ICLEI Local Governments for Sustainability

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# TECHNICAL REPORT:
# TRENDS IN CLIMATE CHANGE ADAPTATION IN SOUTHEAST ASIA

Local Governments for Sustainability (ICLEI)
under Asia Pacific Adaptation Network (APAN)
March 2013

Techincal Report:
Trends in Climate Change
Adaptation in Southeast Asia



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# 1.0 INTRODUCTION

## 1.1 Background of the Report

Many of the communities across Southeast Asia are struggling to cope with a number of climate change-related hazards that include cyclones, rainfall extremes, floods, and droughts with severe damage and loss of life (Yuen and Kong 2009; ADB 2009). The rising frequency and intensity of weather extremes related to climate change has resulted to a wide array of risks and vulnerabilities that necessitated urgent attention and actions. In effect, a growing understanding by the public on the urgent need to adapt to the changing climate could be directly observed in the immediate past years. Such observation is directly correlated to the physical manifestation of climate change, particularly in terms of climate variability and extremes, which are becoming more and more highly observable and with wide-ranging impacts largely felt across the entire spectrum of the society.

Being a region poised to achieve a more-inclusive growth while sustaining its valuable environmental resources, countries in the Southeast Asian region realise that the cost related to inaction is high given that a number of its population has been described to be highly vulnerable to climate change impacts. With a total population of 592 million in 2010 accounting for around 8.6 per cent of the world's 6.8 billion population and an average population growth rate of 1.37, the Southeast Asian region is rated as one of the world's fastest growing regions in terms of population and urban growth (World Bank 2011). The growing interest of proactively pursuing development that take into consideration climate change concerns, has likewise presented a number of opportunities that need to be strategically well captured. Hence, countries in Southeast Asia cannot afford to be complacent given the urgency of climate change concerns and the current developmental stages they are currently in.

The need to improve the resilience of the Southeast Asian region to climate change would largely depend on the optimal combination of technical and financial mechanisms that must be well placed. Generally, adaptation includes adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change (IPCC 2007). UNFCCC (2007) explained that it is a process that enables societies better able to cope with uncertain future which entail taking the right measures to reduce the negative effects of climate change, including exploiting the positive ones, by making the appropriate adjustments and changes.

The specific nature of climate change adaptation actions have been conceptually defined in a number of ways. Overall, adaptive responses could be generally categorised as technological, behavioral, managerial and policy interventions (IPCC 2007). Klein (2002) categorised adaptation measures as reactive and anticipatory wherein the latter involves programmes and interventions implemented even before impacts become apparent, while the former refer to actions done in response to the climate change impacts. Further, Smit et al. (2000) and Klein et al. (2002)

added that adaptation could be grouped in terms of the implementers namely, autonomous adaptation and planned adaptation. In contrast to autonomous adaptation that occurs even without intervention of an informed decision maker, planned adaptation is a product of deliberative process requiring informed and strategic decisions (Klein 2002).

The overall growing understanding among the Southeast Asian populace has been translated into various modes of engagements between and among different stakeholders. These actions take into consideration respective needs-based concerns of specific locality of a Southeast Asian country with particular action situation. To date, these generally involved the formulation of various adaptation strategies and policies with several aimed targets. However, the variation of the opted forms of climate change adaptation engagements and implemented projects reflects the peculiar characteristics and specific requirements of each community across the Southeast Asian countries. In all of these adaptation measures, technology plays a vital role in enhancing the adaptive capacity of vulnerable communities while reducing its vulnerability to weather extremes in the long run.

## 1.2 Southeast Asia: Overview and Climate Change Adaptation Concern

The Fourth Assessment Report of the IPCC (2007) reported that across Southeast Asian region has experienced increases in surface air temperature, inter-annual and spatial variability in rainfall, increased frequency and intensity of cyclones. The existence of climate change is made evident by the observed increasing trend of temperature by 0.1-0.3°C per decade between 1951 and 2000 (Cruz et al. 2007; ADB 2009). The projected increase in tropical cyclone was due to the projected increase in intense precipitation events in Southeast Asia (Cruz et al. 2007). Overall, the occurrence of extreme weather events are projected to increase in Southeast Asia and other parts of Asia including droughts and heat waves, intense precipitation events, and a 10 to 20% likelihood of increase in the intensity of tropical cyclones for every 2 to 4 years.

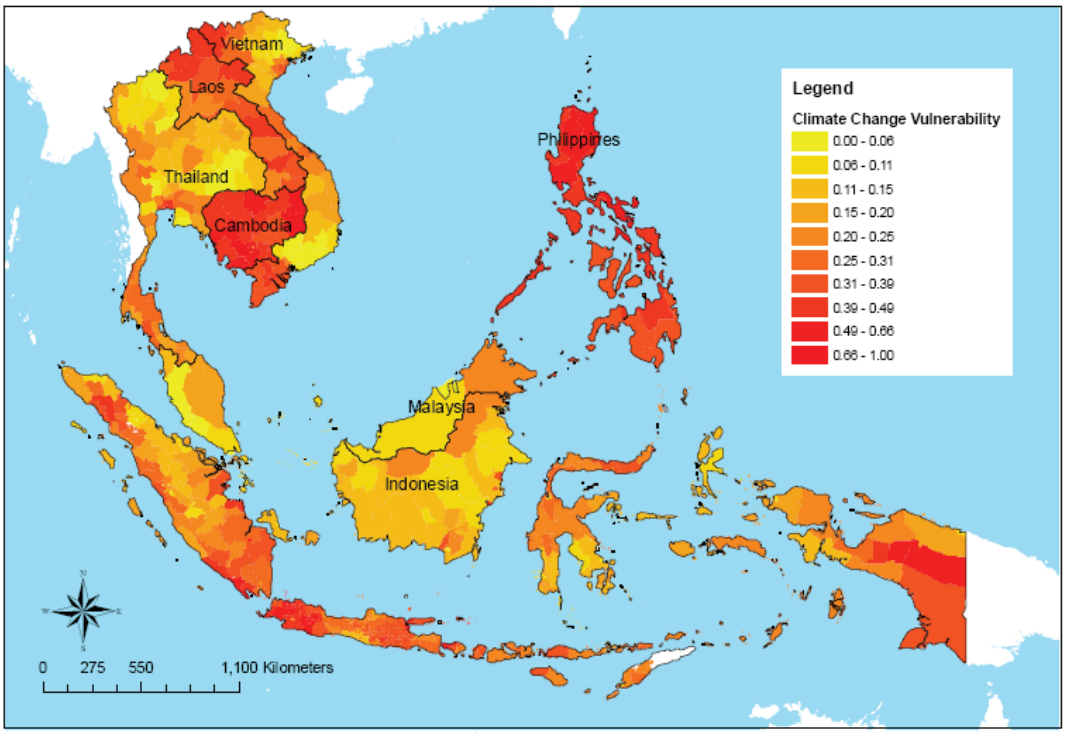


*Figure 1. Climate change vulnerability of the Southeast Asian region.*
*Source: Yusuf and Francisco (2009)*

The Southeast Asian region is composed of eleven countries, namely: Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Vietnam, and Timor Leste. It has a total land area of 4,330,079 $km^2$, comprising about 3.3 percent of the world's total land area (ADB 2009). Most of Southeast Asia is within the tropical climatic zone that is strongly influenced by the Asian monsoons bringing significant amount of rainfall. Interestingly, huge variations in terms of land and population size, economic performance, governance practices, cultural traditions, ethnic groups, religions, and languages can be observed among countries comprising the Southeast Asian region.

Southeast Asian economies are extremely diverse. While the island-country of Singapore, Brunei Darussalam and Malaysia are considered to have advanced economies (OECD 2010), the countries like Cambodia, Lao PDR, Myanmar, Timor Leste, and Vietnam (Raitzer et al. 2010) are at an early stage of economic development. On the other hand, other members such as the Philippines, Thailand, and Indonesia are considered to be in the middle of economic transformation. With a combined GDP of more than USD1.5 trillion in 2008, the GDP per capita varies from USD623 in Timor Leste to over USD 41,000 in Singapore in 2010 (World Bank 2011).

