, as well as on funding support from international governments, NGOs and donor agencies.

Developing countries require substantial financial assistance for adaptation, technology cooperation and mitigation. It is crucial to simplify access to the diversity of international funding sources, vertical funds, and investment opportunities, which pose a heavy burden on developing countries that are seeking to enhance national development through international financing.

Due to financial resources so far, not much has been done in Myanmar to raise the public awareness on climate change issues.

Addressing climate change will require significant changes in the patterns of investment and financial flows. It may need to redirect investments and flows from all sources to more sustainable climate-friendly alternatives such as scaling-up of international private and public finance dedicated to investment in mitigation or adaptation activities or technologies, and optimizing the allocation of the funds available by spreading the risk across private and public investors. The UN system has an important role to play in supporting and enabling developing countries to participate in the carbon market and benefit from its enormous potential as well as prepare for future funding opportunities to catalyze climate action. Myanmar should try to get financial support from the UN to address climate change in a number of critical areas including the following.

Support for access to financing by developing countries

Strengthening national capacity in developing countries to assess investment and financial flows to address climate change; creating an online interface to assist developers of adaptation programs in screening, identifying and accessing adaptation funding; case studies to help emerging economies assess the costs and benefits of less carbon-intensive options, examine financing sources and mechanisms and identify candidate projects and programs; case studies to help developing countries particularly vulnerable to climate change, assess the risks posed by climate change, design better strategies to adapt and understand the cost involved; development of technical methodologies/tools and data collection for specific sectors that facilitate developing countries' access to financial resources by helping them to meet eligibility/ verification criteria of financial mechanisms (e.g. agriculture and forestry, energy options); assistance to countries in combining/ sequencing GEF resources for policy change and leveraging new sources of finance.

Support for development and access to carbon markets

Developing the capacity of low-income countries to access the CDM through the Nairobi Framework; assisting developing countries in leveraging carbon finance for clean energy development and sustainable land use practices; exploring a number of avenues to deepen the reach of carbon finance to support long-term, climate-friendly investments (Carbon Partnership Facility) and harness new carbon finance potentials (Forest Carbon Partnership Facility); linking large-scale ongoing tree planting and afforestation programs in developing countries to carbon credit schemes.

Support to leverage private sector investment in activities addressing climate change

Facilitating finance sector engagement in climate mitigation by building financier capacity and awareness, lowering the costs and barriers of initial transactions, and supporting the development of new financial products that accelerate adoption of climate technologies and markets; equipping financiers with the tools, support, and global network; working with municipalities, small and medium enterprises and other local stakeholders to broaden public- private partnerships and engage new actors.

Support to leverage finance for energy efficiency and renewable energy

Mobilizing funds for greater energy access and security, energy efficiency and clean energy development projects in over 100 countries; improving effectiveness of public financing in catalysing sustainable energy sector growth; facilitating regional cooperation on energy efficiency for climate change mitigation.

Support to pilot innovative sources of finance and market mechanisms

Development of a voluntary global financial mechanism/portfolio approach/forest financing framework for all types of forests to support the implementation of the Non-Legally Binding Instrument on All Types of Forests and the achievement of the Global Objectives on Forests; support of efforts to customize new insurance and re-insurance products for catastrophic and climate-related risks and expand their reach; promotion of Payment for Environmental Services as an incentive for carbon sequestration/mitigation at the community level.

Mobilize new and innovative concessional finance

A new Climate Investment Funds (CIF) portfolio with an expected capitalization of about US$ 6 billion, to build on progress made by many of the developing countries, with the objectives of scaling up investments in low-carbon technologies, and supporting various programs to test innovative approaches to climate action, including for adaptation, forestry and renewable energy.

Project concept notes on GHG mitigation and adaptation projects for financing

Myanmar, as a developing country, is under no obligation to quantified reduction or limitation of greenhouse gas emission. However, Myanmar has made positive contributions to relieving the increase of greenhouse gas emission and protecting global climate by adjusting its economic structure, improving its energy efficiency, developing and using hydropower and other renewable energy.

Myanmar's forest sector plays an important role in GHG emission/reduction processes - partly because the forests can be carbon sinks if properly managed, and partly because the forests can be source of GHG emissions due to deforestation. Developed mitigation strategies aim at reducing carbon emission and increasing carbon sequestration in the forestry sector of Myanmar. Both short-term and long-term considerations are taken into account to determine the effective mitigation strategies to achieve the sustainable carbon sequestration and socio-economic responses.

Diverting unwanted agricultural residues to become energy resource supplements for use in agricultural production would reduce demand pressures on energy sources available in the country.

Most of the livestock farmers only focus on low-profile feeding strategies, and the nutritional status of livestock especially for dairy cattle are usually given only sub-maintenance ration when they are in dry period.

Expanding urbanization and growth in the number of private vehicles have degraded air quality due to smoke and gas emissions, including oxides of nitrogen and carbon. Knowledge of different options in the energy balance within the transport sector and their relationship to the overall energy balance in the country will assist in the formulation of policies and strategies for achieving sustainable energy development. The most important actions to mitigate GHG emissions during the period (2000-2030) are economic and effective use of energy and use of renewable energy.

In Myanmar, most of the municipal waste was buried in landfills and some amount of landfills increased to create urban land. Allocation of waste treatment expenses to the waste producers (volume-based waste fee system), efficient management of food waste and food waste policies for minimizing waste are needed.

Since the national inventories of GHGs indicate that the energy, forestry, land-use and agriculture sectors dominate the GHG emissions in Myanmar, the identification and analyses of mitigation options and abatement projects are focused on these sectors. Based on the year 2000 GHG inventory, fifteen abatement project profiles on GHG mitigation and adaptation are identified in Myanmar. (see Annex I)

13.4. Technical Needs: Mitigation & Adaptation

Technology needs for mitigation of climate change

Updated and improved cost-effective mitigation options assessment for CO_2, N_2O, CH_4, and new assessment of mitigation options for CO, NO_x, NMVC(Non-Methane Volatile Compound), SO_2, HFCs, PFCs and SF_6 for the year 2000, including appropriate mitigation technologies, are needed. Lack of legal and economic instruments for mitigation measures, lack of a national strategy for GHG mitigation, and lack of technical capacity in quantitative mitigation options analysis, including application of relevant methodologies as well as capacity-building are undoubtedly obvious. Technical capacity to effectively integrate V&A assessment and mitigation options analysis into sustainable development programs, and hence to develop national adaptation and mitigation programs of action is still lacking. Under the ALGAS project, a number of mitigation options have been identified for GHG emission reduction in the following sectors: energy, agriculture and land use and forestry, but largely in a rather qualitative manner.

Technology needs for adaptation to climate change

Lack of cost-effective analysis of various adaptation options, including adaptation technologies, lack of national strategy and action plan for adaptation to climate change and its related disaster prevention, preparedness and management and lack of local expertise in the field of vulnerability and adaptation (V&A) assessment and integrated assessment (including assessment modeling) are the same as in the mitigation. Studies on the vulnerability of Myanmar to climate change had not been undertaken previously, and hence adaptation strategy or action plans had not been developed.

Recognizing that little work has been done in Myanmar to conduct vulnerability assessment, all selected priority areas will require participatory rapid appraisals (PRAs) with the aim of collecting information on vulnerabilities to climate change, coping measures currently in place and possible adaptation measures. The objective of the PRA will be to identify vulnerability to the impacts of climate change, coping measures and adaptation to climate change and criteria for selecting priority coping and adaptation activities, specifically on the following sectors: water resources, coastal zones, agriculture, forests, biodiversity, energy, transport, industry and public health.

Adaptation measures that can be considered include installation of better storage facilities, drought resistant crops, effective pest and disease control programs, and generally improved agronomic practices. Other coping options that may be appropriate for Myanmar are: improved irrigation efficiency; crop diversification, improvement in agricultural extension services; and research and development on new drought-resistant crops. Cost-effective technological and policy adaptation measures that are appropriate to Myanmar should be identified. The barriers for the adoption and implementation of these measures should also be highlighted.

Policies on climate change adaptation are still needed to be addressed. Progress in the field of climate change related assessments is insufficient to obtain up-to-date situation in many aspects. There is an inadequate analysis of existing data by local expertise, such as climate variation due to ENSO event.

Inadequate computers and internet access, inadequate information networking, limited internet facility (both within and outside the country), limited climate change related information to function as a clearing house, and limited practice of sharing information among departmental personnel are most commonly obvious. Insufficient training, information and lack of experience on ESTIS (Environmentally Sound Technologies on Information System) are also constraints in this regard.

The hydro-meteorological data sets provide a long-term baseline against which the impact of change in land use and land management on water quality and quantity can be measured. This is an important source of information for understanding the impact of processes and of changes in these processes. This information reinforces much of the knowledge already available on the intensity and distribution of rainfall. Such information is useful for other researchers, in particular, for understanding issues related to global climate change.

Assessment on the development and transfer of environmentally sound technologies (ESTs) has been initiated in Myanmar and the assessment on the Research and Systematic Observation should be promoted.

Traditional water management system can no longer meet the requirements of the market economy. Thus, water management system, including the establishment of a high-level national agency for water resources management has already been formed. The available information on adverse effects of climate change in Myanmar could be compiled, synthesized and analyzed, including trend analysis in temperature and precipitation patterns as well as sea-level rise and frequency of extreme weather events.

Research by the Department of Meteorology and Hydrology shows that climate change has affected the onset and the duration of monsoon rainfall, and this would have significant implications for the water resources of Myanmar. In addition, the melting of Himalayan glaciers would affect the future water supply to the rivers: Ayeyarwady, Chindwin and Thanlwin. The impacts of climate change on water resources and its associated impacts should be assessed in an integrated manner. Adaptation measures for water scarcity and drought include water supply and demand management, improved watershed management, water conservation and increased storage of water. The proposed NAPA will review recommended adaptation measures and suggest priority options for near-term implementation.

To enhance the systematic observation and research activities, technical/ financial/ expertise support will be certainly necessary from various international/ regional organizations.

Myanmar needs to replace the existing conventional instruments with the automatic/ digital ones which will significantly reduce manual operation, and assessment of data will be carried out and transmitted to targeted points on control buttons. Human capacity development needs simultaneous undertaking so that the usual information of WMO/IPCC standard may be followed in no time. Climate change information network should be strengthened nationally/regionally and internationally. This may be achieved phase by phase.

Research works of climate change will be particularly focused on El Nino–Southern Oscillation (ENSO), tropical storms and associated hazards and droughts in Myanmar. Cross-cutting issues of climate impacts on various key national economic sectors, such as agriculture, forest, health, fisheries, energy, transport, universities and related agencies necessitate strengthening human resources in these areas.

Myanmar has signed some 30 international and regional environmental treaties and conventions, including the following:

(i) Vienna Convention for the Protection of the Ozone Layer (1985) (ratified on 24 November 1993);
(ii) Montreal Protocol on Substances that Deplete the Ozone Layer (1987) (ratified on 24 November 1993) and its London Amendment (1990) (ratified on 24 November 1993);
(iii) United Nations Framework Convention on Climate Change (UNFCCC) (ratified on 25

November 1994) and its Kyoto Protocol (acceded on 13 August 2003);

(iv) Convention on Biological Diversity (CBD) (ratified on 25 November 1994) and Biosafety Protocol (signed on 11 May 2001);

(v) United Nations Convention to Combat Desertification (UNCCD) (ratified on 2 January 1997);

(vi) Stockholm Convention on Persistent Organic Pollutants (acceded on 18 April 2004);

(vii) Convention for International Trade in Endangered Species of Wild Fauna and Flora (acceded on 13 June 1997);

(viii) The Convention for the Protection of the World Culture and Natural Heritage (1972) (ratified on 29 April 1994);

(ix) United Nations Convention on the Law of the Sea (ratified on 21 May 1996);

(x) International Tropical Timber Agreement (ITTA) (ratified on 31 January 1996);

(xi) ASEAN Agreement on Transboundary Haze Pollution (ratified on 13 March 2003) (the Agreement entered into force on 25 November 2003); Myanmar has participated in the *National Performance Assessment and Strategic Environment Framework (SEF II) of Greater Mekong Subregion (GMS)* project in collaboration with ADB, GEF, UNEP, IGES and NIES. The SEF II project, initiated in 2003, aims to promote sustainable development in the GMS through the creation of national and subregional environmental performance assessment system, as well as development of national and subregional capacities for implementing such assessment.

13.5. Needs for Capacity Building

An overview of capacity needs

Limited capacity at all levels (human, scientific, technical, technological, organizational, institutional and resource capabilities) relating to climate change issues, limited capacity in climate change negotiation, limited capacity in preparation of climate change projects for bilateral and multilateral funding, limited capacity in assessing the impacts of both technological and policy measures for mitigation and adaptation, and limited capacity in effective implementation of various multilateral environmental agreements, including the UNFCCC, are prominent barriers.

Human capacity and climate change information network should be strengthened nationally/regionally and internationally. Capacity development in the Department of Meteorology and Hydrology, universities and related institutions in the context of climate change is urgently needed.

Training needs for the development of greenhouse gases inventory

Capacity building in IPCC- methodologies for GHG-inventory is still very much needed. It is also urgently needed in V&A assessment, including training on relevant methodologies. Limited human and institutional capacities in assessing, evaluating and verifying ESTs, and inadequate human and institutional capacities in climate data monitoring are evident. Apart from some experiences gained from the participation in the ALGAS project on GHG-inventory and mitigation options analysis, Myanmar has very limited human, scientific, technical, technological, organizational, institutional and resource capabilities that the country requires to fulfill its commitments to the Convention.

The following needs for capacity building have been identified during the informal stakeholders' consultation meeting:

- ❖ There is a need for a continuing training and capacity building program that covers all major aspects relating to climate change at educational, scientific, technical, technological (mitigation & adaptation), legal and policy levels, both nationally and locally;
- ❖ Regular participation in regional and international forums to share information and experiences;
- ❖ Training in V&A assessment in the following sectors: coastal zone (including tidal movement and sea level measurements), marine resources and coral reefs, forestry, agriculture and waste management;
- ❖ Capacity building in identifying, evaluating and verifying appropriate and environmentally sound technologies;

- ❖ Capacity building in assessment of the impacts of both technological and policy measures for mitigation and adaptation;
- ❖ Training of legal officers and policy makers;
- ❖ Improvement in international negotiation skills;

Initiating programs of school education and public awareness on climate change

There are a few of outreach materials (especially in Myanmar language) on climate change issues for different target groups (general public, community, especially for children and young people, policy-makers and private sector). The need to introduce or strengthen climate change science at the primary, secondary and post- secondary levels and through non-formal public education. In school level education, it is preferable to integrate environmental issues into existing subjects in the curricula, rather than attempting to introduce environment as a separate subject.

Diagrams and illustrations should be considerably improved, both in quality and quantity, especially in the text books prescribed for the primary and lower secondary levels. Learning materials other than text books, such as handbooks, supplementary readers' and audio-visual aids need to be prepared for school teaching programs. Findings of climate change research carried out in universities and other institutions need to be continually made available in appropriate form for use by schoolteachers.

It is desirable for practical activities on climate change and environmental studies to be based as far as possible on traditional conservation practices, and to involve interaction of schoolchildren with local villagers so that they can understand the issues. Public education, awareness, and training programs need to be conducted on a large scale throughout the country with particular emphasis on areas of critical concern such as pollution, natural resources depletion and global climate change.

Formulation of the communication network among researchers, institutions and policy makers

Climate change policy, strategy and programs, as well as the integration of this policy and strategy into sustainable development are needed. Although there are some public awareness activities on climate change issues, including climate-induced disaster preparedness, it is a need to strengthen community education on climate change and disaster preparedness.