To date, Southeast Asia is one of the world's fastest growing regions in terms of population and urban growth. In 2010, the region had a total population of 592 million accounting for around 8.6 per cent of the world's 6.8 billion population, and an average population growth rate of 1.37 (World Bank 2011). It is home to one of the most populous countries in the world, Indonesia, which has over 200 million people in 2010, followed by the Philippines with 93 million, Vietnam with 86 million, and Thailand with 69 million (World Bank 2011). Singapore, Brunei Darussalam, and Malaysia have the highest percentage of urban population in the sub-region. Overall, it is estimated that more than half of the Southeast Asia's population live in rural areas.

Agriculture remains a major source of income of the Southeast Asian region employing about 46% of the entire population. ADB (2009) reported that an approximately 115 million hectares of the Southeast Asian region is cultivated for its major agricultural crops such as rice, corn, palm oil, natural rubber and coconut. Agricultural areas remain largely rain-fed, irrigated cropland only accounts to approximately 17 per cent of the total. Rice, sugarcane, and oil palm are the most dominant crops in terms of production volume. The region also raises a significant amount of livestock, whose production has been noticeably growing in developing countries in recent years (ADB 2009; FAO 2006). Poultry and chicken are of greatest importance to Indonesia, whereas the Philippines produce a significant amount of pig meat.

The creation of the Association of Southeast Asian Nations (ASEAN) in 1967 paved the way for regional integration initiatives concerning various economic and developmental concerns across the Southeast Asian countries. As outlined in the ASEAN Vision 2020, the ASEAN countries are gearing towards economic integration that would result to integrate economic, socio-cultural and security community. Recently, the ASEAN member states agreed to accelerate the schedule

to achieve these goals by 2015. The ASEAN has endorsed 11 priority sectors for integration including agriculture, electronics, healthcare, ICT and tourism. Mid-term action plans to achieve the goal of an ASEAN Community were agreed, such as the Vientiane Action Programme covering the period 2004-2010 following the Hanoi Plan of Action for 1999-2004. Other initiatives within the region for international cooperation include the Mekong River Commission (MRC) and the Coral Triangle Initiative (CTI) by the World Wildlife Fund (WWF). The MRC was formed in 1995 and consists of four countries: Cambodia, Lao PDR, Thailand, and Vietnam. It was established for the joint management of shared water resources and economic development of one of the world's greatest river system - the Mekong River Basin. In the same way, the governments of Indonesia, Malaysia, and the Philippines are collaborating for the conservation efforts and sustainable resource management of one of the world's body of water, hosting the highest marine biodiversity through the CTI by the WWF.

## 1.3 Framework and Objectives of the Report

The end goal of ensuring the combined ability of the Southeast Asian region to adapt to climatic changes has become an urgent agenda and will surely remain a priority in the immediate future. To achieve this, the critical ingredients that include the identification and implementation of appropriate adaptation strategies, which are clear by-products of policy mechanisms, plans and programmes necessarily, must be well in place (Figure 2). Such policy mechanisms must be complemented with guiding institutional framework in support of climate change adaptation with sustainable international and national financial mechanisms. On the implementation side, the importance of identifying, choosing and implementing appropriate climate change adaptation actions require relevant technology to ensure achievement of targets. In this aspect, harnessing the power of technology requires serious attention, as this would entail financial and technical investment on the part of implementer, its community, or that of the national government. In this report, analyses on technological utilization in various sectors of agriculture, water, mountains and coastal ecosystems are provided.

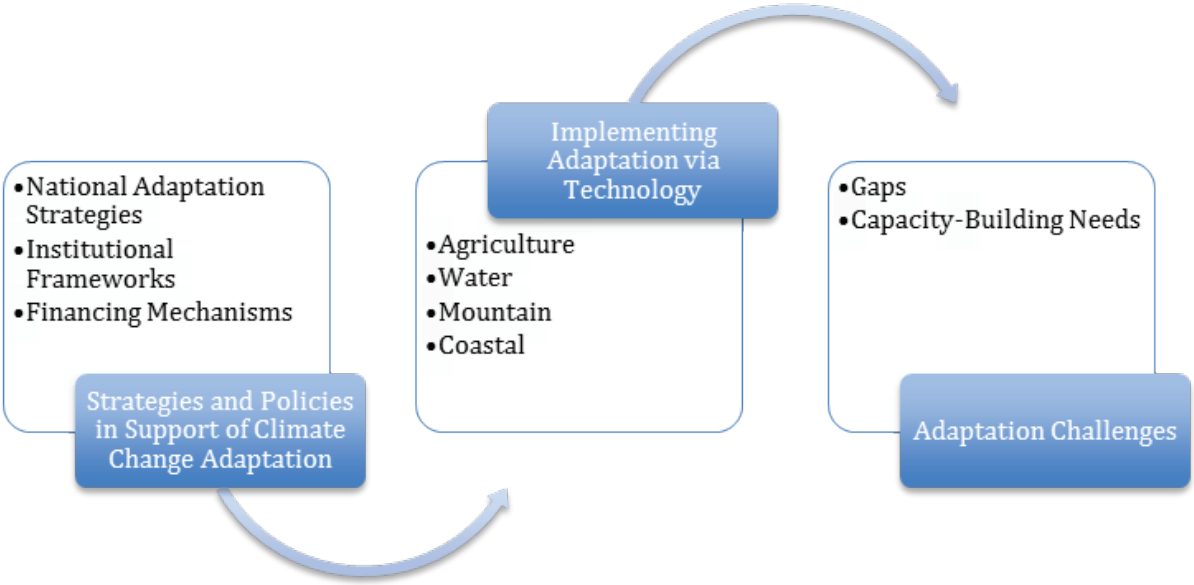


*Figure 2. The conceptual framework of this study.*

Thus, the visible importance of investing and facilitating adaptation actions across various sectors necessitates an analysis of its broad trends across the Southeast Asian region to assess current overall status that would likewise serve as take-off points in future. The main objective of this report is to provide the most updated development in climate change adaptation at the Southeast Asian sub-region and at the national levels of its comprising countries. Specifically, this report focuses on the major changes that have been taking place over the last 2-3 years (2010-2012) with special attention to:

1) Policies, strategies and institutional development in mainstreaming adaptation at the national and local government levels;

2) Priority project planning and preparation in support of climate change adaptation in critical sectors of agriculture, water, mountain, and coastal ecosystems;

3) Presents examples of development in technologies and/or technology application in selected sectors including risk transfer mechanisms;

This report would aim to highlight the: 1) the growing understanding to adapt to the changing climate, 2) how this understanding is being complemented at the strategy and policy level and also at different stakeholder levels, 3) analysing whether there are still some gaps that need to be addressed in the future particularly in terms of capacity building needs, other gaps, etc.

The ICLEI Local Government for Sustainability-Southeast Asia prepared this report as part of its commitment to the Asia Pacific Adaptation Network (APAN) being among its Thematic Nodes in Southeast Asia.

## 1.4 Organization of the Report

The discussion on the general trends of adaptation to climate change in the Southeast Asian context as presented in this report is divided into several chapters. Chapter 1 presents the introduction outlining the rationale and objectives of the study. Chapter 2 focuses on the various strategies and policies in support of climate change adaptation implemented at the national and regional levels in various modes such as policies, programmes and projects. Chapter 3 presents syntheses on the usage of technology in advancing adaptation particularly in selected key sectors. Lastly, chapter 4 and 5 provides the key challenges on adaptation and the report conclusion, respectively.

# 2.0 STRATEGIES AND POLICIES IN SUPPORT OF CLIMATE CHANGE ADAPTATION

This chapter focuses on the various strategies and policy mechanisms that set how climate change adaptation are developed, designed and organised among the countries in Southeast Asian region. It presents an analysis on the general strategies that various governments in Southeast Asia, organizations and communities are so-far implementing to deal with climate change and its impacts. This is important since adaptation to climate change is vital and has been highlighted by most of the developing countries as having a high or of urgent priority. Though uncertainty remains about the extent of climate change impacts, the generation and collation of basic information requirement to get started with the adaptation action has been gaining grounds in many developing countries in its attempt and plan to implement adaptation activities.