Enforcement of policy measures to integrate climate change concerns into national long-term socio-economic and environmental planning is imperative. The ex-sectoral policy conflicts often occur because of inadequate consultation between responsible agencies although these policies have significant interfaces. Adequate consultation between the concerned sectors for the harmonization of ex-sectoral policies is critical. Admittedly, communication network among researchers, various institutions and policy makers is essential.

There is also a lack of a need-based working system as a strong and demanding unit which could ensure linkages between land use capability, land carrying capacities, resource production, forest industries and marketing and integration of the forestry sector with all other related sectors of the economy so that forestry planning would contribute effectively to the overall planning process of the Government. Institutional weaknesses needing priority attention include strategic planning and policy analysis, resource management, environmental impact assessment, biological and economic research, forestry extension and establishment of inter-sectoral linkages.

Building up of a critical mass of human resources with required skills, therefore, is a basic need for any progress in the institutional framework. The formulated National Environmental Policy has elevated the profile of environmental consideration in the country. The Policy calls for harmony and balance between environment and development through the integration of environmental considerations into development process and it forms the basis for developing environmental strategies, programs and plans. Moreover, Myanmar has promulgated Environmental Conservation Law in 2012.

Climate change is a sustainable development issue that links to all socio-economic and environmental sectors. Myanmar has undertaken a few activities relating to other Multilateral Environmental Agreements (MEAs). Although Myanmar has prepared its national Agenda 21, the issue on the integration of climate change concerns into sustainable development plans and programs still remains to be addressed effectively. Indeed, the public awareness on climate change in the country is low at all levels. Access to and the use of information technology such as internet will be essential to ensure efficient exchange and sharing of information both within and outside the country. Information networking is an important activity in any project cycle.

13.6. Activities for Overcoming Gaps

Attempts have been made to estimate GHG emissions from slash and burn, especially in rural areas for the year 2000. Both the reference and the sectoral (bottom-up) approaches were used to estimate CO_2 fuel combustion emissions as recommended by the Guidelines.

The activity data of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6), which are controlled by the Kyoto Protocol, have also been collected for the same base year where available. An improved factor of CO_2 emission/sink from/to soils in Land-Use Change and Forestry in the region with similar conditions to Myanmar has been assessed and identified, as well as methane emission factor from rice fields and agricultural soils, with a view to reducing the uncertainties and enhancing the data quality in these sources and sinks.

As far as capacity-building is concerned, it would be appropriate to maximize the synergies for implementing the United Nations Framework Convention on Climate Change (UNFCCC) and other global environmental agreements, such as Convention on Biological Diversity (CBD) and United Nations Convention to Combat Desertification (UNCCD). The National Capacity Needs Self-Assessment for Global Environmental management (NCSA) project would provide a good basis for such synergies. In addition, a *Capacity-Building Strategy* that highlights the priorities and options, including the development of South-South capacity building programs, will be developed.


Chapter 14 Conclusions and Recommendations

Chapter 14

Conclusions and Recommendations

Systematic observations of the climatic and hydrological data collected at 162 observatory stations set up across the country by DMH have disclosed that the climate change has become apparent in Myanmar since year 1977: the areas with higher latitudes in northern and central parts of the country have experienced a trend of change from warming to cooling starting from 1977; there has been a general warming trend of mean annual temperatures in the whole country since 1979; the annual precipitations in most of the Regions and States have decreasing trend; coastal areas have been hit by cyclones every year since 2002 (except 2005); onset of southwest monsoon has become late and its withdrawal early. In consequence, the country has been facing increasingly the adverse impacts of climate change year by year.

Myanmar is still rich in natural resources. However, many have been depleting, due to exploitation in an unsustainable manner. To make the situation worse, the adverse impacts of the climate change speed up the resource depletion and disrupt the livelihoods of the grassroots poor, farmers in particular, who are dependent on agriculture, fisheries, livestock and forestry all of which are very vulnerable to climate extremes. The Cyclone Nargis in 2008 has very well demonstrated how vulnerable the country and the people are to the effects of the climate change.

Myanmar has proved more than being a carbon sink nation, with a net removal of 67,863 Gg CO_2e in 2000, which had been made possible by the vast forest resources. Thus, it is of vital importance that the forest resources, the only source of carbon sink and reservoir, are sustainably managed in order not to reverse the current trend of the carbon flow.

During the recent decades, in the process of developing national economy following the market-oriented economic system, the Government of Myanmar has accomplished a sizeable number of measures contributing to mitigation of and adaptation to climate change, like promoting re-afforestation and forest conservation programs, encouraging conservation agriculture, improving livestock management , fuel switching from petroleum to CNG, rapidly developing renewable energy sources such as hydro-, solar- and wind- powers. Still, a lot more remain to be done in the face of the changing climate. To successfully address this issue there are limitations to overcome in terms of finance, facilities, institutions, human capacities, public education and awareness.

To ensure the national socio-economic development continue undisturbed, the following recommendation have been identified, based on the findings of the thematic groups involved in the INC project, for timely implementation in order to address the climate change concerns that are happening and projected to happen in the Republic of the Union of Myanmar:

Energy and Transport

1. Energy efficiency and conservation, and increased use of less energy intensive products should be promoted.
2. Environmental standards for energy efficiency should be set and efficiency grades labeled on products.
3. Development of renewable energy resources such as hydropower, biomass, and wind and solar powers should be encouraged.
4. To reduce GHG emission from the transport sector, maintenance of good road networks and fuel switching from petroleum to CNG should be expedited and CNG pipelines and stations expanded.
5. Gasification from rice husk, saw dust, agricultural residues and wastes should be encouraged.
6. Development of alternative fuels and increased use of energy efficient cooking stoves are to be highly prioritized to reduce the need for wood-fuel.

7. Tap all potential power sources including renewable energy for increased power generation and utilization.

8. Bio-energy production from all available sources should be promoted without compromising food security and viability of forests and soils.

9. Upgrade existing power-generation and transmission systems.

10. Improve roads and road networks, traffic demand management and all transport modes.

11. Make all public transports more attractive and affordable.

12. Light-emitting diodes should be increasingly used for traffic lighting.

13. Energy audit should be performed

14. Raise public awareness on GHG emission reduction and energy conservation.

15. Build institutional capacity to monitor ambient air quality.

Industrial processes

1. Power supply from the national grid should be continuous and reliable.

2. Industrial zones should introduce GHG emission reduction measures such as installation of individual or central waste water treatment system, replacement of fossil-fuel engines with low-carbon fuel engines in transportation vehicles.

3. Industries should have improved access to updated EST information so as to help the industries identify the technologies most suited to them

4. The boilers, ventilation system, factory layout and waste disposable system in many factory and plants should be substantially upgraded.

5. Renewable energy resources, efficiency and conservation in energy use, fuel switching to CNG, cost-effective EST and good house-keeping practices in industries and buildings are to be improved.

6. Eco-housing and eco-transportation to save energy and raw materials initiated by the private sector should be encouraged.

7. Set high energy efficiency and environmental standards. Conduct at each industry Efficiency Audit and provide green labels and tax benefitsto the industry and the product that meet the set standards.

8. Further promote the use of CNG, LPG and renewable energies by providing incentives.

9. Introduce energy-saving and process-specific technologies.

10. Initiate the development of carbon capture and storage for energy-intensive plants.

11. Implement energy-saving regulations and improved energy management systems.

12. Construct buildings with designs to increase cross ventilation, prevent direct sunlight in the afternoon and reduce heat gains with shade covers.

13. Advocate extensively conservation of energy and utilization of cleaner energy.

Agriculture and Livestock

<u>Agriculture</u>

1. In rice cultivation , intermitted irrigation with intervals should be conducted rather than continuous flooding.

2. Sulfur-containing fertilizers, slow release nitrogen fertilizers, nitrification inhibitors and gypsum should be used instead of urea to mitigate CH_4 emission without affecting yields.

3. The selection of high yielding rice cultivars with low CH_4 emission potential could be a promising strategy to mitigate CH_4 emission.
4. Compost making and organic agriculture should be encouraged to reduce GHG emissions from biomass burning in the fields.
5. Tillage should be reduced and crop rotation practiced in rice fields.
6. "Conservation Agriculture", "Sloping Agricultural Land Technology" and other climate friendly advanced technologies should be promoted.
7. Water, crop and crop residue management should be improved.
8. Organic farming and bio-fertilizer use should be promoted and the use of chemical fertilizers reduced.
9. Fertilizers and pesticides must be applied properly.
10. Farm management including post-harvest, processing and storage needs improvement.
11. High-quality and stress-resistant plant varieties should be used and climate-resilient agriculture ensured.
12. Water impoundment systems should be expanded through clusters of smaller dams, ponds, lakes and rain water collections.
13. Dry-land agricultural technologies should be promoted.
14. More investment is recommended to strengthen climate risk reduction measures.

Livestock

1. Livestock extension services need to be strengthened.
2. Supplementary feeding of urea molasses blocks and treatment of straw with urea to dairy cattle should be promoted to reduce CH_4 emissions from enteric fermentation.
3. Access to advanced livestock breeding technologies is to be improved.
4. Improved nutritive value and digestibility of diet and provision of correct "energy to protein" ratio in the diet should be ensured in order to reduce methane emission from enteric fermentation.
5. Recycling of manure for biogas production and making compost from manure should be promoted.
6. Improved genetic varieties and improved feed conversion efficiency should be given priority in livestock farming.
7. Pasture, grassland, and forage and its quality should be improved.
8. The use and management of animal waste to harvest producer gas and to use gasification
9. Fermentation-control medicine, fermentation stabilizers and micro-organism repressors should be added to animal diets.

Land use change and forestry

1. Re-afforestation programs should be strengthened and the forest ecosystems managed in a sustainable manner.
2. Private sector involvement in establishment of forest plantation should be encouraged to enhance forest restoration and restore environmental balance.
3. Natural forest conservation and management with the participation of the private sector should be strengthened.
4. Community forestry should be widely advocated and expanded.

5. Activities based on CDM, REDD+ projects and LULUCF projects could be introduced as mitigation measures.

6. EIA and cost-benefit analysis should be conducted prior to any major forest land use changes.

7. Forest fire management should be strengthened.

8. Environmental awareness on forest conservation and utilization should be promoted.

9. Integrated land use practice among the relevant sectors should be enhanced.

10. Forest laws and regulations should be enforced more effectively.

Waste

1. Open-dumping sites need to be properly designed so that emergence of anaerobic condition will be checked.

2. Controlled incineration should be encouraged.

3. Toxic and hazardous wastewater from industries should be treated properly to avoid environmental pollution.

4. Waste-to-Energy power plants for waste combustion in the major cities should be installed and operated.

5. Producer responsibility system, volume-based waste fee system or polluter pay system should be exercised.

6. Recyclable and reusable materials should be used for packaging.

7. The practice of reducing, recycling and reusing of various items of waste should be encouraged.

8. A database on waste generation, disposal and treatment for both solid waste and wastewater should be created.

9. Biological treatment of organic solid waste should be promoted.

10. Waste should be categorized and disposed properly at designated landfills.

11. The use of polyethylene plastic bags must be discouraged.

12. Waste treatment facilities, e.g. landfill, composting and controlled incinerating burning, should be expanded.

13. Market opportunities for recycled waste products should be promoted.

14. Public awareness on proper waste management (generation and disposal) should be raised.

Meteorology and Hydrology

1. The possible extent of water stress and its likely impact on water availability and use should be studied.

2. The possible impacts of rising temperature on human health, agriculture, water resources, etc. should be observed and investigated.

3. Preparation and distribution of user friendly public information on extreme weather events should be improved both qualitatively and quantitatively.

4. More observing stations should be opened to ensure even distribution all over the country and to enable to observe climate in remote and hilly areas. The stations should be equipped with digital sensors and AWOS.

5. Preventive measures against heat stress and water stress should be undertaken not only in El Nino years but also in the preceding and following years of El Nino events.

6. Multi-hazard Early Warning Center under DMH must be upgraded to ensure the timely issuance of hazard warnings and bulletins as required.
7. Disaster risk reduction should be prioritized as Myanmar is vulnerable to climate change-related natural disasters.
8. Daily and seasonal weather forecasting should be strengthened.

Environmentally Sound Technologies

1. Information on pollution problems arising from gaseous wastes, waste water and solid wastes are to be made available through regular monitoring.
2. Awareness raising campaigns on ESTs should be increasingly conducted for industries in both public and private sectors.
3. The establishment of a user friendly data base for EST is essential for the development and transfer of ESTs to Myanmar public.
4. EST Information System (ESTIS) should be installed. Capacity building for ESTIS, particularly on-the-job training must be strengthended.

Capacity Building

1. Capacities in MOECAF, DMH, universities and related institutions concerning climate change should be enhanced.
2. Human resource development in key economic sectors should be promoted to manage climate-related cross cutting issues and their impacts.
3. Training of trainers in the context of climate change should be carried out from time to time.
4. New generations of climatologists and meteorologists, agro-meteorologists, hydrologists, environmentalists, biologists, etc., should be developed.
5. Various environmental organizations should be given opportunities for capacity building to ensure competency to cope with climate change issues.
6. Public awareness campaigns on climate change and adaptation strategies should be launched from time to time, and NGOs should also be involved in such campaigns.
7. Technical and technological capabilities in the use of ICT should be strengthened in tackling the climate change issues, and ICT trainings should be increasingly organized on a regular basis to update and upgrade the local ICT experts.
8. Climate-oriented conferences, seminars, workshops and networking as well as negotiation skills for securing necessary financial and technical support for addressing climate change issues should be promoted.
9. Technologies and related trainings on global warming and climate change issues, such as clean development mechanism (CDM), power generation from renewable energy resources should be identified as the priority capacity-building needs.

Institution

1. Basic infrastructure in industries of both public and private should be improved.
2. The existing conventional instruments at the DMH stations must be replaced with automatic/ digital ones.
3. In order to avoid data loss, it is essential to establish a centre for data archiving.
4. Data sources on which to base GHG inventory should be strengthened in order that the GHG estimates are more reliable.

5. A new ministry should be established to manage the environmental affairs more efficiently and effectively.

6. A fund raising mechanism should be created for mitigation and adaptation of climate change issues.

Research and development

1. Demonstration projects and R&D on technological innovation should be promoted.

2. Research works on ESTs and alternative fossil fuel -saving technologies should be promoted with greater investment.

3. Research and development relating to vulnerability and adaptation (V&A) to climate change has been initiated in the agriculture, livestock, fisheries and health sectors. R&D in these sectors should be promoted.

4. Research activities on climate matters are to be encouraged and networking should be established among higher education institutions.

5. Climate research should particularly focus on the areas of climate variability, climate change, tropical storms, droughts and El Nino, ENSO and La Nina in Myanmar.

6. Myanmar should participate in the development of regional systematic observation system.

7. Participation of Myanmar researchers and field staff, including station managers, in regional and international training workshops, seminars, forums and other relevant meetings should be further promoted.

8. A climate change research centre or a research division under a research institute or attached to a government department should be established to continuously generate competent scientists, conduct national GHG inventories, monitor climate change and suggest mitigation and adaptation measures.

Legal framework

1. GHG mitigation strategies should not have any negative effects on energy security and on the advancement of socio-economic development of the country.

2. While financial and technical support, as well as incentives will be needed for the wider application of the ESTs in the industries, an environmental policy may help promote the transfer and application of the ESTs.

3. A National strategic plan of Research and Systematic Observation with special focus on climate change, tropical storm and drought should be developed.

4. Institutional capacity, clear policy guidance, investment strategy and incentive system should be enhanced to mitigate GHG emission from all sectors.

5. National Land Use Plan should be developed and implemented as a priority.

6. EIA rules and regulations should be enacted as matters of urgency.

Finance

1. Financial support for technology and human resource development is in need of strengthening.

2. To enhance the systematic observation and research activities, technical and financial support will be necessary from various international and regional organizations.