## 2.1 National Adaptation Strategies, Policies, Plans and Programmes

The Southeast Asian countries formulate and implement climate change adaptation strategies in response to its respective growing international commitments on climate change mitigation and adaptation. Thus, the trend clearly shows that climate change-related undertakings at the international level directly influence the likely commitments to be implemented at the national level. While the need to formulate policy at the national level maybe influenced by the international commitments, its design and the necessary organizational and institutional set-up would largely depend on the readily available mechanisms of a given country. These include, among others, the availability and willingness of technical expertise, receptivity of the general public, availability of funding mechanisms and available technology. With this, countries look into the maximization and the strengthening of its available resources.

A common strategy among countries is to integrate climate change concerns in the overall development agenda of a country down to the regional, provincial and local levels. For instance, responses to climate change are mainstreamed in various planning and regulatory mechanisms across various levels and key sectors. As such, the projects on climate change mitigation and adaptation were seen to produce not just solely designed to reduce greenhouse gasses emissions or vulnerability reduction of climate change-related hazard but it must likewise contribute to various social and economic targets such as poverty reduction. As a clear example, many of the key international organizations are discussing climate change side-by-side with food security and food safety concerns justifying that both clearly complement each other.

Clearly apparent among Southeast Asian countries is the prioritization of the most vulnerable communities as the primary recipient of the adaptation programmes and projects. Given the limited financial and technical resources in many of the countries, this prioritization mechanism is understandable. As such, recent trends of research agenda among Southeast Asian countries highlights the need to analyse climate change impacts, mapping vulnerable areas and communities and en-

hancing adaptive capacity. As such, there is a growing interest among Southeast Asian countries in investing to research programmes and the necessary support technology and manpower in assessing climate variability and impacts.

In the past, issues concerning climate change adaptation were not taken much into considerations. But since there has been development in the knowledge bases as a result of the continuing research on climate change, various countries and stakeholders are now putting much attention on how to cushion or reduce the effects or impacts of climate change in various sectors of a country. As such, the number of adaptation strategies and the exploration of additional intervention measures have increased especially in the national context.

Formulation of policies and strategies concerning Climate Change Adaptation, both in the regional and national/local context is developing being more than just an option to more of a necessity as more impacts are realised by the world, as they are magnified through various researches mostly funded by a range of international organizations. Policy formulation on climate adaptation is a multi-faceted and multi-staged process. It consists of hazard identification, vulnerability assessment, and identification of systems at risk and, the determination of responses to reduce the impact of risks and as well as the analysis of the potential of possible adaptation measures. Also, these policies are country specific since the needs and priorities of every country are varied. However, the process of policy formulation is rigorous and is subjected to challenges and limitations. These include absence of specific data sets for the region; inadequacy of monitoring systems (both climate and sea-level); non-specificity of projections from climate models; absence of region-specific climate change scenarios both on climate change scenarios and localised impacts formation; and lack of adequate capacity (individual and institutional) in region, and therefore make the formulation process more difficult. Though there are inadequate date sets, there is an approach used to formulate and improve both regional and national adaptation policies using accessible data and information as basis and will be adjusted as more data and information become available. These policies aim to decrease the vulnerability of the systems, natural, man-made and socio-economic to present-day change in climatic condition. Thus, also can develop the resiliency of the region, as well as of the individual countries within the region, to face the effects of long term climate variability, and in the long run make the region attain sustainability (CEDERA, 2003).

An example of an international initiative to combat the effects of the climate change took effect in 1996. The ASEAN-Mekong Basin Development Cooperation (AMBDC) is an agreement between autonomous intergovernmental bodies and created primarily to develop and improve the Mekong basin's economic contribution to each country within the basin. Nevertheless, such agreement was mostly created for the economic development of the Mekong basin. Aside from Commissions such as these, it is hoped that the constitution of intergovernmental authorities, which have autonomous decision-making power and economic independence in cooperation with local political and scientific institutions, could directly manage the scientific research and infrastructural interventions in the different basins. A combination of political pressure and economic incentives may be used to encourage countries to cooperate. Local governments and river basin

management organizations have to cooperate to achieve important aims such as:

- Advanced monitoring and statistical analysis of the basin;
- Constant diffusion of information and strong interaction with local institutions;
- Floods and river overflows forecasting and alert system;
- Rational regulation of the use of water;
- Scientific study of the infrastructure that have to be realised to regulate the river's flow during wet and dry seasons;
- Study and realization of security basins which provoke controlled floods;
- Efficient natural resource system management;
- Efficient use of water resource;
- Land use planning;
- Geographical relocation of population that live in places strongly exposed to a high degree of risk;
- Financial assistance; and
- Transparency in information management.

The benefits that will be gained by different countries concerned, as well as the political strain from other countries will most likely push all the concerning parties to cooperate. There are also the objectives of the agreement that are achieved through the support coming from different local governments and from different river basin management organizations. These objectives are also in line with the policies concerning climate change mitigation and adaptation.

One issue, however, that needs to be addressed is the fact that the numbers of national governments that take climate change adaptation measures in their development agenda are still few. According to Gass (2011), "few governments have a solid policy framework for adaptation and most, where they do make these considerations, do so only with respect to the sectors of coastal zone management, water management, agriculture and, to a lesser extent, human health." In addition, there are national governments that denounce their desire to include climate change adaptation needs and priorities in their development plan but still in the initial stages.

On the other hand, there are issues that need to be addressed such as the uncertainty of the climate change scenarios and the dynamism of policies in the national and regional level, in order to formulate an effective framework for climate change adaptation strategies that can be used by all the stakeholders (local government and affected communities). Also, the role of the community and of the public in the process must be recognised. An adequate public participation

in the process of information dissemination, assessment of the dynamic changes that is necessary in the institutional set-up of key policy makers, and also in the consideration of the standards presently existing relevant in the adaptation process must be considered. It is also vital that the policies will be made acceptable by the stakeholders to ensure effectiveness.

Also, the policy formulation by the countries depends on the needs and priority issues existing within their country. Though there are issues that are trans-boundary, such as flooding and food security, each country respond differently since every country differ in their needs, and general characteristics including culture and living requirements. Also, the geographical location and characteristics differ among the countries within the region. Thus, the effects would in turn differ greatly. As shown in Table 1, the issues per country in South East Asia are divided into three sectors, water, agriculture, and socio-economic.

*Table 1. Priority issues per sector in climate change adaptation policy formulation per country.*

| Country | Water sector | Agriculture Sector | Socio-economic sector |
|---|---|---|---|
| Brunei | Flooding, soil erosion and risk on coastal communities | Logging and conversion of forests to industrial zones | Solid waste management |
| Cambodia | Flooding and drought | Productivity and irrigation practices | Disaster risk reduction |
| Indonesia | Water availability | Food security | Loss of property and lives due to sea level rise |
| Lao PDR | Flooding | Food security | Public health, income, employment |
| Malaysia | Flooding, erosion and sedimentation | Crop production | Flood mitigation plans |
| Myanmar | Flooding and drought | Irrigation | Economic and mortality rates |
| Philippines | Flooding | Food security | Mortality due to flood |
| Singapore | Flooding | Insignificant | Public health |
| Thailand | Availability of water for Agriculture | Crop production | Disturbance of economic activities |
| Vietnam | Flooding | Food security | Economic development |

*Source: ICLEI*

All throughout the region, there have been numerous proposals to cushion the effect of the climate change in both regional and national levels in the South East Asian region. According to CEDERA 2003, these adaptation measures include early warning systems and better forecasting; land-use planning and zoning; adjusted building codes; better disaster mitigation strategies (including floodplain and other hazard mapping); inventories of resources (such as water); the use of water-saving devices and watershed management; the inclusion of traditional knowledge, especially in agriculture; and the integration of climate change considerations into the day-to-day management of all sectors.

Among all the countries in the region, the Philippines, together with Indonesia, is recognised as one of the countries with the most comprehensive framework of policy concerning climate change adaptation, strategies and measures. Through the enactment of the RA 9729 or the Climate Change Act of 2009, climate change issues and strategies were then integrated with disaster risk reduction and management. Also, the RA 9729 mandates the establishment of the National Climate Change Action Plan (NCAP). Since the plan recognises that the issue on climate change is cross-sectoral issue, the plan focuses on developing a strategy wherein government agencies will work together to combat the effects of climate change.