3. Financial and technical resources used for promoting climate change information sharing and networking should be considered as promising investments.

4. Regional and international supports should be mobilized to finance climate change mitigation and adaptation measures.

5. Payment for environmental services system as well as polluter pay system should be developed.

Networking

1. Networking within the country and with relevant regional and international organizations should be further strengthened.

2. Information exchange among departmental personnel needs to be enhanced.

3. Cooperation with regional, international and UN organizations on climate change matters should be promoted.

4. Climate change information networks, being essential for promoting climate change information exchange as well as for enhancing cooperation and coordination among the stakeholders, should be established at all levels.

MOECAF

1. MOECAF is well placed to undertake the task of coordinating line ministries and ensuring the integration of climate change concerns into the national and sectoral development plans and programs.

2. MOECAF should be strengthened to be able to coordinate and cooperate among ministries and agencies for the integration of environment and development at all levels.

3. MOECAF should coordinate and manage the EIA process in Myanmar. Therefore, it should be restructured and significantly strengthened in order to be able to carry out this task.

4. MOECAF should be empowered to ensure the integration and monitor the implementation at all levels and in all localities relating to environmental affairs.


ANNEXURES

Annex I

Abatement Project Profiles on GHG mitigation and adaptation in Myanmar

Project No 1

Project Title: ***Rural Electrification Through Bio-energy***

Project Brief/ Introduction: The proposal is a request for project development support. Funds from the grant will be used to conduct the necessary pro-investment activities to develop a pilot bioelectricity project. The expected outputs of the project development activities are:
(i)an evaluation of resource availability, demand for energy, and manpower availability;
(ii)identification of location and size of the pilot project;
(iii)assessment of the project GHGs abatement potential;
(iv)estimation of both the incremental costs and the total budget for the project;
(v)identification of sources of baseline funding;
(vi)development of the institutional and organizational structures for planning, design, implementation, management and monitoring of the project;
(vii)participation of local community, private, and public sector; and
(viii)identification of barriers to bio-energy and measures to overcome them. Based on the results of the project development activities, a pilot project will be detailed for implementation. It intends to cover five villages in the Kachin State of northern Myanmar with a total population of 20,000. The pilot project will contain the following major components:
(i)Design and installation of a 1MW bioelectricity system.
(ii)Formulation of the organizational and institutional arrangements for the operation and management of the system.
(iii)Monitoring and verification of GHGs emissions.
(iv)Development of the necessary institutional arrangements for the large-scale dissemination of bioelectricity technology.
(v)Development of sustainable biomass feedstock production.

Project Baseline: The baseline involves the use of diesel oil for power generation and the use of kerosene for residential lighting.

Project Objectives: The principal goals of the project are to:(i)achieve large scale dissemination of bio-energy technology for rural electrification,(ii)reduce GHGs emissions,(iii)install as pilot project a 1 MW bio-energy system, and(iv)demonstrate the operational and functional viability of a bio-energy system.

Global Environmental Benefits: It is estimated that 1 MWh of bioelectricity substituting for 1 MWh of electricity generated from a diesel-fired power plant leads to carbon emissions reduction of 0.88-1.3 tonnes of CO_2. Therefore, a 1 MW capacity biomass gasifier system, if operated at 75 percent capacity, can mitigate 4,404 – 6,606 tonnes of CO_2 annually, and from 132,120 – 198,180 tonnes of CO_2 over the expected 30 year lifetime of the pilot project. The mitigation potential of bioelectricity as a substitute for kerosene home lighting has not been estimated.

Other Social and Environmental Impacts: Additional environmental benefits of the project are the reclamation of degraded land, the protection of valuable watershed zones, and the conservation of biodiversity. Furthermore, significant employment opportunities will be generated to assist in growing and processing wood, as well as in the operation and maintenance of the system.

Implementation Plan/ Duration: With project development support, a pilot bioelectricity project will be designed for implementation in the Kachin State of Myanmar. With lessons learned from the pilot project and the establishment of institutional arrangements, a program may be developed to disseminate the bioelectricity technology on a large-scale.

Agency: Ministry of Environmental Conservation and Forestry

Cost: US $ 120,000 for project development support

Source: ALGAS Project Report

Project No 2

Project Title: ***Dissemination of Biogas Technology for GHGs Emissions Reduction***

Project Brief/ Introduction: The full project will promote the use of biogas in rice growing areas of Shan State by installing 1,000 biogas plants as a demonstration project in selected villages. The project development activities will include:
(i)Identification of exact locations for the 1,000 biogas plants that will be constructed.
(ii)Preparation of a technical design package for each biogas plant, cooking gas system and electricity generation system.
(iii)Formulation of an institutional arrangement for project implementation, operation, management and monitoring.
(iv)Creation of awareness and training programs for village community members and other potential players such as NGOs and government staff.
(v)Preparation of a detailed budget by activity for the full project and estimation of the incremental costs.
(vi)Organization of meetings to bring biogas plant builders and manufacturers together.
(vii)Formation of a well defined project proposal for international funding.

Project Baseline: The base line for the biogas project is the continued use of unfermented manure as fertilizer for rice production, kerosene for lighting, and firewood for cooking.

Project Objectives: The main objectives of the project are to:
(i)Demonstrate the advantage of biogas sludge fertilizer has over unfermented organic manure for rice production and methane emissions reduction.
(ii)Substitute fuelwood with biogas as a cooking fuel in order to help reduce deforestation.
(iii)Provide decentralized biogas electricity to village communities, substituting for kerosene, thus providing a reliable source of electricity and improving the living standards of village people.

Global environmental benefits: The greenhouse gas mitigation potential of biogas sludge fertilizer compared to unfermented organic fertilizer is 0.072 tonne of methane per ha per year or 1.5 tonnes of CO_2 equivalent per ha per year. The 1,000 biogas plants will produce biogas sludge fertilizer for 6,000 ha, resulting in 430 tonnes of methane emissions reduction per year or 9,000 tonnes of CO_2 equivalent reduction per year. Furthermore, if 70 percent of the biogas generated is used for cooking and 30 percent for lighting, the biogas will replace 22 tonnes of fuelwood and 1,500 liters of kerosene per year. This will also lead to carbon emissions reduction by reducing the use of fuelwood and kerosene, as well as conserving forest sinks.

Other Social and Environmental Impacts: The use of biogas will bring about various social and environmental benefits.

(i)It will save valuable foreign exchange for the country as a substitute for imported urea fertilizer for agriculture and fossil fuels for cooking and electricity.
(ii)It will improve the living standards of rural inhabitants, especially women, due to a shift from fuelwood and kerosene lamps.
(iii)Biogas for lighting will lead to savings for village communities as it costs less than fossil fuels.
(iv)Forests and biodiversity will be conserved due to reduced extraction of fuelwood.
(v)Farmers will experience an increase in rice yields and profits.
(vi)Local employment will be generated as the biogas industry grows.

Implementation Plan/ Duration: A detailed plan including the institutional arrangements for the implementation of 1,000 biogas plants will be developed during the project development phase. With lesson learned from the initial biogas plants, a full program for further dissemination of biogas plants in Myanmar may be implemented. 6 months for project development activities 3 years for installation of 1,000 biogas plant.

Agencies: Ministry of Environmental Conservation and Forestry & Ministry of Agriculture and Irrigation

Cost: US$ 0.2 million for project development support
US$ 9.0 million for installation of 1,000 biogas plants

Source: ALGAS Project Report

Project No 3

Project Title: ***Developing Institutions And Capacity for Inventory of GHGs In Myanmar***

Project Brief/ Introduction: The project will form the basis of a national institutional framework for addressing the issues of climate change. It will also allow Myanmar to develop the technical and analytical capacity to explore various least-cost options for reduction of GHGs emissions and to assemble policies aimed at reducing future growth in emissions. Most importantly, it will help Myanmar to carry out periodic GHGs emissions inventories and enable it to report findings to the United Nations Framework Convention on Climate Change (UNFCCC). The proposed project includes the following activities:
(i)Creation of an institution for monitoring GHGs inventory.

(ii)Procurement of equipment necessary to carry out monitoring activities.
(iii)Training of local staff in monitoring practices.
(iv)Procurement of external assistance for training purposes.
(v)Publishing of inventory results on a periodic basis.
(vi)Conducting awareness building programs targeting policy makers and the general public.

Project Baseline: The proposed project is a capacity building project, thus establishment of a GHGs emissions baseline is not relevant.

Project Objectives: The main goals of the project are to:
(i)develop an institution for monitoring and verification of GHGs inventory, and
(ii)create the capacity in Myanmar to conduct long-term monitoring and inventory of GHGs.
Further, the specific transport sector goals relating to GHGs inventory are to:
(i)develop the capacity to define and establish motor vehicle emission standards,
(ii)improve air quality standards in metropolitan cities, and
(iii)reduce emissions from vehicles.

Global Environmental Benefits: The CO_2 abatement potential of this project is not quantified. Once the necessary institutions and capacity to measure GHGs are in place, the benefits will be realized in future GHGs mitigation projects.

Other Social and Environmental Impacts: Successful execution of the project will increase the awareness of the general public and policy makers about the importance of climate change. The project will also act as a demonstration for other capacity building endeavors in Myanmar.

Implementation Plan/ Duration: The project will establish an international frame work for updating the GHGs inventory. A training program will also be conducted to further increase the technical and institutional capacity in the country for development of accurate GHGs inventories. Three years for capacity building activities and establishment of institutions to address the issues of climate change.

Agency: Ministry of Environmental Conservation and Forestry

Cost: US $ 250,000

Source: ALAGAS Project Report

Project No 4

Project Title: ***Fuel-Efficient Cook stoves And Participatory Forestry for Carbon Emissions Reduction***

Project Brief/ Introduction: The program consists of three main components:
(i)Dissemination of 400,000 improved cookstoves. This component has three parts to its successful implementation: (i) a marketing and promotion program; (ii) an information, educational and communication (IEC) program and; (iii) institutional support for government agencies and private sector participants.

(ii)Reforestation of 20,000 ha through community forestry. This component has four parts to its implementation: (i) design of a fuelwood supply master plan; (ii) preparation of forest management plans in villages; (iii) launching of the information and education campaign program in villages and; (iv) reforestation of 20,000 ha of land.

(iii)Forest monitoring and assessment of forest vegetation status. This component intends to build the capacity to monitor the status of targeted forests.

Project Baseline: The baseline options for the proposed program components are: (i) the continued consumption of 1.4 and 2.5 tonnes of wood a year in inefficient cook stoves in urban and rural households, respectively (Domestic home cooking constitutes approximately 99% of total fuelwood use in the country); and (ii) continued current forestry practices that have led to an average deforestation rate of 220,000 ha per annum (Average deforestation rate in Myanmar from 1975 to 1989).

Project Objectives: The main goal of the program is to achieve forest and forest carbon sink conservation through adoption of improved furl-efficient stoves, as well as instituting a more participatory approach to the reforestation of degraded forests than has traditionally been promoted.

Global Environmental Benefits: The estimated abatement potential of the cook stoves component is 1.25 million tonnes of carbon in 5 years due to a reduction in the amount of fuelwood needed for the more efficient stoves. The mitigation potential of the forestry component of the program has not yet been estimated.

Other Social and Environmental Impacts: The implementation of program will provide a number of local environmental and socioeconomic benefits. The local benefits are:
(i)improvement in the quality of life of rural women;
(ii)generation of rural employment from reforestation activities, and the manufacture and dissemination of improved cooking stoves;
(iii)conservation of biodiversity due to reduced pressure on forest;
(iv)reclamation degraded land; and
(v)strengthening of the capacity of rural communities to better manage natural resources.

Implementation Plan/ Duration: With project development support, the program proposal will be further developed. The program may also include a pilot project and a monitoring program in the initial stage prior to implementation of the full program. Five years for capacity building activities, dissemination of 400,000 improved cook stoves, and reforestation of 20,000 ha of degraded forest.

Agencies: Ministry of Environmental Conservation and Forestry

Cost: US $ 10 million

Source: ALGAS Project Report

Project No 5

Project Title: ***Promotion of Liquefied Petroleum Gas Cookers to Replace Electric Cookers***

Project Brief/ Introduction: The pilot project is designed to help remove the barriers to LPG cookers in Myanmar through the dissemination of 100,000 LPG cookers. The pilot project will establish a primary LPG storage station and several distribution facilities. The project will also train a corps of personnel in technical and management activities. Further, public awareness and advertising campaigns to promote the technology will be conducted as well.

Project Baseline: The baseline scenario for the project is continued use of electric cookers in the targeted areas.

Project Objectives: The principal goals of the pilot project are to:
(i)remove the implementation barriers for the use of LPG as a cooking fuel;
(ii)conserve electricity and hence natural gas used in its generation; and
(iii)save on resources needed for electricity generation, transmission and distribution facilities and to divert those resources to other needy sectors of society.

Global Environmental Benefits: It is estimated for every electric cooker replaced by an LPG cooker, approximately 0.24 tonnes of CO_2 are abated annually; thus the use 100,000 LPG cookstoves will avoid 24,000 tonnes of CO_2 emissions per year.

Other Social and Environmental Impacts: Local social and environmental benefits of the use of LPG cookers are; (i)less degradation of the local environment due to reduced requirement for power generation; and
(ii)conservation of resources usually needed for electricity generation and transmission and distribution.

Implementation Plan/ Duration: A monitoring and evaluation program will be included in the institutional arrangement of the pilot project. With lessons learned from the dissemination of initial 100,000 LPG cookers, a full program may be developed to mainstream LPG cookers in the residential sector. 4 year for dissemination of 100,000 LPG cooker.

Agency: Ministry of Environmental Conservation and Forestry

Cost: US $ 225,000 for pilot project

Source: ALGAS Project Report

Project No 6

Project Title: ***Green House Gas (GHGs) mitigation of bio-energy potential to improve the livelihood and to attain the energy security of rural communities in Myanmar***

Project Brief/ Introduction: Myanmar, traditionally agricultural country, basically relied on agricultural sector has total land areas of 67.65 million hectares (ha), of which 6 million ha (8.84%) is still available to expand for different crops. Many farming systems as crop production produce GHGs mainly CH_4 because of continuous flooding in rice growing, CO_2 due to organic matter decomposition and N_2O owing to nitrogen fertilizer application. The project will consist of:

(i)Evaluate the users' acceptable bio energy production technologies in target areas.

(ii)Make awareness of GHGs mitigation measures through participating in bio energy production and utilization along with the effective use of biomass material which is easily available to respective target regions by organizing training and public demonstration.

(iii)Foster national agricultural research and extension system (NARES) and farmers' perceiving capacity in bio energy production and utilization with GHGs mitigation option.

Project Baseline: The baseline involves the use of diesel oil and gasoline for power generation and rural energy.

Project Objectives: The overall goal of the project is to improve the livelihood of rural communities through effective use of ubiquitous biomass materials in accord with bio energy production and to attain the rural energy security under adverse environmental scenario due to climate change. The main objectives are:

(i)to identify the most feasible bio energy (bio-fuel, bio-gas, bio-mass) production technologies to enhance rural energy security.

(ii)to foster the capacity building of partners (farmers, researchers, and extension agencies) from institutional level, and from private sector involved.

Global Environmental Benefits: One of the function of major global warming potential (GWP) accounted as 25% is brought about by increased facilities of regional mobility. As a consequences, such kinds of GHGs contributors, the climate change impacts could be subjected to impinge on sustainable development of rural communities.