As with the advancement of the climate change adaptation framework of the Philippines, other countries in South East Asia follow its lead. In the case of Lao PDR, numerous policies were also established as a response to the need of climate change mitigation. These initiatives were established in parallel with climate change initiatives. These are as follows: Water Law 1996, Agriculture Law 1998, Forest Law 1996, Land Use Law 1996, Electricity Law 1997, Mining Law 1997, Road Transportation Law 1997, Urban Planning Law 1999, Decree on Social and Environment Impact Assessment, June 2010, Policy on Sustainable Hydro-power Development, and Clean Development Mechanism Regulation. Moreover, on 2010, the national government of Lao PDR accepted the National Strategy on Climate Change (NSCC). NSCC is formulated based on different current strategies. These are the strategies on biodiversity, environment, forestry, environmental education and awareness and renewable energy. The strategy focuses mainly on the seven identified priority areas, namely, agriculture and food security, forestry and land use change, water resources, energy and transport, industry, urban development, and public health.

Table 2 shows that there have been numerous national policy formulations and strategies to decrease the effects of the hazards brought about by climate change among the members of the South East Asian region. Most of these policies were made to adapt to the effects of water level rise that result to flooding, especially in low-lying areas within the region. However, not all the strategies used to approach these hazards were the same but majority are on disaster risk management.

*Table 2. Local Coping Mechanisms in the South East Asian Region.*

| HAZARD | IMPACT | STRATEGY | ACTION |
|---|---|---|---|
| Storm | Coastal inundation/ erosion | Natural resource | Mangrove Reforestation in Southern Thailand |
| Floods; Sea-level rise; Storms | Loss of crops; loss of land; Damage to human settlements | Disaster risk management | Building forecasting Capacity and Building an adaptation strategy for the Mekong Delta |
| Floods; Storms | Damage to human settlements | Disaster risk Management | Community-based disaster preparedness in the Philippines |
| Floods; Storms | Damage to human settlements | Disaster risk Management | Disaster preparedness in the Philippines |
| Floods | Damage to human settlements | Disaster risk Management | Preparing for floods in Northeastern Thailand |
| Floods | Damage to human settlements | Disaster risk Management | Early warning for cyclones in the Philippines |
| Vector-borne | Increased disease incidences | Vector Control | Dengue-fever prevention in Vietnam |
| Floods | Damage to human settlements | Improved housing design | Flood-resistant housing in Attepeu, Lao PDR |
| Drought/aridity; Floods | Loss of crops | Alternative cultivation methods | Rice-fish farming on West Java, Indonesia |
| Storms | Damage to human settlements | Improved housing design | Typhoon-resistant housing in the Philippines |
| | | | Building low-cost houses through the core shelter housing project |

*Source: UNFCCC*

The early warning system for cyclones in the Philippines, as explained by the UNFCCC, utilises resources such as drums and horns. This local early warning system originated from the indigenous communities of the country, which made their simple ways of adapting to climate change, as well as its negative impacts on people, such as loss of properties and human lives. The early warning system was based on the forecasting through the abnormalities in the movements and behaviour of the animals in the environment. The warning is then conveyed to the community through horns and drums.

Some communities in the Philippines may still use this kind of system. However, there is now integration of modern technology into it (Figure 3). In some areas in the country, the system called Local Flood Early Warning System (LFEWS) is adopted. LFEWS is a watershed-based system which is managed by the stakehold-

ers, the local government unit and as well as the members of the community which are directly affected by the flood. The centre of operation of LFEWS operates round the clock (24 hours, 7 days a week) to observe the precipitation rate, as well as the rise in the water level, and disseminates the necessary warning to the communities as early as possible. The larger the gap between the warning and the actual occurrence of flood incidence is, the higher the probability that the community will be able to prepare, thus, decreasing the number of loss and damages that may be incurred by the people concerned. The communication of the signals to the affected community takes different forms. This may take in the form of modern communication media such as phones, radio and megaphones and also in the form of traditional and old communication media such as the use of bells, neighbourhood ***rondas*** (human communicators on foot).

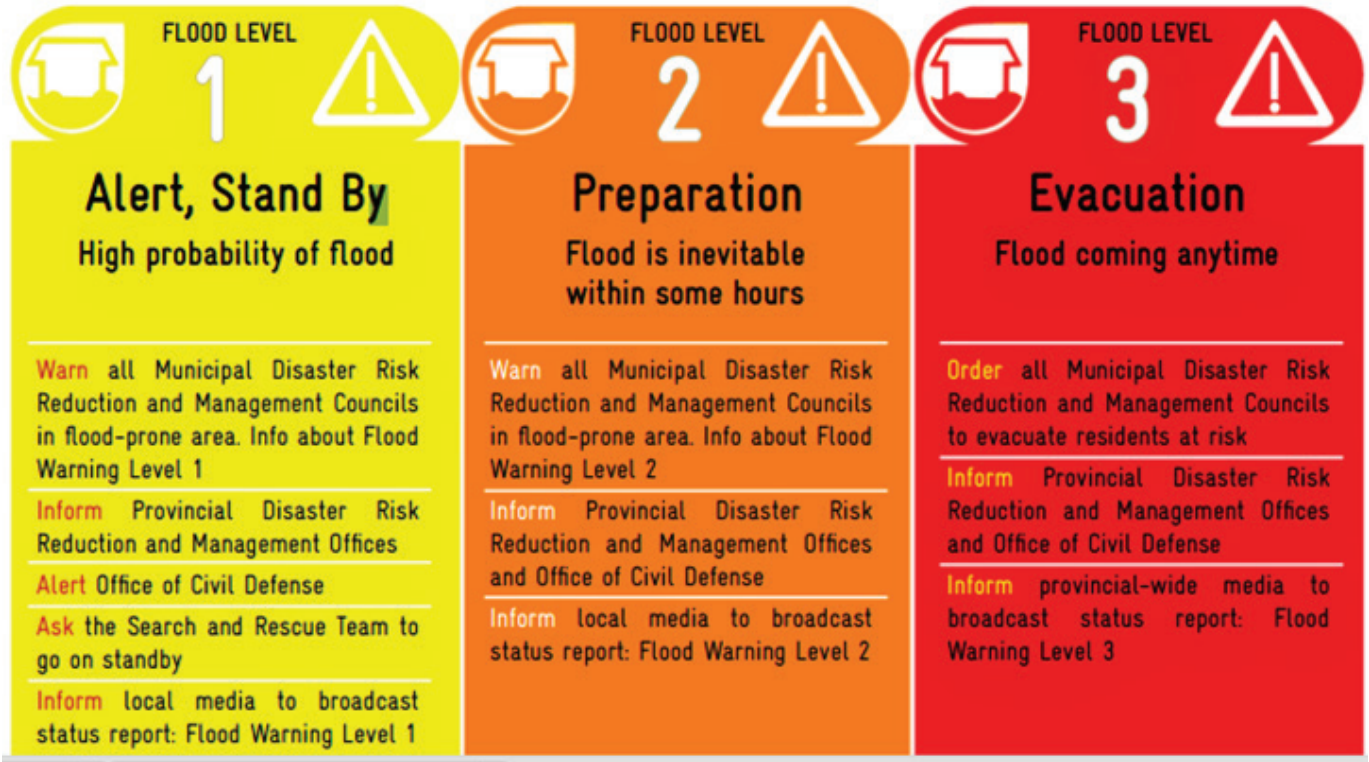


*Figure 3. The three colors of FEWS' warning and alert levels used in the Binahaan watershed.*
*Source: GIZ*

## 2.2 Institutional Framework in Support of Climate Change Adaptation

Institutionalizing climate change adaptation is one of the gaps that need to be take into account since the effects of climate change in many countries especially in the region has been clearer and therefore providing a more stable basis for developing national policies and a governing body that will focus on implementing them (ICLEI 2012). As with the case of Myanmar and Lao PDR, it is known that their adaptive capacity to the effects of climate change is low. Thus, it is recommended that the institutions of these countries need to further improve their policies. Through the institutionalization of climate change adaptation, it will be translated that there will be more budget allocation for the climate change adaptation measures.

The UNFCC and the Kyoto Protocol provided for a stronger ground for the formation of a national agency, which will focus on the issues of climate change, and in most cases for countries in the region, the focal agency is the agency for environmental management.

*Table 3. Government agencies serving as the focal point on climate change issues per country.*

| Country | Environmental Agency |
|---|---|
| Brunei Darussalam | Department of Environment, Parks and Recreation |
| Cambodia | Ministry of Environment |
| Indonesia | Ministry of Environment: Climate Change Division |
| Lao PDR | Department of Environment: Water Resources and Environment Administration |
| Malaysia | Ministry of Natural Resources and Environment |
| Myanmar | National Commission on Environmental Affairs |
| Philippines | Presidential Task Force on Climate Change |
| Singapore | Ministry of Environment and Water Resources |
| Thailand | Ministry of Natural Resources and Environment: Office of Natural Resources and Environmental Policy and Planning |
| Vietnam | Ministry of Natural Resources and Environment: Department of Meteorology, Hydrology and Climate Change |

*Source: Bhullar, L. & Koh Kheng Lian, 2010*

Though there are national agencies which attend to the issues concerning climate change, these are not enough since they are not focused mainly on the issues and therefore, most countries formed a high governmental body, dedicated solely to address the issues revolving around the climate change. These bodies also lead the formulation of plans, policies and strategies that will help to reduce the effects of climate change in a national and local level.

*Table 4. High level government body concerning climate change, per country.*

| Country | National Climate Change Task force |
|---|---|
| Brunei Darussalam | National Council on Climate Change |
| Cambodia | National Climate Change Committee (April 2006) |
| Indonesia | National Committee on Climate Change and Environment (1992)<br><br>National Council for Climate Change (July 2008) |
| Lao PDR | National Steering Committee on Climate Change (2008) |
| Malaysia | National Steering Committee on Climate Change |
| Myanmar | NA |
| Philippines | Inter-Agency Committee on Climate Change (1991)<br><br>Presidential Task Force on Climate Change (2007)<br><br>Advisory Council on Climate Change Mitigation, Adaptation<br><br>Climate Change Commission |
| Singapore | National Climate Change Committee (2007)<br><br>National Climate Change Secretariat (2010) |
| Thailand | National Committee on Climate Change (1993)<br><br>National Board on Climate Change Policy and Climate Change Coordinating Unit (2007) |
| Vietnam | National Climate Change Committee |

***Source: Bhullar, L. & Koh Kheng Lian, 2010***

In the case of the Philippines, Climate Change Commission (CCC) was created in 2009 through the enactment of RA 9729. CCC is headed by the President of the republic, together with three other commissioners. It is also composed of consultative body which is represented by people from different government agencies, private sector, academe, local government units and non-government agencies. CCC is also the lead agency that deals with recommendation of policies, laws and other legislations that will help in the country's climate change adaptation measures. As mandated by RA 9279, the commission also provides the integrated framework that serves the basis for planning, development and researches on climate change, the management of the information bases and also a guide in the assessment of various climate change activities.

## 2.3 International and National Climate Change Financing Mechanisms

In the recent years, climate change adaption has been included in the development plan by most countries as it is currently seen as an important issue to be taken into account. Most Least Developed Countries and developing countries in the region, however, need support in their capacity building activities and decreasing their vulnerability through various financial aids from different international organizations and developed countries. According to MCII 2010, it is expected that the role of the climate change adaptation financing will play a crucial and vital part in the formulation of the climate change adaptation strategy framework since it is seen that extreme weather condition continues to affect most of the countries and is expected to increase in its intensity and will happen more in the future. Thus, the development of sustainable financial mechanisms for adaptation that ensures the sustainable implementation must be established.

At current condition, developing countries need external support for adaptation that must be institutionalised in the context of national planning for sustainable development, more capacity building and transfer of technology and funds. At the local level, farmers lack access to credit, insurance, and markets that would allow for investment in agricultural practices and management. In addition, some climate management practices like soil and water conservation infrastructures may require high upfront costs, therefore the need for innovative financial mechanisms (Hoffman 2011, McKinsey 2009, FAO 2009 as cited by Hove 2011).

As a response to climate change adaptation financial needs, there are a lot of international funding grants available to support the reduction and sharing of risks associated with climate change. These initiatives are related in particular with the transfer of funds from global to national sectors. One of these initiatives is the Munich Climate Insurance Initiative. Aside from these, there are more international funding sources that can support financing in the climate change adaptation. According to Bouwer and Aerts (2006), these include:

- Funds under the UNFCCC;
- the Global Environment Facility (GEF);
- non-compliance fund;
- disaster relief and risk reduction;
- public expenditures, including public–private partnerships (PPPs);
- insurance and disaster pooling;
- development assistance; and
- foreign direct investment (FDI)

Nifadkar (2013) related that "estimates of financing needs for climate change mitigation and adaptation vary widely, reflecting the uncertainties associated with potential climate change scenarios and their likely impact." Furthermore, it is added that the current projection of the financing investment needs for the support needed by the developing countries for their climate change adaptation measures lacks hundreds of billions of dollars annually and will continue in the future. Though there are various financing mechanisms such as the Clean Development Mechanism (CDM) as established by the Kyoto Protocol, the global Environment Facility and different special funds such as the Clean Energy Investment framework and Climate Investment Fund, among others, it is estimated that these will not be enough to meet the demand for financial support by the least developing countries and developing countries.

Financing for climate change responses are seen to be growing as various sources such as national budgets, international donors and private sector sources. However, AKP (2011) raised an important concern for the urgent need of additional sources that must clearly trickle down to the local and grassroots levels. Various modes fund appropriation related to climate change projects has been employed across Southeast Asia that are directly related to funding organizations priorities. For instance, many local government units and non-governmental organizations are recipient of financial grants and loan mechanisms that are targeted for adaptation-related projects. On the other hand, many of the funding organizations also allocate substantial amount of financial resources for research and capacity-building purposes depending on the needs of a specific community or country. Overall, the current condition of many of the countries in Southeast Asia in terms of financial mechanisms could be related to the observation of ADB (2009) that there is a need for an enhanced institutional capacity and potential international funding sources for an enhanced allocation of resources towards critical sectors. Critical on this is the role of the governments in facilitating access to current and potentially available financial sources through better information dissemination and technical assistance (ADB 2009).

Overall, the dependable financial resources sufficient for the implementation of climate change adaptation mechanism could be materialised once financing mechanisms would be streamlined to the strategies and policy needs of each country. So far, this is currently lacking in many cases of several countries in different parts of the world particularly in Southeast Asia.

*Table 5. Overview of the financial mechanisms needs of the Southeast Asian countries.*

| Southeast Asia Countries | Concerns |
|---|---|
| Brunei | There is a lack of funding to support climate change activities (MoD2010). |
| Cambodia | The country is facing limited financial resources or funding for climate change related activities. Investments in infrastructure and support services are found to be minimal and inadequate (AKP 2009). |
| Indonesia | The lack of financial assistance and local funding mechanisms adds to the continuous degradation of ecosystems and unsustainable agriculture in the country (Republic of Indonesia 2007). |
| Lao PDR | Limited resources severely undermine government's capability to help farmers improve their productivity. Indeed, the absence of funding for irrigation, seed input, technology support, and extension work, among others, is a recurring theme that emerged in all interviews with farmers groups as well as local and national government officials (WREA 2009). |
| Malaysia | Financial support, mobilization, resource allocation, and insurance are highly important (Salmahet al.2010) but may be hindered by economic setbacks of the country and the state of the poor affecting the implementation of climate change strategies that may be long-term and costly (Yussuf 2012). |
| Myanmar | Lacking financial resources has compromised the setting up of reliable climate change related programme such that it's responses depend to a great extent on transfer of technologies from neighboring countries, capacity building, as well as funding support (DAP-MAI 2009). |
| Philippines | The need to mobilise and source-out additional funding mechanisms in support to the achievement of reliable financing for climate change adaptation across the national and local levels has been noted to realise plans and programmes. |
| Singapore | The financial resources may not be limiting but clear and sustainable need to be ensured. |
| Thailand | Prioritization and integration into local development, financial support, and insurance is seen to be urgent. |
| Timor Leste | Lack of funding is seen as one of the major constraints for the level of human and technical capacity in the country (DRoTL 2010). |
| Vietnam | Investment costs and limited financial capacity of farmers to implement their measure to fight climate change, limits wider use of available resources (AKP 2010). The government recognises the need for local resource mobilization, seizing opportunities of foreign funding and the development of financial plans for climate change responses (MONRE 2010). |

## 3.0 IMPLEMENTING ADAPTATION VIA TECHNOLOGY

While the physical aspect of climate change and its impacts may not be directly under human control, humans are in direct control in utilizing technologies to plan and implement projects related to such threats. It is in this respect that the formulation of combinations of above set of adaptation technologies needs to carefully take into account the peculiar condition of the target recipient area and community. The overall aim is to clearly reduce given vulnerability to climate change and its impacts and substantially enhance adaptive capacity.