Other Social and Environmental Impacts: Improving public awareness of opportunities associated with bio-energy via education system. All bio-fuel users, researcher and extensionist will be trained in GHGs mitigation related bio-fuel production and utilization technologies. Reduction in cost of fire wood and lighting infrastructure. Improving recycling of biomass so as enhancing personal and environmental hygienic and protecting deforestation. Reducing GHGs emission and relatively source rural energy supply.

Implementation Plan/ Duration: 3 years

Agency: Department of Agriculture Research, Ministry of Agricultural and Irrigation

Cost: US $ 300,000

Source: INC Project GHG Team Report

Project No 7

Project Title: ***Bamboo Bio-ethanol production and utilization in rural area***

Project Brief/ Introduction: Bamboo material is organic matter of high polymer, composed of cells of different shapes and properties. Myanmar has over 100 species, falling under about 17 genera, covering an area of nearly (7000 sq. miles) 18000 sq. kilometres. Bamboo grows mixed with tree species. Bio ethanol is one kind of the clean energy. Young bamboo (1-3 years) are used as the bio ethanol production raw material. The bio ethanol/ clean energy production and utilization technology will be disseminated to the 3 village in Sagaing, Pegu and Mandalay Division which are located near bamboo forest.

Project Baseline: The baseline involves the use of diesel oil and firewood for rural energy.

Project Objectives: To reduce the carbon emission and perform the clean environment through the production and utilization of bamboo bio ethanol in rural area especially for the area near bamboo forests.

Global Environmental Benefits: By production and utilization of bamboo bio ethanol, it can reduce carbon dioxide emission and can perform the clean environment.

Other Social and Environmental Impacts: Bamboo is rich in starch and cellulose content. Bio ethanol can be produced from the starch and cellulose rich raw materials. Bamboo is one of the most important forest products next to timber and has long been utilized by the human being.

Implementation Plan/ Duration: Duration will be 1 year.

Agency: Forest Research Institute, Ministry of Environmental Conservation and Forestry

Cost: US $ 14,900

Source: INC Project GHG Team Report

Project No 8

Project Title: ***Low Cost Plastic Bio-digester Proposal***

Project Brief/ Introduction: The project description will consist of:
(i)Identification of villages;
(ii)Awareness raising among the local village community on the advantages of biogas plant in cooking, time saving for collection of fuel wood, using sludge as the fertilizer and improving the quality of life and environment;
(iii)Conducting Training for installation of biogas digesters;
(iv)Planning and procumbent of biogas digesters;
(v)Installation of biogas digesters;
(vi)Operation and maintenance of biogas digesters;
(vii)Monitoring and evaluation of the effectiveness of the program.

Project Baseline: The baseline for the plastic bio-digester project is the continued use of unfermented manure as fertilizer in agriculture sector and fuelwood for cooking.

Project Objectives: The biogas digester will be installed in Dry zone and Shan State of Myanmar. Fuel wood for cooking will be conserved by using biogas for cooking. Biogas digester producing sludge which can use as fertilizer in Agriculture sector.

Global Environmental Benefits: It will improve air quality, reduce ground water pollution and green house gas emissions and reduce deforestation and resulting soil erosion.

Other Social and Environmental impacts: The use of low cost plastic biogas digester will bring about various social and environmental benefits. It will improve health and reduce respiratory elements. It will be better management of animal dung and human excrement. The slurry provides an excellent fertilizer and thereby increases crop production, or can be sold to generate income.

Implementation Plan/ Duration: The following institutions will be involved in planning, implementation, operation and monitoring.
(i)Ministry of Livestock and Fisheries;
(ii)Field implementation, Livestock Breeding and Veterinary Department;
(iii)Monitoring Myanmar Technical Expert, Livestock Breeding and Veterinary Department;
(iv)Project Coordination and Management, Livestock Breeding and Veterinary Department. Duration for 50,000 low cost plastic biogas digester will be installed in 4 years period.

Agency: Livestock Breeding and Veterinary Department, Ministry of Livestock and Fisheries

Cost: US $ 210,000

Source: INC Project GHG Team Report

Project No 9

Project Title: ***Dissemination of A-1 Fuelwood Improved Cookstoves for GHGs Emission Reduction***

Project Brief/ Introduction: The full project will promote the use of A-1 fuelwood improved cookstoves in dry zones and other regions where fuelwood is scare by distributing 100,000 A-1 cookstoves in selected villages.
The project development activities will include:
(i)Identification of exact locations for the A-1 cookstoves manufacturing factories that will be established.
(ii)Preparation of a technical design package for each factory.
(iii)Creation for awareness for saving of fuelwood and training programs for making A-1 cook stoves for village community members and other potential players such as NGOs and government staff.
(iv)Preparation of a detailed budget by activity for the full project and estimation of the incremental costs.

(v)Formation of a well-defined project proposal for international funding.

Project Baseline: The baseline for the project is the continued use of inefficient wood stoves and the resulting high demand for fuelwood from natural forest. Dissemination of A-1 cookstoves are already accepted by most of the fuelwood users.

Project Objectives: The main objectives of the project are to:
(i)Establish A-1 cookstoves manufacturing factories at proper places.
(ii)Distribute A-1 fuelwood cookstove at free of charge to the villages where fuelwood is scare.
(iii)Demonstrate the proper usage and maintenance of A-1 cookstove in order to extend the service life (life-span) of A-1 cookstoves.
(iv)Give trainings on making A-1 cookstoves to local potters who are well-versed in pottery.

Global Environmental Benefits: The greenhouse gases (GHGs) mitigation potential of 100,000 A-1 cookstoves compared to traditional open-fire stove is 120,736 tonnes $CO_2\ yr^{-1}$. Taking the average service-life of A-1 stove as 3 years, total amount of CO_2 which can be reduced by using 100,000 A-1 cookstoves will be about 362,208 tonnes CO_2.

Other Social and Environmental Impacts: The saved fuelwood from improved cook stoves will reduce anthropogentic impact on forest resources and the time required by the rural population especially women and girls in the collection of fuelwood. The local environmental benefits are:
(i)improvement in the quality of life of rural women;
(ii)generation of rural employment from manufacture and dissemination of improved cooking stoves;
(iii) conservation of biodiversity due to reduced forest degradation of the local environment.

Implementation Plan/ Duration: Duration will be 3 years.

Agency: Forest Research Institute, Ministry of Environmental Conservation and Forestry

Cost: US $ 200,000

Source: INC Project GHG Team Report

Project No 10

Project Title: ***Agricultural Opportunities for Green House Gas (GHGs) mitigation in Myanmar***

Project Brief/ Introduction: Owing to an agricultural country, Myanmar basically relied on agricultural sector has total land area of 67.65 million hectares, of which 16% is net sown areas. Among the diverse crops grown as rice, oil seed, pulses, cereals, industrial and culinary crops, rice occupied as largest as 41% while others as upland crops are accounted as 59% of total sown areas. Total population of the country is 58.38 million in 2009 with 15% growth rate and projected to be 60 million in 2012, Energetic effort to increased crop production will have been engaging as ever-lasting activities. Methane, N_2O and CO_2 are long lived in the atmosphere and are the major contributor to positive increase in radiative forces, resulting climate change. No reliable information is available regarding quantifying GHG emission and its impact, and planned effective mitigation measures so far in Myanmar, low land as well as up land crop production will have been existing for increasing population as historic task. The project will consist of:

(i)Identify integrated crop management technologies evaluated and adopted in target region.

(ii)About 5000 farmers involved in rice production were made aware of effective mitigation measures through training and field days.

(iii)Enhance NARES and farmers perceiving capacity in rice production with mitigation aspect.

Project Baseline: Agricultural activities are significant producers of Green House Gas (GHGs), mainly consist of CH_4, N_2O and CO_2.

Project Objectives: The overall goal of the project is to improve the farmers, researchers and extension agencies to achieve better livelihoods through sustainable crop production by means of utilizing mitigation and adaptation measures. The main objectives are:

(i)To evaluate the rice production technologies to enhance food security, soils fertility with reducing GHG but without declining crop yields.

(ii)To strengthen the capacity building of partners (farmers, researchers and extension agencies) with rice production technologies that mitigate the GHG .

Global Environmental Benefits: Increased crop production across the country to meet domestic consumption and export. At least 10% yield increase in rice productivity for export.

Other Social and Environmental Impacts: Farmers income will increase by 20% (through saving fertilizer cost, labor cost and yield increase) and the cost of cultivation will reduce 5000 farmers and all researchers and extensionist in target regions will be trained in environment friendly crop management technologies associated with climate change mitigation.

Implementation Plan/ Duration: 3 years

Agency: Department of Agriculture Research, Ministry of Agricultural and Irrigation

Cost: US $ 300,000

Source: INC Project GHG Team Report

Project No 11

Project Title: ***Mitigation of CH_4 Emission from Rice fields by Fertilizer Management Practices***

Project Brief/ Introduction: Rice grows well in all States and Divisions of Myanmar. Most rice farmers apply organic fertilizers in the form of residue from the previous rice crop, which is left standing, ploughed, and integrated into the soils. Being an agricultural country, Myanmar's economy largely relies on the agricultural sector. To uplift its economy, agricultural production must have been increasing, including rice production. The intensification of rice cultivation by increasing irrigation will cause fields to be flooded more often and for longer duration, thus enhancing CH_4 emission. The total amount of CH_4 released depends primarily on the amount of organic substrate available. The application of synthetic fertilizers has also been found to influence CH_4 emissions. The experimental set up will be carried out for CH_4 emission measurement from the rice fields at Yezin agricultural University Farm. The experiment sites will be selected as sandy loam soil and rice cultivar is Manawthuka, a high yielding variety with 120-130 days of maturity, representing the most agro-ecosystems of the Pyinmana Township, over the entire rice cropping seasons. The experiment will be 0.5 ac (0.2 ha) in a split plot design with 4 replicates.

Project Baseline: The baseline is the continued current practice of traditional rice cultivation which produces a relatively high rate of methane emission.

Project Objectives: To generate an appropriate method (fertilizer management) for reducing CH_4 emission from rice fields of different ecosystems of central Myanmar.

Global Environmental Benefits: The knowledge and experience from the research project can improve the assessment of GHG abatement options and formulation of least cost strategies.

Other Social and Environmental Impacts: The experimental results will contribute to accelerate the improvement of GHG inventory as a key to mitigation actions in a measurable, reportable and verifiable manner.

Implementation Plan/ Duration: The experiments will be conducted for 2 different agro-ecosystems under irrigated and rain-fed farming system. Duration will be 2 crops in successive seasons.

Agency: Yezin Agricultural University, Ministry of Agriculture and Irrigation

Cost: US $ 12,320

Source: INC Project GHG Team Report

Project No 12

Project Title: ***Mitigation of CH_4 Emission from Rice fields by Water Management Practices***

Project Brief/ Introduction: Flooded rice fields serve as an important source of CH_4 emission. Most of the rice in all States and Divisions in Myanmar (more than 90%) are grown in flooded fields as wet-land rice. The water management system under which rice is grown is one of the most important factors affecting CH_4 emissions. In Myanmar, about 70% of rice is grown under rain fed condition in monsoon season, while about 30% is under irrigated in pre-monsoon and monsoon seasons and all are continuously intermitted flooded conditions. The experimental set up will be carried out for CH_4 emission measurement from the rice fields at Yezin Agricultural University Farm. The experiment sites will be selected as sandy loam soil and rice cultivar is Mnanwthuka, a high yielding variety with 120-130 days of maturity, representing the most agro-ecosystems of the Pyinmana Township, over the entire rice cropping seasons. The experiment will be 0.5 ac (0.2 ha) with and Randomized Complete Block design and 3 replications.

Project Baseline: The baseline is the continued current practice of traditional rice cultivation which produces a relatively high rate of methane emission.

Project Objectives: To generate an appropriate method (water management) for reducing CH_4 emission from rice fields of different ecosystems of central Myanmar.

Global Environmental Benefits: The knowledge and experience form the research project can improve the assessment of GHG abatement options and formulation of least and strategies.

Other Social and Environmental Impacts: The experimental results will contribute to accelerate the improvement of GHG inventory as a key to mitigation actions in a measurable, reportable and verifiable manner.

Implementation Plan/ Duration: The experiments will be carried out for 2 times in pre-monsoon seasons of successive years.

Agency: Yezin Agricultrual University, Ministry of Agriculture and Irrigation

Cost: US $ 11,480

Source: INC Project GHG Team Report

Project No 13

Project Title: ***Mitigation of N_2O Emission from Lowland Paddy field by Organic Manuring and Water Management***

Project Brief/ Introduction: Rice (Oryza sativa L.) paddy soils have the potential to emit both of the greenhouse gases methane (CH_4) and nitrous oxide (N_2O), depending on redox potential. Many researchers reported that CH_4 emission is mitigated by water management treatments that decrease the length of flooding time, however, emission occurs most prominently when floodwater disappears. N_2O emission is aggravated by inorganic N fertilizer application. Nitrous oxide emission has higher impact (310 times of CO_2) to global warming potential compared to CH_4. Paddy production is one of the most important economic sector of Myanmar for won consumption as staple food and export earning. Flooded rice cultivation with improper water management and fertilization may cause the higher N_2O gas emission as well as CH_4. A field study will be carried out at Yezin Agricultural University Farm for N_2O emission measurement with inorganic and organic fertilization and water management. Rice (Oryza sativa L.) variety Manathuka (Myanmar a high yielding variety already well adapted in Myanmar) will be used as a test crop. Total experimental site will be 0.5 acre (0.2 ha) and the area had been under lowland rice cultivation for many years.

Project Baseline: The baseline is the continued current practice of traditional rice cultivation which produces a relatively high rate of nitrous oxide emission.

Project Objective: To establish a suitable management practice for mitigation of N_2O emission from paddy fields using organic manuring and water management.

Global Environmental Benefits: The knowledge and experience form the research project can improve the assessment of GHG abatement options and formulation of least cost strategies.

Other Social and Environmental Impacts: The experimental results will contribute to accelerate the improvement of GHG inventory as a key to mitigation actions in a measurable, reportable and verifiable manner.

Implementation Plan/ Duration: The experiment will be conducted for 2 seasons in irrigated rice and monsoon rice (May to September and November to February).

Agency: Yezin Agricultural University, Ministry of Agriculture and Irrigation

Cost: US $ 17,000

Source: INC Project GHG Team Report

Project No 14

Project Title: ***Effect of Integrated Nutrient Management and Method of Fertilizer Application on N_2O Emission from Commercial Cabbage Production in Myanmar***

Project Brief/ Introduction: Cabbages are grown in a commercial scale in Shan States and a few areas in central Myanmar. N_2O emissions during both oxidations of NH_4 and denitrification are increased by N fertilizer applications to soils. N_2O emissions from agricultural lands are also likely to increase in Myanmar in future because of increase in both the extent of cultivated land and fertilizer input. Consumption of N fertilizer in Asia will increase approximately 50% by 2030 which will most likely be accomplished by a proportional increase in N_2O emission. Vegetables growers can be recommended for the proper method of application and integrated fertilizer management to reduce the N_2O emission from soil without affecting their crop yields. A field experiment will be carried out at two experimental sites (Yezin Agricultural University Farm and grower's field at Nweyit village in Tatkone Township) in post-monsoon season 2011.

Project Baseline: The baseline is the continued current practice of other crop cultivation which produces a relatively high rate of nitrous oxide emission.

Project Objectives: The main objectives of the project are:
(i)To investigate the effect of integrated nutrient management system using organic manure, with and without inorganic N fertilizer on cabbage production and N_2O emission from soil;
(ii)To study the application methods of chemical fertilizers on N_2O emission form soil.

Global Environmental Benefits: The knowledge and experience from the research project can improve the assessment of GHG abatement options and formulation of least cost strategies.

Other Social and Environmental Impacts: The experimental results will contribute to accelerate the improvement of GHG inventory as a key to mitigate actions in a measurable, reportable and verifiable manner.