The IPCC (2007) categorised various adaptive responses as technological, behavioral, managerial and policy interventions. Related to this, this chapter focuses on showing how technological innovation is indeed critical in the advancement of climate change adaptation. Interestingly, it is through harnessing technology that is a product of learned process that the translation of climate change adaptation policy and targets be realised. However, if not well crafted and is found inappropriate could otherwise result to mal-adaptation.

Adaptation technologies have been generally grouped into hard, soft and organizational technologies (Figure 4). Hard technologies refer to tangible aspects that include manufactured objects, machinery, equipments, and tools that are required to produce good and services while soft technologies refer to the processes associated with the production and use of the hardware, including the know-how, experience and practices (Clements 2011). On the other hand, organization technologies refer to the institutional framework, or organization, involved in the adoption and diffusion process of a new technology that primarily relate to ownership and institutional arrangements of the community/organizations where the technology will be used (Clements 2011). Additionally, UNFCC (2006) also refer to organizational adaptation as orgware.

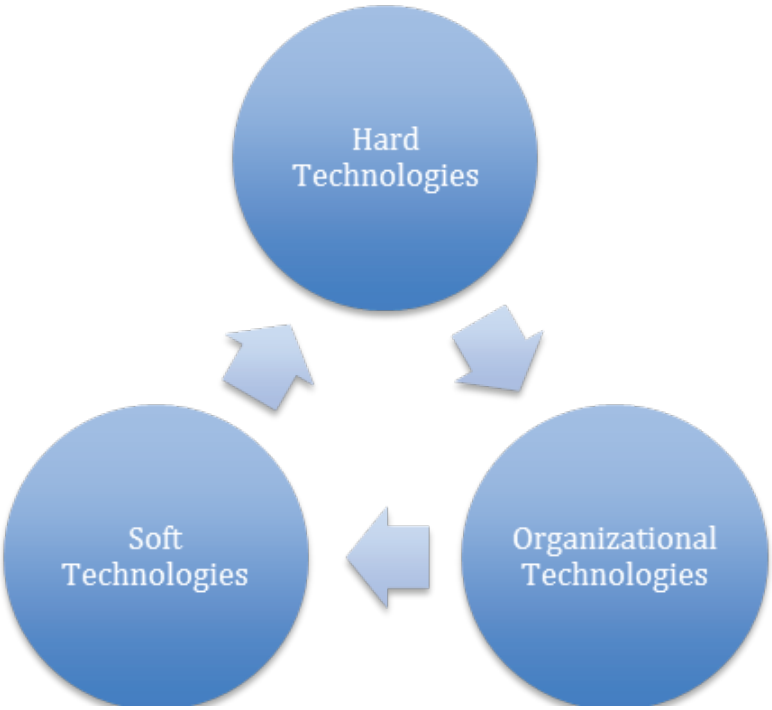


*Figure 4. The three major types of adaptation technologies.*

To better appreciate the importance of adaptation technology, Table 6 below shows an overview of the adaptation technology needs of the Southeast Asian countries. Overall, it is apparent that a general trend wherein the hard, soft and organizational adaptation strategies and projects are all needed to various degrees across different countries in Southeast Asia. The variation in adaptation technology needs reflect the differences in climate change impacts, vulnerabilities and the level of capacity and of available resources.

*Table 6. Overview of the technology needs of Southeast Asian countries.*

| Country | Existing Condition and Technology Needs |
|---|---|
| Brunei | Climate change vulnerability and impact studies are currently lacking coupled with very low level of public awareness and knowledge on the impacts of climate change (MoD 2010). |
| Cambodia | Very little knowledge is available on local adaptation strategies (Roth 2009). Also, information, if available, does not reach the local farmers (AKP 2009).<br><br>There is the need for improved extension services, access to inputs and markets, and strengthening of the existing community-based adaptation schemes by farmer's organization, water users, and community fisheries (MOE 2011).<br><br>Climate change adaptation strategies must be centred on the improvement and expansion of existing irrigation schemes and facilities in the country (MOE 2011). |
| Indonesia | These include the development of a system to provide climate information to actors at different scales, for example seasonal forecasts, and training in how to use this information effectively to manage climate risks. Training in vulnerability analysis and assessment of adaptation options would help to identify priorities for adaptation. Initiatives such as the development of community action plans to cope with flooding are being pursued in the field of disaster risk reduction (DRR), but are equally relevant in building community resilience to future climate change. Following this model of community engagement in projects would address one of the problems identified with several ongoing climate change initiatives in Indonesia, that of a lack of community ownership in projects. Encouraging dialogue between different actors will help to foster the relationships needed to enable adaptation to take place. For example, farmers does not have access to reliable information, lacks knowledge on the proper response strategies, have limited capacity, and lacks a well-coordinated system of water distribution and management (AKP as cited from the UNDP Indonesia 2007). |

| Country | Existing Condition and Technology Needs |
|---|---|
| Lao PDR | There are very limited measures on the ground for promoting climate change adaptation awareness and measures (Snidvongs 2007 and WFP 2007). There is a need to have a better analysis of related costs and benefits as well as opportunities and risks for various key groups that are currently reliant on unsustainable systems such as slash-and-burn agriculture.<br><br>The local and traditional knowledge of the farmers is gradually being eroded and replaced by specialised knowledge suitable for cash crop production, contract farming, among others. However, the full variety of appropriate technologies and the range of options do not reach the local farmers. Often, technologies reaching the villages are pre-selected according to certain commercial interests (Snidvongs 2007). |
| Malaysia | Mitigation options are mainly focused on rice management, manure management and nitrogenous fertilizer management. Preliminary analysis of mitigation benefits for local farmers must be conducted. Local adaptation practices for agriculture have not been sufficiently studied nor assessed. However, limited information on available technologies and crop responses are available. There is also a lack of coordinated approach to increase public awareness (Philip and Nick 2009). |
| Myanmar | There is a general lack of information on mitigation and adaptation strategies for the agriculture sector (MAI 2009). The quality of climate data needs to be further enhanced and a database on existing adaptation strategies and indigenous technologies is not yet in place. The existing information and communication tools and communication facilities are not adequate in most of the government departments and other relevant organizations. Only a few experts are available and more training are needed (DAP-MAI 2009). There is a need for the promotion of a balanced and efficient use of plant and animal nutrients to intensify agriculture in sustainable manner. The 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.<br><br>Also lacking are 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 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, 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 programmes need to be conducted on a large scale throughout the country with particular emphasis on pollution, natural resources depletion and global climate change (MAI 2009). |

| Country | Existing Condition and Technology Needs |
|---|---|
| Philippines | Past and current adaptation strategies to disaster-related events are largely not documented. New designs and construction protocols for agri-fishery infrastructure needs to be upgraded to withstand typhoons, strong winds, and salt water intrusion, among others. Efficient and cost-effective technologies for water management and storage are also needed. |
| Singapore | Climate change vulnerability and impact studies for agriculture are currently lacking. The sector needs to strategise on how to sustain meeting the domestic demand for essential fresh farm produce: poultry, eggs, pork, some vegetables, and fish. |
| Thailand | It is very critical that the effects of climate change be understood at the local and national levels. Such understanding will enhance the ability to select or apply appropriate methods and tools prepared for adaptation. In addition, technologies development and the integration of traditional and local knowledge are still needed. Technology transfer and communication to both local people and policy makers are very necessary for the effectiveness in the adaptation activities. The adaptation process of the successful schemes, sharing mechanism should be recorded and documented for dissemination to the public.<br><br>It is very crucial to raise awareness on potential impacts of climate change among involved groups. Moreover, all stakeholders should recognise and accept that climate change is real and the impact has already been experienced. There is a real need to develop and disseminate good quality information on technology options for villages in disaster-prone areas. The need for support is seen in the following: Analytical techniques to prioritise selected adaptation options across different sectors and issues, and to convey the message meaningfully at policy-making levels; Technologies for warning systems for disaster-prone areas; and, Technologies for agricultural climate forecast and warning system |
| Timor Leste | The capacity in terms of human innovativeness and resilience is seen as strong, whereby some communities' sources of income is being diversified and in others coping strategies are in place to address their highest vulnerabilities. However, the awareness on climate change and how it will impact the livelihood of the people is very low (DRoTL 2010). |
| Vietnam | The action plan does not identify specific adaptation measures but contains main tasks to allow the development of such measures (AKP 2010). An assessment of current adaptation practices and the creation of a database is also needed (MONRE 2010). Tools, information database and technologies for GHG inventory and reduction of emissions are incomplete and inadequate. The use of environment-friendly technologies need to be improved with increased investment, reduced capital costs and enhanced capacity and local knowledge (MONRE 2010). |

The implementation of adaptation technology has been done in per sector basis. Common among different plans of countries in Southeast Asia are the important sectors of agriculture, water, mountains and the coastal ecosystems. These are the major sectors, which primarily support the overall economic development of many of these countries.