Implementation Plan/ Duration: The experiment will be conducted for 2 seasons (winter and monsoon).

Agency: Yezin Agricultural University, Ministry of Agriculture and Irrigation

Cost: US $ 10,200

Source: INC Project GHG Team Report

Project No 15

Project Title: ***Small Scale Reforestation Pilot Project in Ayeyarwady Delta, Myanmar***

Project Brief/ Introduction: The Ayeyarwady delta is one of the areas where most serious deforestation took place during this period. The proposed project activities are aimed at demonstrating the applicability of the CDM process to rehabilitate mangroves on such degraded croplands and grasslands. The proposed project area will be in the southern part of Ayeyarwady Delta. It is proposed to establish the CDM AR plantation on five strips of lands that have been identified as A, B, C, D and E with the GPS locations. The nature of project area is croplands degraded due to repeated incursion of sea water with a smaller extent of similarly degraded grass lands and an insignificant part of the inter-tidal lands.

Project Baseline: The baseline for the project consists of minimal afforestation efforts with no mechanisms to determine appropriate tree species or provide other support services. The carbon sequestration potential of the baseline is currently unknown. The loss of mangrove forests resulted from charcoal production, aquaculture, fuelwood extraction under mangroves has decreased to less than 40% of that recorded in the 1920s.

Project Objectives: Demonstration of the possibilities of rehabilitation of Mangroves on the Ayeyarwady Delta Coastline to protect communities from cyclone using A/R CDM process thereby mitigation climate change, conserving biodiversity, and enhancing incomes of local community.

Global Environmental Benefits: The project shall result in net Anthropogenic removal of 8000 tonnes of CO_2 per year. A total estimated 185258.664 metric ton of net anthropogenic GHG removals by mangrove tree plantation is envisaged throughout 20 years period.

Social and Environmental Impacts: The project will positively impact to the socioeconomic or livelihood of local people by to be achieved CER and spin off benefits from project.

Implementation Plan/ Duration: The project activities will be implemented in the Ayeyarwady Delta. Duration will be 5 years.

Agency: Forest Department, Ministry of Environmental Conservation and Forestry

Cost: US $ 350,000

Source: INC Project GHG Team Report

Annex II

PROJECT ON INITIAL NATIONAL COMMUNICATION

Repot on

Research on ENSO Impact on climate fluctuation and frequency of extreme climate anomalies in the region and in Myanmar

By

RESEARCH AND SYSTEMATIC OBSERVATION GROUP (Department of Meteorology and Hydrology)

January, 2010

ENSO

The westward spread of warm sea current from south east Pacific, off coast of Peru has some impact on global weather and climate. Myanmar is no exception. During the period 1900 to 2008, strong El Nino has occurred in 1901-02, 1913-15, 1918-20, 1972-73, 1986-88, 1991-92 and very strong El Nino occurred in 1940-41, 1957-58, 1982-83, and 1997-98. The El Nino in 1997-98 is known to the strongest followed by that of 1982-83.

When the El Nino year is taking place simultaneously with the Southern Oscillation of the near global scale atmospheric circulation in the south Pacific and the Indian Oceans, the climate of Myanmar was more rampant and adverse extreme weather prevailed in the country in such years as 1982/83 and 1997/98.

Maximum highest temperatures records were set in 1998 ENSO year in Mandalay Division, Rakhine State ,Shan state, Magway, Bago, Yangon, Ayeyawady and Taninthayi Divisions, Kayah, Mon and Kayin States which is almost the whole country except Sagaing Division, Kachin, and Chin States.

Maximum temperature records in 1997-98 ENSO years in Myanmar are shown in **Table (1)**. Eleven out of fourteen States and Divisions experienced the ever recorded heat. In 1998, Maximum Record Temperature of Hpaan was 43.6°C which is 2.6°C higher than the last maximum in 1988.

Table (1) - The highest maximum temperature records in 1998 in Myanmar

State/Region	Station	Last Record		1998 Record	
		(°C)	(d-m-y)	(°C)	(d-m)
Mandalay	Meiktila	42.4	- -5-66	43	5-Oct
	Pyinmana	42	1-5-80	43.5	9-5
Shan	Lashio	40	26-4-97	40	4-5
Rakhine	Thandwe	39	12-5-80	40.4	4-5
Magwe	Minbu	45.2	17-4-73	45.8	9-5
Bago	Taungoo	42.2	10-5- 59	42.9	8-5
	Tharawady	42	14-3-63	43.6	9-5
Yangon	Mingaladon	41.7	25-4-58	42	8-5
	Kaba-Aye	41.3	27-4-83	42	8-5
Ayeyawady	Pathein	41	27-4-83	41	8-5
	Hinthada	42.9	30-4-95	43.6	9-5
Mon	Mawlamyine	40	21-4-95	40.2	8-5
	Thaton	40	16-4-75	41	8-5
Kayah	Loikaw	37	17-4-83	38	14-4
Kayin	Hpa-an	41	25-5-88	43.6	6-5
Taninthayi	Dawei	38.5	11-4-98	38.9	6-5
	Myeik	38	4-5-83	38	6-5
	Kawthaung	38	3-4-98	38.5	6-5

(Tun Lwin, 2007 ; El Nino of 1997-98. A girl named La Nina and collection of natural disaster related articles, Myanmar heritage, Yangon, p-260.)

In 1998, ENSO set new lowest records in Shan, Kayah, Kayin and Mon States, Bago, Ayeyawady and Taninthayi Divisions. The lowest annual rainfalls were recorded in 1991 El Nino year in Shan state Sagaing, Mandalay, Bago and Kayah states.The lowest annual rainfalls ever recorded in 1998 were shown in **Table (2)**. The data period is from 1902 to 2003 with some years missing particularly around the World Wars. The most significantly low annual rainfall occurred in Taungoo of Bago Division in 1998 with 1366 mm which is 19% less than the former record of 1682 mm in 1989.

Table (2) - Least annual rainfalls (mm) recorded in 1998 ENSO year*

State/Region	Station	Data Period	Old record (Year)	1998 Record
Shan	Taunggyi	1903-1941	1208 (1976)	992
		1950-2003		
Magwe	Magwe	1971-2003	445 (1972)	442
Bago	Pyay	1903-1930	816 (1972)	798
		1946-2003		
	Taungoo	1903-1937	1682 (1989)	1366
		1951-2003		
	Bago	1902-1937	2596 (1987)	2373
		1961-2003		
Kayah	Loikaw	1907-1937	770 (1993)	751
		1952-2003		

*(Tun Lwin, 2007; El Nino of 1997-98. A girl named La Nina and collection of natural disaster related articles, Myanmar heritage, Yangon, pp-260.)

In 1998, *the* most extensive heat wave is found to cover 156,250 sq miles or 60% of the country. It may be noted that the year is the ENSO year when El Nino and Southern Oscillation were both active.

El Nino : During the El Nino years, the southwest monsoon was negatively affected on several features.

Monsoon onset and withdrawal:- The monsoon onset dates are late and the withdrawal earlier in El No years in general compared to the normal and this pattern is particularly true for the preceding years of the episode. Thus the rainy season have shorter duration in the El Nino years. Recently, El Nino was strong in 1991-92 and very strong in 1997-98. The monsoon onset in the country was late by 12 days in 1991 and 16 days late in 1998. Monsoon withdrawal was early by 16 days and 21 days in 1991 and in 1998. The length of monsoon duration was reduced by 24 days in 1991 and by 36 days in 1998. Strong monsoon days decreased in 1991 and 1998 by 17 days and 28 days.

Monsoon intensity:- There is weak relationship between the late monsoon intensity and the El Nino event though there is likelihood of rather a weak monsoon intensity particularly in the preceding the peak El Nino event. Thus the monsoon intensity as a whole is more likely to be normal during the major El Nino years with a possibility of 80% based on the last six events during the last 48 years i.e., 1951 to 1998. Though the relationship between the early monsoon intensity and the El Nino event does not perform well, below normal to normal monsoon intensities are more likely during the early monsoon periods of both the preceding and the following years of the peak El Nino events. More than 50% of the intensity of peak monsoon during El Nino events could experience failure or weakening of monsoon comparing to normal condition. This is particularly true for the preceding year of the episode.

During the southwest monsoon peak season, there was a normal occurrence of inactive monsoon period commonly known as **"Monsoon Break"**. It was almost totally absent in most of the years through 1989 to 1997. This is particularly true in 1993 to 1996. However a very prolonged monsoon break condition returned in 1998. The 1990s marked the warmest decade of Myanmar in the 20th century.

- Frequency of storms:- The relationship between the El Nino events and the frequency of storms in the Bay of Bengal has been a controversial for long time. However the storm frequency is below normal in the preceding year and it is below normal to normal in the following year of the peak of El Nino events.
- Temperature and Rainfall:- The impacts of the El Nino are also observed upon the general climate of Myanmar during the **preceding year** as well as during the **following year** of the El Nino. About 70% (preceding year) to 85 % (following year) of the El Nino events, the maximum temperature in most parts of the country were higher than normal during the dry months of April and May. In 70% (preceding year) to 85 % (following year) of the El Nino events, both the annual rainfall and monsoon rainfall are below normal in the country.

La Nina

During the last two decades, the temperatures have been rising by day and by night in most part of the country. However record low minimum temperatures were observed in cool season of 1999-2000 which is the La Nina year, in many parts of the country. The lowest minimum temperatures of some selected stations in different states and divisions, observed in 2000 La Nina year are shown in Table (3).

Table (3) - Lowest minimum temperatures records of the capitals of states and Regions

State/Region	Station	Lowest MinTem(C)	Date	Remark
Kachin	Myitkyina	5	2/1/1963	La Nina
Chin	Haka	-6	30-12-91	
Upper Sagaing	Homalin	3	8/2/1980	None
Lower Sagaing	Monywa	6.7	31-1-64	La Nina
Mandalay	Mandalay	7.2	31-1-64	La Nina
Northern Shan	Lashio	-2.2	16-1-89	La Nina
Eastern Shan	Kyineton	1.7	27-1-53	El Nino
Southern Shan	Taunggyi	0.3	20-1-74	None
Magwe	Magwe	5	26-1-93	
Rakhine	Sittwe	8.9	21-1-70	La Nina
Kayah	Loikaw	0	27-1-53	El Nino
Northwest Bago	Pyay	7.2	17-1-54	
Northeast Bago	Taungoo	8	30-12-75	
South Bago	Bago	7	11/2/1997	El Nino
North Ayeyawady	Hinthada	7	29-12-97	El Nino
South Ayeyawady	Pathein	10	30-12-75	La Nina
Yangon	Yangon	9.1	9/2/1997	El Nino
Karen	Paan	9.4	1/1/1974	None
Mon	Mawlamyine	10.8	2/1/1976	El Nino
Taninthayi	Dawei	5.5	26-12-99	La Nina

Some La Nina either develop just prior to or following the El Nino event are shown in Table (4).

Table (4) - La Nina years preceded or followed by El Nino years during 1950-1989.

La Nina followed by El Nino		La Nina preceded by El Nino	
La Nina	El Nino	El Nino	La Nina
1950	1951	1953	1954
1955-56	1957-58	1963	1964
1964	1965	1969	1970
1967-68	1969	1972	1973
1970-71	1972	1982-83	1984-85
1975	1976	1987-88	1988-89

Myanmar, belonging to the non-Annex I, invites supports from international/regional organization/institutes.

Annex III

Estimation of CH4 Emission from Rice Cultivation in Myanmar Field Survey Research Paper

1. Introduction

Due to the specific conditions in water availability and constraints in cultivation, rice ecosystems in Myanmar are generally categorized into five categories: Regular / favourable rainfed lowland, Drought-prone rainfed lowland, Deep Water Rice, Submerged and Salt Affected Rice and Upland Rice. Rice grows well in all regions and 20 - 30% is irrigated and the rest are under rain-fed condition. According to its cropping patterns and agro-ecological regions, rice varieties used and the agronomic management practices such as water and nutrient management considerably vary among the different regions of Myanmar. Rice is mostly grown in flooded fields under anaerobic conditions and it has been recognized that significant amounts of CH_4 are released to the atmosphere and consequently contributing to global warming more than any other crops.

The level of emissions varies with soil conditions, climate and production practices. Intensification of rice cultivation by increasing irrigation will cause fields to be flooded more often and for longer duration, thus enhancing CH4 emission. Based on the scientific research findings, several cultivation practices such as use of chemical fertilizer (urea) and organic fertilizer (cow dung) have shown to increase methane emission from rice fields. Crop management practices like water management and weed management also have impacts on CH4 emission. Different rice varieties have different durations as well as different morphological and anatomical characteristics. These are also influencing factors on CH4 emission. Rice –based cropping patterns of rotation of upland crops (pulses, oilseed crops) after rice were found to produce less CH4 than rice after rice cropping pattern. All these factors which have significant influences on the rate of CH_4 emission from rice fields should be taken into account for the estimation CH_4 emission. For the implementation of Initial Communication Inventory of Myanmar, it is, therefore, necessary to study the conditions of rice cultivation for obtaining the activity data as precise as possible.

2. Methodology

Being a developing country, Myanmar is weak in agricultural statistical data, particularly in the availability of activity data related to the estimation of GHG emission. Moreover, official statistical data do not include such kind of agronomic practices essential for estimation of CH_4 emission.

2.1 Survey Research Period:

A large number of sample surveys across the country were carried out from April 2009 to December 2009.

2.2 Survey Sites:

The survey sites were Maubin Township (Ayeyarwaddy Division, Delta), Bogalay Township (Ayeyarwaddy Division, Delta), Kalaw and Aungban Townships (High land, Southern Shan State), Kyaukme Township (for upland rice and Taung-yar farming), Pyinmana and Yamethin Townships (Central Myanmar) and Nyaung-u, Mandalay and Magwe Townships (Central Dry Zone).

2.3 Data Collection:

Methods such as sample survey and on-site observation were used to obtain the information necessary for preparing the GHG inventory. Farmers interview with questionnaire and group discussion were also conducted. The data collected were rice varieties used (duration and plant type), water management practices (rain-fed, intermitted irrigation or single irrigation), and nutrient management practices (type and amount of chemical fertilizers and organic manure, time and method of application.), etc.

2.4 Survey Research Team:

1. Dr. Khin Lay Swe: Team Leader, Pro-rector (Academic Affairs), YAU
2. Dr. Nang Sang Hom: Member, Associate Professor, Agricultural Botany Department,
3. Dr. Kyaw Kyaw Win: Member, Associate Professor, Agronomy Department, YAU
4. U Kyi Toe, Member, Lecturer, Agricultural Botany Department, YAU
5. Dr. Thanda Min: Member, Lecturer, Agronomy Department, YAU

3. Survey Research Finding

In the INC report, Tier 1 method, IPCC 2006, was used for the estimation of CH4 emission from flooded rice fields. Default emission factors and scaling factors together with activity data for harvested area and cultivation period was calculated based on the survey results and secondary data collected from Myanmar agriculture Service and Settlement and Land Record Department of respective townships. The following assumptions are the examples of calculating the CH4 emission.

For determining the value of SFp (default CH4 emission scaling factors for water regimes before the cultivation period), water management pre-season and rice cultivation period were noted.

1. Under irrigation: Early Rice and Late rice of double rice cropping
   Non-flooded pre-season < 180 days: SFp = 1
2. Regular Rainfed Rice : Single Rice Cropping (May / June to Oct./Dec.)
   Non-flooded pre-season > 180 days: SFp = 0.68
3. Drought-prone Rainfed Rice:
   Non-flooded pre-season > 180 days: SFp = 0.68
4. Deep Water Rice:
   Non-flooded pre-season < 180 days: SFp = 1

For the assumption for organic amendments and determination of the value of CFOA (default conversion factor for different types of organic amendment), the survey findings were taken into account.

Straw are incorporated shortly (<30 days) before cultivation CFOA*i* = 1

Farm yard manure CFOA*i* = 0.14

Annually, amount of straw (Rice stubbles) incorporated into the field = 1 ton / ha (Straw production = 4 - 5 ton/ ha of rice field, ¼ left in the field)

Amount of cow dung (Farmyard manure) added to the field = 1.5 ton/ ha

(Average application is 3 bullock-carts / acre = approx. 0.6 ton/acre)

For the assumption of cultivation period of rice (tijk) for different rice ecosystems, the most common rice varieties used in various regions were recorded.

1. Irrigated rice: Early duration varieties = 110 days (110-120)
2. Regular Refined Rice: Medium duration varieties = 140 days (135-145)
3. Drought-prone Refined Rice: Medium duration varieties = 130 days (125-135)
4. Deep water Rice: Traditional varieties = 170 days (160-180)

4. Survey Research Budget

No.	Particulars	Amount (FEC)
1	**March 2009**: Field surveys to Ayeyarwady, Bago and Yangon Divisions - 3 persons x 10 days Traveling costs, meals and accommodations	300
2	**April 2009**: Field surveys to Mandalay and Magwe Divisions - 3 persons x 5 days Traveling costs, meals and accommodations	200
3	**Sept. 2009**: Field surveys to Kalaw and Aungban Townships, Southern Shan State - 5 persons x 5 days Traveling costs, meals and accommodations	300
4	**Oct. 2009**: Field surveys s to Kyaukme and Lashio Township (Northern Shan State) - 3 persons x 7 days Traveling costs, meals and accommodations	300
5	Daily Subsistence Allowance / Honorarium 150 FEC x 6 persons	900
6	Laboratory soil analysis for five different rice growing regions	200
7	Cost of materials (questionnaires survey forms, photographs, labour charges, etc.)	100
8	Data analysis and paper writing	200
	Total	**2,500**

5. Survey Research Outcome

For the INC report and the national GHG inventory, the agriculture sector includes the following categories.

1. CH4 emission from flooded rice fields,
2. N2O emission from agricultural soils and
3. GHG emissions from field burning of agricultural residues

In the survey trips the data concerning with all these categories were recorded. As an example, for the N2O emission from agricultural soils, the inputs of chemical fertilizer (Urea) and organic manure (cow dung) to the upland agriculture for cereals (rice, wheat, maize), oilseed crops (sesame, groundnut, sunflower), pulses, fruits, vegetables, and kitchen crops were taken into account. Therefore, the amounts of urea and cow dung application to the crops were recorded from different regions. Moreover, the use of previous crop residues for the next crop was also an influencing factor to this category. In the regions where the cattle feeds and household fuel are scarce, especially in dry zone areas of Myanmar, the residues of pulses, rice and corn are used for cattle and stem residues of sesame, pigeon pea, and cotton are used for fuel. Therefore, no significant amounts of crop residues are applied to the field.

The farmers' practices of field burning of agricultural residues differ from regions to regions as well as from plot to plot. It varies according to their cropping systems, economy, available labour, topography and etc. Concerning with rice stem residues, field burning can be seen in some fields of the double rice cropping system (summer rice — monsoon rice). It is because the harvest time of summer rice coincides with the monsoon rains, the wetted rice straws are not suitable for cattle feed and they were burnt down for clearing. The residues left in the field, such as sugarcane, wheat, corn and rice are burnt with the purpose mainly for land clearing of next crop. Questionnaire for farmer's practice of residue burning were also used in interviews with local farmers.

The survey results will provide more accurate data for the assumption of activity data and scaling factors for the national GHG inventory. The survey results will contribute to accelerate the improvement of GHG inventory as in a measurable, reportable and verifiable (MRV) manner. The knowledge and experience from the research project can also be used as a base line data for the assessment of GHG abatement options and formulation of mitigation strategies, and consequently it helps in the fulfillment of Myanmar's commitments under the UNFCCC.

Annex IV

Draft National Climate Change Policy, Strategies and Actions

1. Introduction

The draft national climate change policy addresses climate-related issues resulting from GHG emissions originating in the energy, industrial processes, agriculture and livestock, land use change and forestry, and waste sectors.

In developed countries the energy and the industry sectors used to be the largest GHG sources, while in the developing countries, which are less industrialized, agriculture, land use change and forestry, and waste production contribute most to global warming.

In this perspective, the 1997 GHG inventory conducted for the first time in Myanmar, under the ALGAS project attempted to describe the state of GHGs emitted in 1990 from the above-mentioned sectors of economy. The GHG inventory had indicated that Myanmar was a net sequester of CO_2 with 5,910 Gg in 1990. But, with emissions of CH_4, N_2O, NO_x and CO the country emitted a total of 41,500 Gg of CO_2 e which included 6,086 Gg of CO_2e (14.67%) from Energy, 180.44 Gg of CO_2e (0.43%) from Industrial Processes, 39,203 Gg of CO_2e (94.47%) from Agriculture & Livestock, -6,656 Gg of CO_2e (-16.04%) from Land use change and Forestry, and 2,686 Gg of CO_2e (6.47%) from Waste sectors. It is evident therefore that agriculture had been the biggest contributor of GHGs in 1990 followed sequentially by energy, waste and industrial processes. Land use change and forestry removed GHGs more than it emitted by a very big margin which made Myanmar a net sequester in 1990 in terms of CO_2 emissions.

In the agriculture & livestock sector, net CO_2 e emissions dropped to 25,342 Gg in 2000 from 39,203 Gg in 1990 contributing approximately 57.41% to the total net CO_2e emissions in Myanmar. Notwithstanding the vast amount of methane emissions, rice cultivation has to be and been being increased yearly by expanding cropping area and enhancing per unit area production. Furthermore, the increased populations of the cattle and buffalos, compounded the problem, but for Myanmar, they are the inevitable in agricultural development.

Energy has two-way effects on social, educational and economic development in a country. For the development, energy is a driving force. Myanmar has been promoting resource-based industries, and as a result net CO2e emissions in both energy and industrial processes sectors had increased enormously. The net CO_2e emissions of 6,086 Gg in 1990 had increased to 45,140 Gg in 2000 in the all energy sector, while that of 180 Gg in 1990 had increased to 3,014 Gg in 2000 in the industrial processes. The continuing economic development will certainly lead to increased GHG emissions beyond limits if not properly planned and effectively controlled.

Thanks to the land use change and forestry, Myanmar again became a net sequester of CO_2 gases in 2000. However, with the estimated annual deforestation rate of about 400,000 hectares, the currently estimated sequestration effect may have disappeared by the turn of the new millennium as commented in the EPA (Environmental Performance Assessment) report, March 2006.

Adverse impacts of climate change will lead to forest depletion, degradation and complete destruction over time if no appropriate responsive measures are undertaken in time. It is extremely necessary to enlarge and conserve forests to reduce global warming. Additionally, people need forests to survive and prosper in a livable environment. In view of this, sustainable forest ecosystem management, together with private forestry and community forestry is to be highly prioritized for climate change mitigation and adaptation.

In the waste sector, the net CO_2 e emissions had increased by 140 Gg only - from a net total of 2,686 Gg CO_2 equivalents in 1990 to 2,826 Gg CO_2 equivalents in 2000. In this case, reduction of per capita waste generation, waste treatment and recycling are the main strategies.

This draft national climate change policy is not fully comprehensive in terms of scope since it covers only five priority economic sectors. On the other hand, it is considered a good and inevitable initiative for future expansion and improvement to base upon.

2. Goal and Objectives of the Policy

Goal:
To progressively develop national economy in a stable and environmentally sound climate

Objectives:
To stabilize greenhouse gas (GHG) concentrations in the atmosphere below dangerous levels without compromising national economic growth; To mitigate climate change and its adverse impacts by limiting or reducing anthropogenic GHG emissions in various economic sectors and sources.

1. To preserve and enhance GHG reservoirs and sinks.
2. To enable adaptation measures to immediately cope with the impacts of changing climate and minimize the damages.
3. To ensure that food production is not disrupted enabling national socio-economic development to proceed in a sustainable manner.

3. Priority Sectors identified for Climate Change Concerns

Five economic sectors namely Energy, Industrial Processes, Agriculture and Livestock, Land Use Change and Forestry, and Waste sectors have been identified as priority areas in the context of climate change in Myanmar-

4. Climate Change Concerns

Both causes and effects or impacts of climate change are climate change concerns. Although not exhaustive, they are identified sector-wise and presented in the following table.

Sector	Causes	Effects
Energy	• Fossil fuel combustion emitting CO_2	• Reduced hydroelectric power supply due to inadequate water resources resulting from shortened monsoon period and intense drought
	• Fugitive emission from oil and natural gas systems and coal mining, contributing CH_4	• Increased consumption of electricity due to rising ambient air temperature
	• Transport (mobile combustion of all kinds of fuel) emitting CO_2, CH_4, N_2O, CO, NMVOC. SO_2, PM, NO_x	• Increased expenditures to replace energy inefficient equipment, vehicles and machineries with more efficient ones
	• Fugitive emission from fuel inefficient old vehicles, poor roads, road network, traffic jams producing various GHGs	• Increased investments to improve roads, road networks, and transportation facilities
		• Loss of old, outdated and energy inefficient vehicles and machineries
Industrial	• Production of construction materials such as cement, glass, iron and steel etc. and of foods and drinks producing CO_2, CH_4, NMVOC.	• Increased investment for development and use of energy efficient and environment friendly technologies
Processes	• Product use such as refrigerators, air conditioners, electrical appliances emitting CO_2, CFC, HFC, PFC, SF_6	• Increased investment to develop and deploy new energy technologies including GHG capture, storage and utilization for power generation in industrial processes
		• The technical and regulatory need involving probably heavy financial investment to implement environmental standards for energy efficient use and for constructing GHG-efficient infrastructures.
Agriculture	• Rice cultivation emitting CH_4	• Change in growth rates of crops
and	• Land clearing emitting CO_2, CH_4, N_20	• Water stress in some regions due to frequent and intense droughts
Livestock	• Application of chemical fertilizers and pesticides producing N_2O, NO_x, etc.	• Water excess and flooding in some regions due to fluctuations in rainfall
	• Managed soils contributing CO_2,N_2O	• Changes in crop productivity (increased or decreased yields of some major crops due to increased warming)
	• Enteric fermentation of ruminant livestock and manure management, leading to CH_4 emission	• Decline in food quality due to increased CO_2 concentration in the atmosphere
	• Farming of swine and its manure management, leading to CH_4 emission	• Increase of agricultural pests and diseases due to rise in temperature
	• Animals directly emitting N_2O	• Increased vulnerability of some crop strains to climate extremes
	• Animal waste management producing CH_4, and N_2O	• Loss of arable lands due to drought, floods, salt water intrusion and sea level rise
		• Heat stress on livestock including aquaculture
		• Increased incidence of animal pest and diseases due to fluctuations in rainfall
Land Use	• Deforestation contributing CO_2, CO, CH_4, N_2O, NO_x	• Shifts in the ranges of trees and animals
Change and	• Forest degradation contributing CO_2	• Change of species composition
Forestry	• Forest fires contributing CO_2, CO, CH_4, N_2O, NO_x	• Effect of sea level rise on the distribution and abundance of mangroves.
	• Burning after forest clearing contributing CO_2. CO, CH_4, N_2O, NO_x	• Forests becoming drier
	• Soil disturbance emitting CO_2, NO_x	• Risk of extinction of rare or geographically restricted species
		• Increases in the frequency & severity of forest fires, and the lengthening of fire season
		• Increase in pests and diseases.
		• Change in growth rates and yields
Waste	• Solid waste emitting CH_4, N_20 and other GHGs	• Environmental pollution
	• Domestic and industrial waste water emitting CH_4	• Loss of aesthetic values
		• Spread of various diseases

5. Basic Principles

The national climate change policy will be founded on the following basic principles:

- The Climate Change Policy (CCP) shall enable key economic sectors climate-adaptive and resilient while securing continued progress of national economic growth.
- CCP shall be committed to promoting low-carbon economy
- CCP shall be country-specific, scientific-based, technology driven and cost effective in implementing climate change mitigation and adaptation measures.
- CCP shall contribute to global efforts of stabilizing atmospheric CO_2e concentrations under dangerous level through enhanced carbon sequestration, reduced GHG emissions and efficient energy supply and demand
- CCP recognizes that disaster risk reduction is strongly linked with climate change mitigation and adaptation efforts.
- CCP recognizes that innovation, transfer, deployment and dissemination of ecologically sound technologies, and research and development (R & D) are the keys to address the challenges of climate change, particularly in the long run.
- CCP recognizing the climate change as a global issue shall encourage cooperation and collaboration with all state and non-state actors globally.

6. Objectives, Policies, Strategies and Actions

6.1 Energy Sector

6.1.1 Objective

To reduce GHG emissions from all types of production, distribution and utilization of energy, and from transportation

6.1.2 Policies

To improve energy conservation and efficiency, to enhance energy production and ensure energy security, to promote efficiency in transportation, and to regulate imports of second-hand vehicles

6.1.3 Strategies

To perform energy audit, **t**o tap all possible potential power sources to accelerate energy production, to encourage generation and utilization of renewable energy, to improve traffic control and public conveyance system, and to establish national ambient air quality standards

6.1.4 Actions

<u>Mitigation measures - Demand Side:</u>

1. Set energy efficiency standards and label efficiency grades on the products
2. Provide financial support and tax benefits for energy-efficient products
3. Provide energy advices and inspection, and encourage the use of energy-efficient appliances and equipment, and energy-saving compact fluorescent lamps
4. Capture fugitive gaseous emissions at fuel service stations.
5. Eliminate the behavior of using stand-by settings in all energy-consuming appliances
6. Develop voluntary agreements with incentive measures for increased use of highly energy-efficient electrical equipment and appliances

Mitigation measures - Supply Side:

1. Invest more in the exploration and utilization of natural gas
2. Construct hydro-electric facilities further where EIA permits
3. Promote the production of cleaner fuels and wind and solar power
4. Implement nuclear power generation project to meet increasing demand for electricity
5. Remove or upgrade existing inefficient power generation systems
6. Upgrade coal-burning industrial boilers through the use of quality coal
7. Extract coal-bed methane to reduce methane emission from coal mining
8. Improve power transmission and distribution system to reduce power loss
9. Promote combined heat and power generation at commercial buildings
10. Promote production of bio-energy from agricultural residues and, human and animal wastes without adversely affecting food security, soil status and forest resources

Mitigation measures - Transport:

1. Accelerate converting gasoline or diesel vehicles to CNG.
2. Construct CNG pipelines and CNG stations across the country
3. Improve energy efficiency through retrofitting and managing vehicle usage
4. Implement stringent standards for reducing CO_2 emissions from vehicles
5. Improve railway and waterway systems for increased containerized freight transport
6. Improve roads and road networks, and construct road detours
7. Increase the installation of light-emitting diodes in traffic lighting
8. Undertake land use, urban and transport planning to improve traffic management, transport systems, including non-motorized transport (cycling, walking)

Adaptation measures

1. Construct buildings with designs to improve cross ventilation, prevent direct sunlight in the afternoon, and reduce heat gains with shading covers
2. Develop and implement environmental standards for efficient use of energy
3. Discourage the import and the use of outdated and fuel- inefficient motor vehicles
4. Impose heavy taxes on the imported luxury cars and encourage car pools
5. Make public road, rail and water transports more comfortable and affordable
6. Build institutional capacity to monitor ambient air quality and air pollution regularly
7. Raise the awareness of the public on the values of energy conservation and reduced GHG emissions, and their uncontrolled impacts

6.2 Industrial Processes Sector

6.2.1 Objective

To realize energy saving, conservation and efficiency through improved management systems, increased use of cleaner energy, energy-efficient technologies and equipment, and adoption of environmental regulations and standards.