## 3.1 Agriculture Sector

By far, majority of the Southeast Asian countries are largely agricultural economy though significant increases in other sectors such as the manufacturing and service sectors have likewise been noted. While more than 50% of the combined population of the Southeast Asian region are rural, it is indeed not surprising that agriculture remains a major source of livelihood. Most importantly, it is primarily through agriculture that the aim of achieving food security and safety across different sectors of the society would be achieved. As such, the challenge of making it climate-smart is among the key agenda of all of the countries in Southeast Asian region.

Initially, the challenge of maintaining and if possible, increasing productivity of the agricultural sector, remains somewhat an elusive target given the ballooning population and unmitigated environmental problems. The on-set of climate change has been seen to likely compound the concern on agricultural productivity primarily on major staple commodities in Southeast Asian region such rice, corn, roots crops, among others. A long list of concerns have been reported wherein erratic weather patterns, long drought seasons, increased frequency and intensity of flooding, more frequent destructive typhoons, among others, have in turn resulted to concern on pest infestation, irrigation-related concerns, physiological stresses and higher costs on additional input and transport of produce, etc. Given the importance of the agriculture sector, the effects of climate change would not only compromise socio-economic development concerns but would also significantly reduce its ability to adapt to climate change.

Smithers et al. (2001) related that technology innovation would be critical in ensuring a climate-smart agriculture (Figure 5). They raised the challenge in agriculture sector wherein a better appreciation between farmer's day-to-day decisions is of course affected not just by the biophysical characteristics of its farm lots but also with other key influences such as the government support and regulatory mechanisms, market and social forces and of course the level and types of technology used. With this, Smithers et al. (2001) highlights the importance of effective and sustainable agricultural research and development programmes that would look into the achievement of yield growth and sustainability, and how different stakeholders would be enjoined to contribute while also building necessary knowledge and institutional support in response to likely adaptation constraints.

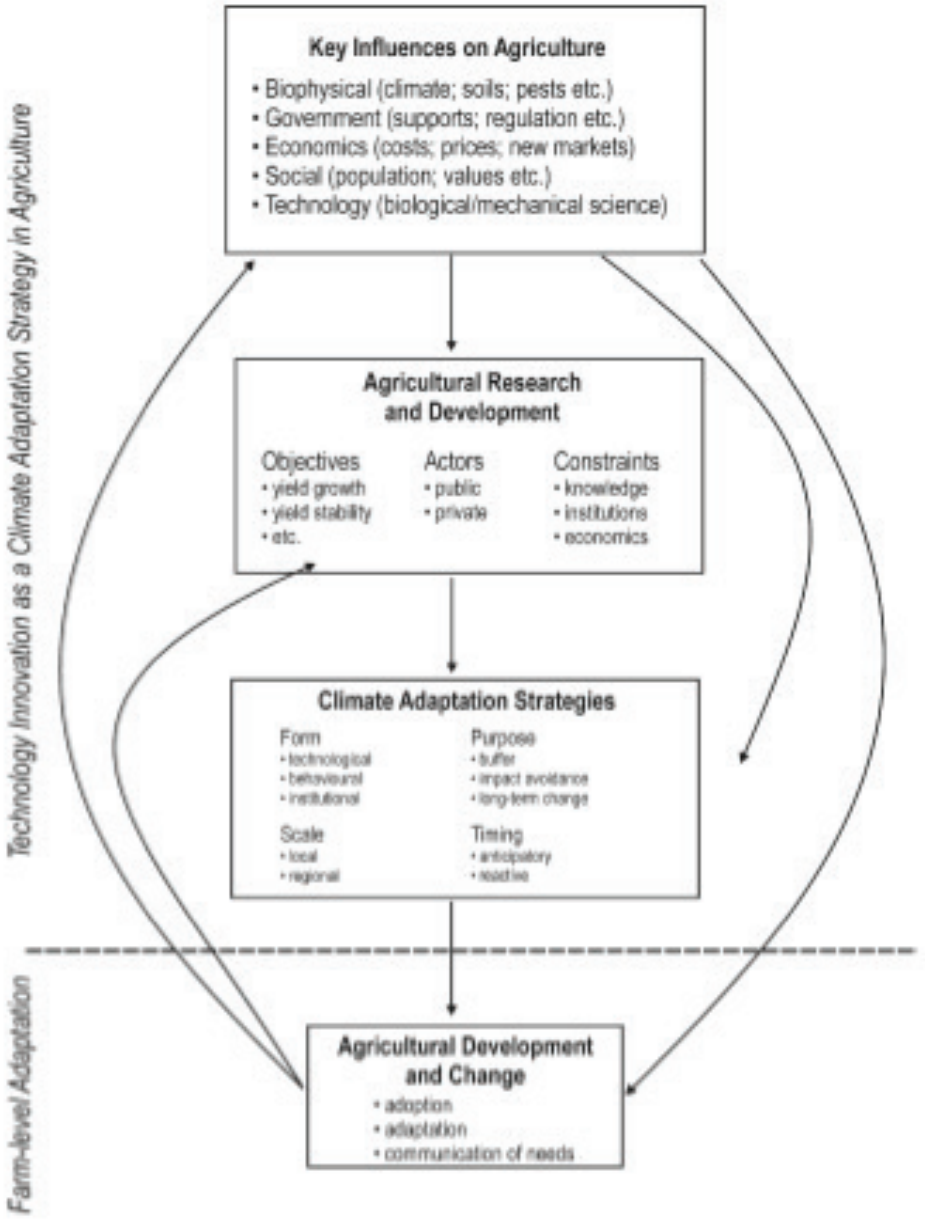


Fig. 1. Technology innovation and climate adaptation in agriculture.

*Figure 5. Technology innovation and climate adaptation in agriculture.*
*Source: Smithers et al. (2001)*

Related to above, various technologies and the corresponding innovations have been highlighted to ensure the achievement of well-adapted agriculture sector in Southeast Asia. As shown in Figure 5, these could be categorised into several technology innovation in the agriculture planning stage in response to specific climatic characteristics of the local and the region where farming is located, sustainable water usage, soil management, crop management, livestock management, a more systematic and holistic farming systems implementation and capacity-building initiatives.