6.2.2 Policies

To adopt energy efficiency standards and labeling system, to prohibit manufacture and import of GHG inefficient products, and to promote energy efficiency and emission control technologies

6.2.3 Strategies

To practice Green Certification Program, to promote clean technologies and cleaner production

6.2.4 Actions

Mitigation measures

1. Set high energy efficiency and environmental standards for efficient use of energy
2. Conduct at each industry Efficiency Audit and label the industry and the product, if they satisfy the set standards, for example, Green Industry, and High Efficiency Product respectively.
3. Support such industries by providing tax benefits.
4. Encourage use of renewable energies such as solar and wind by providing incentives.
5. Further promote use of CNG and LPG in industrial processing through subsidies.

Adaptation measures

1. Encourage the use of more energy efficient boilers, motors, and furnaces
2. Introduce energy-saving, process-specific technologies
3. Initiate the development of carbon capture and storage for energy-intensive plants
4. Implement measures to capture nitrous oxide from industrial processes.
5. Implement energy-saving regulations, standards and improved management systems
6. Provide energy efficiency-related information services such as handbooks and educational talks, and conduct advocacy extensively for energy conservation and use of clean energy through all available media

6.3 Agriculture and Livestock Sector

6.3.1 Objectives

1. To reduce GHG emissions from the agricultural sector while increasing food production that secures self sufficiency and surplus for export.
2. To keep CH_4 emission under control in enhancing paddy production
3. To limit the emission of CH_4 and N_2O from livestock through improved management.

6.3.2. Policies

Follow "Code of Good Agricultural Practice" strictly, ensure increased food production in a climate friendly manner, and improve livestock management so as to mitigate GHG emissions.

6.3.3. Strategies

Improve rice cultivation method and water management, promote organic farming,research and develop on climate-resilient crop varieties, breed genetically improved strains of animals and regulate their population, and improve animal feed with quality forage and mineral supplements.

6.3.4 Actions

Mitigation measures

1. Reduce tillage in rice fields, and improve water and crop management, select rice varieties properly, practice crop rotation, and promote climate friendly technologies such as Conservation Agriculture and Sloping Agricultural Land Technology (SALT).
2. Apply herbicides to inhibit nitrification and de-nitrification to reduce N_2O emission.
3. Practice intermittent irrigation technique in rice fields to reduce CH4 emission.
4. Reduce use of mineral fertilizers, use phosphor-gypsum in combination with urea to reduce CH_4 emission, and apply slow release fertilizers to reduce N_2O emission.
5. Promote organic farming with increased use of bio-fertilizers and via improved crop residue management and manage properly the application of fertilizers and pesticides.
6. Introduce straw mulching with zero tillage in deep-water rice fields
7. Produce high quality forage, avoid over-grazing, and improve pastoral management.

8. Improve manure management, and Store manure in lagoons to use as bio-fertilizer
9. Use mineral supplements to reduce feeding amount, and supplement poor quality roughage with urea molasses, legume and/or low-cost agricultural by-products.
10. Store manure in anaerobic lagoons to use as bio-fertilizer by deep application
11. Collect CH_4 emitted from manure and use as fuel for heating and lighting

Adaptation measures

1. Adjust agricultural cropping systems such as crop diversification, and multiple, mixed, inter-cropping, and improve management measures, such as water saving, optimized fertilization, soil and water conservation, and increased use of bio-fertilizers.
2. Promote stress-resistant genetic strains of crops, encourage the increased use of high-quality stress-resistant plant varieties, bio-fertilizers and eco-friendly pesticides.
3. Develop incentive/disincentive measures and practice crop-mix and organic farming to ensure agricultural ecosystem to adjust better and resilient to climate change effects.
4. Increase and expand water impoundment systems through ponds, dams, lakes and rain water collection facilities, and improve water use conservation and efficiency
5. Upgrade and enhance dissemination of weather-related early warning system
6. Improve post-harvest treatment and use better storage facilities
7. Identify and integrate climate risk reduction measures into agriculture, and ensure human resources, budget and advanced technology for implementing these measures.
8. Promote dry-land agriculture, and preserve soil moisture and fertility in the Dry Zone
9. Protect pastures against wild fires, man-made burning, over-grazing, and soil erosion.
10. Supplement ruminant fermentation-control medicine in livestock diets.
11. Add fermentation stabilizers and micro-organism repressors to animal diets
12. Breed high-quality varieties to increase productivity and total production with optimized number of animals, and protect livestock against heat stress
13. Establish livestock farming zones to facilitate the livestock management with joint undertakings, including installation of common manure disposal, among others.

6.4. Land Use Change and Forestry

6.4.1 Objectives

1. Preserve and enhance forest carbon reservoir and sink to help combat climate change
2. To minimize GHG emissions from land use change

6.4.2 Policies

Promote carbon sequestration through sustainable forest ecosystem development, and cause change of land use to be preceded by EIA in accord with broad National Land Use Plan

6.4.3 Strategies

Introduce private forestry, manage state (or public) and non-state forests in a sustainable manner, intensify re-afforestation programmes, promote community forestry and urban tree plantings, encourage manufacture of long lasting value added forest products, develop national land use plan, and let EIA precede any major land use change

6.4.4 Actions

Mitigation measures

1. Protect existing forests, expand forest extent, and increase forest density and growth

2. Expand Protected Areas System, conserve biological diversity and productivity, recover endangered species, and maintain structural diversity of forest and species mixture
3. Avoid clear felling of forest in timber harvest, practice "reduced impact logging system", and restore or replant harvested areas, depleted areas and degraded forests
4. Increase advocacy and educate public about community forestry (CF)
5. Apply agro-forestry or aqua-forestry systems, as appropriate, to establish CFs in order to generate early financial benefits and thus ensure community participation
6. Continue Forest Department's program of free distribution of seedlings for roadside and urban greening, and consider incentives to ensure the survival of the planted trees
7. Develop technologies of manufacturing superior quality forest products to extend the lives of wood end uses, and meet forest related human needs
8. Promote the use of wood products in place of energy-intensive construction materials.
9. Develop and implement national land use plan to sustain permanent forest estate
10. Conduct EIA and cost-benefit analysis prior to deciding any major land use change.

Adaptation measures

1. Enrich and sustain biodiversity, and develop stress-resilient genetic strains
2. Practice multi-culture and structurally complex forest ecosystems management
3. Promote private and community forestry, and intensify mangrove re-afforestation
4. Conduct research and encourage planting drought- and fire- resistant tree species
5. Establish an efficient forest fire fighting mechanism
6. Raise public awareness and participation in forest management and development.

6.5. Waste Sector

6.5.1 Objectives

To reduce GHG emissions through improved waste management and energy recovery from waste, to make both urban and rural areas free from environmental pollution and health hazards, and to enhance aesthetic appreciation of cities

6.5.2 Policies

Strengthen "Green and Clean Country" campaign to make the country green and clean reducing GHG emissions and environmental pollution.

6.5.3 Strategies

Minimize per capita waste generation, recycle waste, generate heat and electricity from waste treatment, advocate self-cleanliness and public hygiene, practice "Polluter Pay System"

6.5.4 Actions

Mitigation measures

1. Reduce the volume of waste per capita, and educate the public on waste management.
2. Categorize waste and dispose it properly at designated landfills, expand waste storage and treatment facilities, and generate electricity using landfill gas
3. Encourage waste recycle and promote market opportunities for recycled products
4. Eliminate the use of polyethylene plastic bags.
5. Enforce regulations, standards, and "polluter pay system" for waste management

Annex V

EST Database on Emission Reduction Projects

1. GHG Emission reduction(EST) projects proposed under the ALGAS project in 1998.

The proposed projects based on GHG emission reduction under the Asia Least-cost Greenhouse Gas Abatement Strategy-Myanmar(ALGAS-Myanmar) project implemented by National Commission for Environmental Affairs(NCEA) in cooperation with GEF, ADB and UNEP in 1998 are as follows:-

(1) Developing Institutions and Capacity for Inventory of GHGs in Myanmar.
(2) Rural Electrification through Bioenergy.
(3) LPG cookers to replace electric cookers.
(4) Dissemination of Biogas Technology for GHGs Emission Reduction in Shan State.
(5) Fuel-Efficient Cookstoves and Participatory Forestry for Carbon Emissions Reduction in Shan State of Myanmar.

2. Emission reduction(EST) projects identified for Myanmar in 2005 to be selected as CDM project.

Taking advantage of the Projects on needs assessment on Technology Transfer to Mitigate the effect of Global Warming in Myanmar, implemented in 2005 by the National Commission for Environmental Affairs(NCEA), Myanmar in cooperation with NEDO, KRI., Inc, Japan. The following 33 ESTs were identified for Myanmar to be selected as CDM projects.

The Outline of 33 Environmentally Sound Technologies identified for Myanmar to be selected as CDM projects are shown in Appendix (A).

The most preferred technologies of various ministries concerned are as follows-

1. Generation of wind power, waste power and solar power
2. Utilization of energy from methane fermentation
4. Rehabilitation of dye-works, introduction of energy saving equipments
5. Making boiler plants more energy efficient
6. Spread of low-pollution vehicles, clean energy automobiles
7. Modal shift
8. Rehabilitation of petrochemical plants
9. Introduction of energy-saving equipment
10. Fuel conversion
11. Promoting increased use of biodegradable plastics
12. Rehabilitation of refineries, introduction of energy saving equipment
13. Introduction of new transportation systems (dual-mode bus system, etc)

CDM related projects undertaken in cooperation with NEDO, Japan 1998-2004

CDM related projects based on emission reduction under the Kyoto Protocol have been implemented by various ministries in Myanmar in cooperation with NEDO, Japan (1998 to 2004). The status of these projects are shown in Appendix (B).

1. Proposed emission reduction(EST) projects under UNFCCC-INC in 2010

The proposed projects based on GHG emission reduction under the Preparation of the INC under the UNFCCC Project implemented by NCEA in cooperation with UNEP in 2008-2010 are as follows:-

1) Green House Gas (GHGs) Mitigation of Bio-energy Potential to Improve the Livelihood and to Attain the Energy Security of Rural Communities in Myanmar.
2) Bamboo Bio- ethanol Production and Utilization in Rural Area.
3) Low cost plastic Biodigester Proposal.
4) Dissemination of A-1 Fuel-wood Improved Cook-stoves for GHGs Emission Reduction Project.
5) Agricultural opportunities for Green House Gas (GHGs) mitigation in Myanmar.
6) Mitigation of CH4 Emission from Rice Fields by Fertilizer Management Practices
7) Mitigation of CH4 Emission from Rice Fields by Water Management Practices
8) Mitigation of N2O Emission from Lowland Paddy Field by Organic Manuring and Water Management
9) Effect of Integrated Nutrient Management and Method of Fertilizer Application on N_2O Emission from Commercial Cabbage Production in Myanmar.
10) Project Proposal for Small Scale Reforestation Pilot Project in Ayeyarwady Delta.
11) Wind power generation.
12) Waste power generation.
13) Utilization of energy from methane fermentation.
14) Rehabilitation of dye-works, introduction of energy saving equipments.
15) Making boiler plants more energy efficient.
16) Spread of low-pollution vehicles, clean energy automobiles.
17) Modal shift.
18) Solar power generation.
19) Rehabilitation of petrochemical plants, introduction of energy-saving
20) Equipment
21) Fuel conversion.
22) Promoting increased use of biodegradable plastics.
23) Rehabilitation of refineries, introduction of energy saving equipment.
24) Introduction of new transportation systems (dual-mode bus system, etc).

Appendix V(A)

Sr. No	Environmentally Sound Technologies	Outline	Specification	Cost
1	Solar power generation	-Direct conversion by solar cell panel -For housing, industries, public use -Depend on sun shine	-Efficiency < 15% -Battery, trans, inverter	-Approx $ 5,000/ 1KW (moduled system for housing, Japan basis) -Panel size: 1.3 X 0.9m Output : 190W
2	Wind power generation	-Low emission of CO_2 -Energy efficiency < 40%	- Various scale 0.4-2,000KW	- Nearly M$ 3 / 1unit (1,000KW
3	Medium and Small-scale hydraulic power generation	-Electrical generation using flowing water power -Especially useful in rural or non-electrified areas	-Ex) 10-50 kWh. Water flow 0.1-8 m^3/s -Suitable for combination with solar or wind power	
4	Waste power generation	- Carbon neutral	- Waste 150-1,000 tons/day - Efficiency < 20%	- Nearly M$ 30/1 unit(10,000kW)
5	Utilization of Biomass energy such as from wood/chaff	-Agricultural waste, wooden waste -Power generation by direct combustion of gas formation -Pelletization for easy handling -Carbon neutral (No more CO_2 emission)	-Continuous supply of biomass material -100kWh → 60-70kg CO_2 reduction (crude oil, NG generation)	
6	Utilization of energy from	- CH_4 Gas reduction	- Gas engine generation	- Nearly M$ 8 / 1,700kW Plant
7	Fuel Conversion of Power Plant : switching crude oil or coal to natural gas	-Existing fuel(Crude oil or coal ; much CO_2, SO_2 emission - Natural gas ; 10-20% CO_2 reduction	- Boiler burner system change -Main equipment; burner and gas supply system	- Approx. M$ 1

8	Introduction of combined cycle	- Combined power generation system by gas and steamed turbines -Suitable for heat consumption facilities	-650-10,000 kWh -Generation efficiency , 45% existing gas turbine; 20-25% (assumed)	-Approx. $ 1,000/ kWh
9	Reduction of transmission losses	- Reduction of transmission losses of electric power -Reduction of power transmission system	- Replace or rehabilitation of transmission facilities (transmission loss in Japan ; 6-9%)	
10	Rehabilitation of heat supply facilities, fuel conversion, updating of equipment	- Rehabilitation of heat supply facilities or boiler house -Fuel switching from heavy oil or coal to natural gas	-CO_2 reduction ; 10-20% -Improving energy consumption efficiency -Main equipment; burner and gas supply system	
11	Repair and Optimization of gas pipelines	-Inspection of gas leakage -Maintenance of gas pipe line -Corrosion-proof, painting	- Pipe replacement -Anti-corrosion treatment	
12	Methane gas recovery from coal mines	-Methane gas recovery from coal mines -Power generation, waste heat recovery	-Generation efficiency; 25-40% -100kWh ---60-70kg-co_2 reduction (crude oil, NG generation)	
13	Associated gas recovery from oil fields	-Catching head gases from oil fields as LPG -Gas supply to town	- Ex) LPG; butane 95%, propane 5% Ex) LPG; butane 95%, propane 5%	

14	Rehabilitation of steel mills, introduction of energy-saving equipment	-Waste heat recovery from	- Depend on the results of	
		furnaces or exhausted gases of	diagnosis	
		iron work industry (ex. Coal	-100kWh----60-70kg-co_2 reduction	
		oven gas)		
		-High efficiency power with		
		inverter drive		
15	Rehabilitation of refineries, introduction of energy-saving equipment	- Heat recovery system (e.g.	- Depend on the results of diagnosis	- Depend on situation; Approx. M$ 1-100
		steam generation)		
		-High efficiency equipments(e.g.		
		oil heater)		
		-Recovery off gas, LPG, hydrogen		
		-Reduction heat loss		
16	Rehabilitation of petrochemical plants, introduction of energy-saving equipment	- Heat recovery system (e.g.	- Depend on the results of diagnosis	- Depend on situation; Approx. M$ 1-100
		steam generation)		
		-High efficiency equipments(e.g.		
		oil heater)		
		-Reduction heat loss		
		-Energy saving of total plant		
17	Rehabilitation of cement plants, introduction of energy-saving equipment	- Power generation by waste heat	- Depend on the results of	
		-Vertical mill, high-efficiency	diagnosis	
		equipments		
		-High efficiency power with		
		inverter drive		
18	Rehabilitation of pulp & paper mills, introduction of energy-saving equipment	- Rehabilitation of black liquor	- Ex) black liquor boiler	
		evaporator, dryer hood and	Black liquor 2,900ton/day, generation 85,000kW	
		press machine	Calorific value of black liquor; 12.6 MJ/ton(dry)	
		-Introduction of private power		
		generation		
		-Energy saving of whole factories		

19	Rehabilitation of dye-works, introduction of energy-saving equipment	-Low liquid ratio dyeing machine system -Waste heat recovery equipment	-Energy saving 40-60% -Water saving 30-50%	- Nearly M$ 0.2/ 1 unit (200ton/y)
20	Rehabilitation of food factories, introduction of energy-saving equipment	- GHG reduction from waste-water or waste disposal -High efficiency boiler, reduction heat losss and switching fuels	- Heat pump -Coefficient of Performance (COP): 1-3	
21	Making boiler plants more energy-efficient		- Heat efficiency 90-95% -Various scale 100 kg/h – 10 ton/h	- Nearly M$ 0.02/ 1 unit (1.5ton/h
22	Spread of low-pollution vehicles, clean energy automobiles	-CNG vehicle	- Usage of CNG -CO_2 reduction- 30% -NO_x reduction- 95%	- Remodeling cost $ 8,000/ 1 vehicle -Construction of CNG station M$ 1
23	Modal shift	- Long-distance transport	-Reduction of CO_2 - to 1/5 by Railway transport - to ¼ by Sea transport	- Improvement of energy consumption efficiency
24	Use of ITS	-Provide drivers road and traffic information -Support drivers to choose the best route -Reduction of energy consumption -Emissions of GHG accompanied		
25	Introduction of new transportation systems(Dual-mode bus system, etc.)	- GHG reduction in Urban Area -Bus runs in economical speed on the exclusive road -Improvement of convenience of bus		

26	Adoption of co-generation by businesses	-Utilization energy efficiently -Introducing cogeneration into private facilities - Hospitals - Hotels - Office buildings - Shopping Centers etc.		- M$ 5,000-7,000 /55MW
27	Making electric household appliances more energy-efficient	- Lower standby electricity of home electronics	- Standby electricity requirement accounts for 105 of all power consumption -Videocassette recorders(VCR) -Gas-burning water heaters -Audio appliances -Telephone with FAX -Television	
28	Introduction of high-efficiency lighting	-Reducing the power consumption	-Making of lighting Fluorescent lamp -LED Traffic lights: -power consumption is about 1/5 of the lamp types	-Two times general Lamp
29	Making buildings more energy--efficient	- Reducing the power consumption	- Introduction of energy consumption technique into Buildings or Hotels	
30	Making water and sewage treatment plants more energy--	- Introducing inverter-controlled systems	- Reduction of power consumption(Effect of 30% or more	- M$ 1.5-3 / 100kW
31	Promoting increased use of Eco-cement and Ready-mixed	- Effective Use of incineration Ash, sewage plant sludg	- Performance equal with general cement	- Manufacturing cost : $250/ton (Capacity 110,000ton/year)
32	Utilization of Recycled food waste	- Recycle food waste to composts or feeds	- Making of food waste loss in weigh	
33	Promoting increased use of biodegradable plastics	- Carbon neutral	- Reduction of CO_2 -Plastics of biomass origin -Resolve by microorganism in soil	- Material Cost: Three times general plastics

Sr. No.	Project Name	Counterpart Agency	Implementation Site	Duration of Project
1	Demonstrative Research on Prediction Method of Average Wind Speed	Ministry of Electric Power(MOEP)	Nationwide	1999
2	Wind power and Photovoltaic Energy Assessment by Numerical Weather Method	Department of Meteorology and Hydrology	Nationwide	1999
3	Feasibility Studies for Research Cooperation on Photovoltaic Power Generation System	Ministry of Electric Power Enterprise(MEPE)	Nationwide	1998
4	Cooperative Research Project on Water and Wastewater ; Small Equipment Adaptation by Photovoltaic Power Generation System Utilization	Kownship Development Affairs	Kyaukse Township	2001
5	Feasibility Studies for the Model Project Implementation Saving Energy in Fertilizer Plant	Ministry of Energy(MOE), Petrochemical Enterprise(MPE)	MOE, MPE, No. 3 Kyaw Zwa Fertilizer Factory	1999
6	Feasibility Studies for the Model Project for High Efficiency Gas Turbine Technology	Ministry of Electric Power(MOEP)	DPE, MOEP, Ywama Power Plant	2001
7	Basic Research Project for Efficient Energy consumption and Cooperation Project for Energy consumption Seminar	Foreign Economic Relations Department(FERD), Ministry of Energy	Yangon	1999
8	Survey on Adaptation of Energy conservation Equipment for a Pulp Plant	Ministry of Industry No.(1)	Myanmar Paper and Chemicals Enterprise, Sittaung Paper Mill	2001
9	The Adaptation of Pipeline in the Crude Oil Unloading System at Thanlyin Refinery		MOE, MPE, Thanlyin Refinery	2001
10	Feasibility Studies for Greenhouse Gases Reductions by Installing Modem Refinery Facilities at Thanlyin Refinery		MOE, MPE, Thanlyin Refinery	2000
11	The rehabilitation Project as CDM Aimed at Reducing Emissions of GHG		Tharkayta Gas Turbine Power Plant, owned by the Myanma Electric Power Enterprise(MEPE)	2000
12	Project for Reduction of Integrated Loss from Supply and Demand/ Thermal Power Generation		Bago, Magwe and Mandalay	1999
13	Demonstrative Research on a Grid-Connected Photovoltaic power Generation System	Department of electric Power, Ministry of Electric power	Chaungthar, Ayeyarwady Division	1999-2004
14	The Model Project on High-Efficiency Gas Turbine Technology	Ministry of electric Power	Myanmar electric Power Enterprise, Yangon	2002-2004
15	The Model Project for Energy Conservation in Fertilizer Plant	Myanmar Petrochemical enterprise(MPE), ministry of energy	No. 3 Kyaw Zwa Fertilizer Factory, MPE	2000-2002

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Acronyms

A

AAC	Annual Allowable Cut
A1TMES	Reference Scenario of Climate Secnarios of Various Climatic Elements
ADORC	Acid Deposition and Oxidant Research Center
ADPC	Asian Disaster Preparedness Center
AL	Affected Level
ALGAS	Asia Least Cost Greenhouse Gas Abatement Strategy
AR	Afforestation/Reforestation
ASCMG	ASEAN Subcommittee on Meteorology and Geophysics
AWOS	Automatic Weather Observing Systems

B

BANCA	Biodiversity and Nature Conservation Association
BBIMSTEC	Bay of Bengal Initiatives for Multi-Sectoral Technical and Economic Cooperation
BEHS	Basic Education High School
BEMS	Basic Education Middle School
BEPS	Basic Education Primary School
BMD	Burma Meteorological Department
BOD	Boichemical Oxygen Demand
BSS	Burma Selection System

C

CBD	Convention on Biological Diversity
CBO	Community Based Organization
CCC	Climate Change Concern
CCR	Coastal Community Resilience
CDM	Clean Development Mechanism
CDMA	Code Division Multiple Access
CFC	Chlorofluorocarbon
CFI	Community Forestry Instructions
CGAP	Code of Good Agriculture Practice
CH_4	Methane
CIC	Climate Information Center
CIF	Climate Investment Funds
CITES	Convention on International Trade in Endangered Species of wild flora and fauna
CL	Confidence Level
CLICOM	CLImat COMputing
CLMV	Cambodia, Laos PDR, Myanmar, Vietnam
CMA	China Meteorological Administration
C/N	Carbon/Nitrogen ratio
CNG	Compress Natural Gas
CO	Carbon Monoxide
CO_2	Carbon Dioxide

CONOPS	Concept of Operations
COP	Conferences of the Parties
CPU	Catch Per Unit
CSIRO	Commonwealth Scientific and Industrial Research Organization
CSO	Central Statistical Organization

D

DDA	Department for Development Affairs
DFN	Departure From Normal
DMH	Department of Meteorology and Hydrology
DNA	Designated National Authority
DoF	Department of Fisheries
DO	Dissolved Oxygen
DZGD	Dry Zone Greening Department

E

EANET	Acid Deposition Monitoring Network in East Asia
ECC	Environmental Conservation Committee
ECCDI	Ecosystem Conservation and Community Development Initiative
EIA	Environmental Impact Assessment
EEZ	Exclusive Economic Zone
ENSO	El Nino Southern Oscillation
EPA	Myanmar National Environmental Performance Assessment
EST	Environmentally Sound Technology
ESTIS	Environmentally Sound Technologies Information System
ETPA	Education, Training and Public Awareness on climate change

F

FAO	Food and Agriculture Organization
FCR	Crop Residue Fertilizer
FD	Forest Department
FON	Organic Nitrogen Fertilizer
FPRP	False Positive Report Probability(Genetics)
FRA	Forest Resource Assessment
FREDA	Forest Resources Environment Development Association
FSN	Synthetic Nitrogen Fertilizers

G

GDP	Gross Domestic Product
GFDL	Geophysical Fluid Dynamics Laboratory
GEF	Global Environment Facility
GHG	Greenhouse gas
GLOSS	Global Observing Sea Stations
GMS	Greater Mekong Subregion
GPG	Good Practice Guidance
GSM	Global System for Mobile Communication
GSN	Global Surface Network

H

HCFC	Hydrocholrofluorocarbon
HFA	Hyogo Framework for Action
HFC	Hydrofluorocarbon
HPMP	Hydrofluorocarbon Phase out Management Plan
HWP	Harvested wood products

I

ICS	Incident Command System
ICT	Information Communication Technologies
IEC	Information Education and Communication
IETC	International Environmental Technology Centre
IFAD	International Fund for Agricultural Development
IIT	Indian Institute of Technology
IMO	International Meteorological Organization
INC	Initial National Communication
IndOOS	Indian Ocean Observing System
INGO	International Non Government Organization
IOC	Intergovernmental Oceanographic Commission
IPCC	Inter-governmental Panel on Climate Change
ITTA	International Tropical Timber Agreement
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resources Management
IWT	Inland Water Transport

J

JAXA	Japan Aerospace Exploration Agency
JCOMM	Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology
JI	Joint Implementation
JICA	Japan International Cooperation Agency
JIFPRO	Japan International Forestry Promotion and Cooperation Center
JMA	Japan Meteorological Agency

K

KOICA	Korea International Cooperation Agency

L

LBVD	Livestock Breeding and Veterinary Department
LDCF	Least Developed Countries Fund
LNGO	Local Non Government Organization
LPG	Liquefied Petrolium Gas

M

MAGICC/SCENG-EN	Model for the Assessment of Greenhouse gas Induced Climate Change/ SCENario GENerator Scenario generator is the software to specifically desigened to allow simulation of whole health and social care systems
MAPDRR	Myanmar Action Plan on Disaster Risk Reduction
MDG	Millennium Development Goal
MEA .	Multilateral Environmental Agreement
MESSAGE	Model for Energy Supply Strategy Alternatives and their General Environmental impact
MFPTMA	Myanmar Forest Products and Timber Merchants' Association
MIAT	Multidisciplinary Integrated Assessment Team
MOECAF	Ministry of Environmental Conservation and Forestry
MOF	Ministry of Forestry
MOGE	Myanmar Oil and Gas Enterprise
MOMSEI	Monsoon Onset Monitoring and Its Social & Ecosystem Impacts
MOU	Memorandum of Understanding
MPA	Myanmar Port Authority
MPBND	Ministry of Progress of Border Area Development and National Races and Development Affairs
MPCI	Myanmar Paper and Chemical Industries
MRCS	Myanmar Red Cross Society
MSS	Myanmar Selection System
MSW	Municipal solid waste
MSY	Maximum Sustainable Yield
MTE	Myanmar Timber Enterprise
MV	Modern Varieties

N

NAP	National Action Program
NAPA	National Adaptation Programmes of Action
NMVC	Non-Methane Volatile Compound
NBSAP	National Biodiversity Strategy and Action Plan
NCCC	National Climate Change Committee
NCEA	National Commission for Environmental Affairs
NCSA	National Capacity Needs Self-Assessment
NCV	Net Calorific Values
NDPCC	National Disaster Preparedness Central Committee
NECC	National Environmental Conservation Committee
NEDO	New Energy and industrial technology Development Organization
NFC	Northern Forest Complex
NFMP	National Forest Management Plan
NGO	Non Government Organization
NIOT	National Institute of Ocean Technology
NMS	National Meteorological Center
NMHS	National Meteorological

NMVC	Non-Methane Volatile Carbon
NMVOC	Non-Methane Volatile Organic Carbon
NPP	Net Primary Production
NR	Natural Regeneration
NST	National Study Team
NTWCs	National Tsunami Warning Centres

O

ODS	Ozone Depleting Substances
ODU	Ozone Depleting Unite

P

PAS	Protected Area System
PCCDs	Pollution Control and Cleansing Departments
PFC	Perfluorocarbon
PFE	Permanent Forest Estate
PMT	Project Management Team
PRA	Participatory Rapid Appraisal
PRECIS	Regional Climate Impact Studies
PTC	Panel on Tropical Cyclones
PV	Photovoltaic

R

RC	Regional Centre
RDF	Refuse-Derived Fuel
REAM	Renewable Energy Association Myanmar
REDD	Reduction of Emission on Deforestation and Degradation
RIMES	Regional Integrated Multi-hazard Early Warning System
RMP	Refrigeration Management Plan
ROAP	Regional Office for Asia and the Pacific
RSO	Research Systematic Observation
RTF	Round-trip Paddling Fermenter

S

SCCF	Special Climate Change Fund
SEA	South East Asia
SEA START RC	South East Asia SysTem Analysis Research and Training Regional Centre
SEAFDEC	Southeast Asian Fisheries Development Center
SEAGOOS	South East Asia-Global Observing System
SF_6	Sulphur hexafluoride
SM	Mean Score
SME	Small and Medium Enterprises
SPA	Strategy Priority for Adaptation
SRES	Special Report on Emission Scenarios

SSB	Single Side Band
SST	Sea Surface Temperature
START	SysTem Analysis Research and Training
SWDS	Solid Waste Disposal to Site

T

TARNS	Tsunami Alert Rapid Notification System
TCP	Tropical Cyclone Programme
TICA	Thailand International Development Cooperation Agency
TNA	Technology Needs Assessment
TNA	Technology Needs Assessment
TRS	Tropical Revolving Storm

U

UKHadCM3	UK Hadley Centre Coupled Model version 3
UKHadGEM1	UK Meteorological Office Hadley centre Global Enviroment model
UMMB	Urea Molasses Mineral Block
UNCCD	United Nations Convention to Combat Desertification
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNEP-ROAP	UNEP Regional Office for Asia and the Pacific
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
UNOCHA	United Nations Office f or The Coordination of Humanitarian affairs
USAID	United States Agency for International Development

V

V&A	Vulnerability and Adaptation
VI	Vulnerability Index
VL	Vulnerability Level
VSS	Vital Statistic System

W

WCP	World Climate Programme
WCS	Wildlife Conservation Society
WESTPAC	Western Pacific
WHO	World Health Organization
WLL	Wireless Local Loop
WMO	World Meteorological Organization
WWW	World Weather Watch

Y

YCDC	Yangon autonomous City Development Committees

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