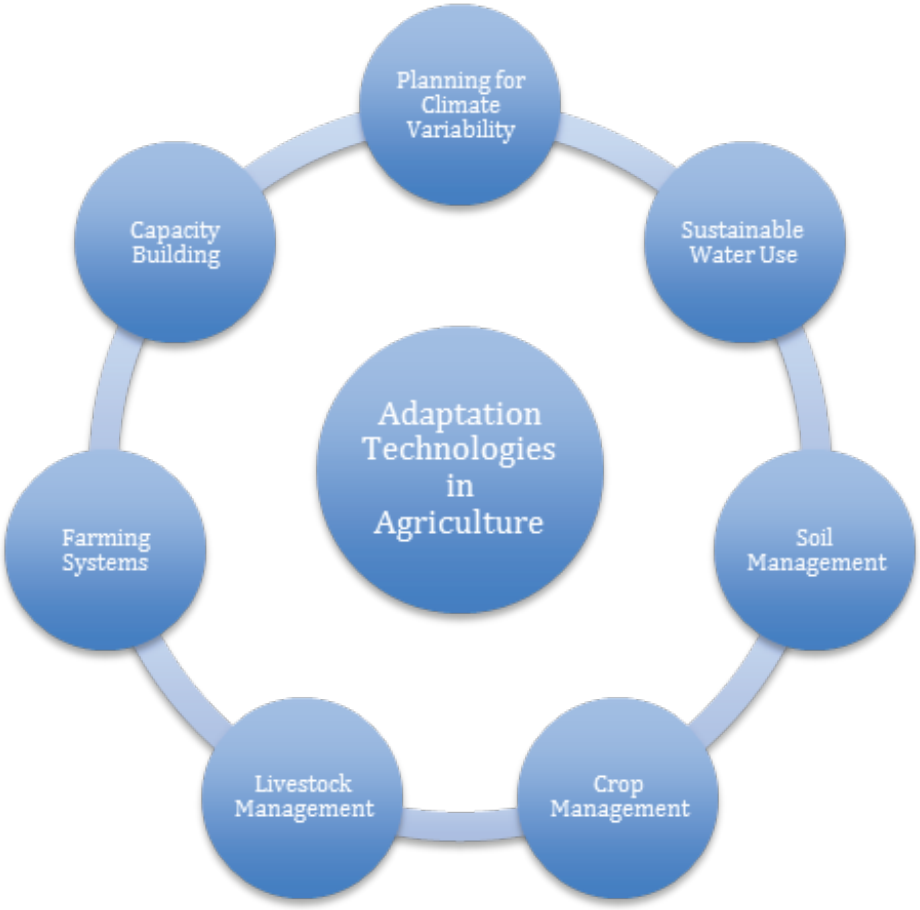


*Figure 6. Major types of adaptation technologies in agriculture.*

Overall, general bias of the agricultural sector in Southeast Asia is on short-term technological innovations as these are primarily cheaper and with immediate effects felt by the farmers making such necessary adjustments. For instance, changes in fertilizer inputs and other management-related actions have been employed by most of the farmers as an immediate response to weather variability. As such, most of these coping strategies would tend to become ineffective in more devastating erratic weather events in the long run.

*Table 7. Overview of adaptation technologies in Southeast Asian countries.*

| Adaptation Actions | Examples of Specific Strategies | Selected Examples |
|---|---|---|
| Adaptation Planning | • Enhanced weather and climate monitoring stations<br>• Community-based weather stations as input to decision-support mechanisms<br>• Capacity-building mechanisms for enhanced disaster awareness and adaptation innovations | • All of the Southeast Asian countries have their respective weather/climate monitoring stations. |
| Water Management | • Irrigation<br>• Less-water demanding crop varieties<br>• Upland farming | • Projects related to this are happening among countries in Mekong River Commission (MRC) as well as in Malaysia and Indonesia, and Philippines |
| Soil Management | • Sloping agricultural land techniques (SALT) | • This may exist across different areas in each of the countries of Southeast Asia. However additional investment on this is wanting. |
| Crop Management | • Flood-resistant varieties<br>• Crop diversification | • In support of various international and national organizations (ie. IRRI), several crop varieties that are highly adaptable have been produced/ |
| Livestock Management | • Selective breeding<br>• Supportive infrastructure<br>• Livestock-Environment interactions actions | • Initial research on this aspect may be far from being complete so far. But growing interest is happening in Indonesia and Philippines. |
| Farming systems | • Agro-forestry<br>• Agro-forest-aquaculture<br>• Diversified farming | • Many parts of Southeast Asia have been implementing these technologies. However, more incentives to farmers in implementing these technologies would be needed. |

## 3.2 Water Sector

Of urgent importance is the need to make the water sector highly adaptable to climatic changes and its impacts. Bates et al. (2008) related that many experts of the Intergovernmental Panel on Climate Change (IPCC) have concluded that water and its availability and quality, will be the main pressures on, and issues for, societies and the environment under climate change. On top, the overall importance of the water in the domestic, industrial, commercial, etc purposes and the clear increase in demand related to population increase and the reduction of quantity has been observed, thereby highlighting the likely importance of various technological innovations in halting these major concerns.

The direct effect of climatic change to the water resources can be seen in terms of its impacts to the hydrologic cycle. The increase in global average temperature has been projected to result to increase in evaporation and hasten ocean thermal expansion leading to sea level rise and more frequent and intensified typhoons (IPCC 2008). Further, extreme weather events could exacerbate water scarcity on the one hand and increased surface run-off on the other, among others. This is particularly important since the availability of water for various purposes is not equally uniform. Thus, though some may not be significantly affected by water shortage, others would be highly affected. Given the various socio-economic facets of water as a resource, the lack of it would greatly hit those that are initially experiencing less water availability.

In response, various technologies on water sector adaptation have been identified and been tried to be mainstreamed across different communities in Southeast Asia. The basic groupings of water sector adaptation technologies include: expanded water harvesting, water storage and conservation techniques, water re-use, desalinization, water-use efficiency and efficiency in irrigation (IPCC 2007). On the other hand, Elliot et al. (2011) categorised adaptation technologies in the water sector to include: diversification of water supply, groundwater recharge, preparation for extreme weather events, resilience to water quality degradation, storm water control and capture and water conservation (Figure 6).


*Figure 7. Major types of adaptation technologies for water.*

In the Southeast Asian countries, above water adaptation technologies can also be observed. However, this is far from complete due to the differences in terms of resources and capacity in accessing such different types of technologies to be used as part of its overall climate change adaptation programme. Following Christiansen et al (2011), an overall analysis of the technology implementation for climate change adaptation across Southeast Asian countries is provided below.

*Table 8. Adaptation technologies in water sector in Southeast Asian countries.*

| Water Use Category | Supply Side | Demand Side | Selected Examples |
|---|---|---|---|
| Municipal or domestic | • Increase reservoir capacity<br>• Desalinate<br>• Make inter-basin transfer | • Use "grey water<br>• Reduce leakage<br>• Use non-water-based sanitation<br>• Enforce water standards | • Though some households and communities are implementing these, this is currently far from being fully institutionalised |
| Industrial cooling | • Use lower-grade water | • Increase efficiency and recycling | • Laguna de Bay in the Philippines |
| Hydropower | • Increased reservoir capacity | • Increase turbine efficiency | • Many Southeast Asian countries are implementing this |
| Navigation | • Build weirs and locks | • Alter ship size and frequency of sailings | • Not implemented to bring in significant effect |
| Pollution control | • Enhance treatment works<br>• Reuse and reclaim materials | • Reduce effluent volumes<br>• Promote alternatives to chemicals | • Current attempts are consonant to these aims such as in Indonesia and Philippines |
| Flood management | • Build reservoirs and levees<br>• Protect and restore wetlands | • Improve flood warnings<br>• Curb floodplain development | • Key cities in most of the countries of Southeast Asia are on its way of fully implementing these |
| Agriculture | • Rain-fed: improve soil conservation<br>• Irrigated: Change tilling practices<br>• Irrigated: harvest rainwater | • Rain-fed: Use drought tolerant crops<br>• Irrigated: increase irrigation efficiency<br>• Irrigated: change irrigation water pricing | • Currently on its way simultaneous with field testing and dissemination to target recipients |

## 3.3 Mountain Ecosystems

Mountain ecosystem remains to be the home of many rural and indigenous communities as it provides them wide array of environmental services including non-timber forest productions. ICIMOD estimated that about 12% of the global population lives in mountain ecosystems and over 50% of the world's population depends directly or indirectly on mountains, which cover 24% of the world's total surface area and provide up to 80% of the planet's freshwater supplies. Thus, the overall maintenance of the integrity of the mountain ecosystems is a critical component in the overall climate change adaptation efforts.

Particularly in the case of the many parts of the Southeast Asian region, many development efforts are not as high compared with that of the lowland areas. This bias is a product of long history that favors concentration of socio-economic activities in the urban centres that more often are at the lowland areas. As such, limited climate change adaptation efforts have so far been documented despite the seeming vulnerability of such ecosystems to climate change and its impacts.

In addition to rural and indigenous communities that are located in marginal upland areas, several mountain ecosystems have likewise been transformed into upland urban centres. For instance, Baguio City in northern Philippines has been noted as the summer capital of the Philippines and has marked its own niche as a tourism destination. Another remarkable situation is in the case of Bandung in Indonesia, which has shown equally remarkable boom in its economy thereby making a reputation of its own. The expansion of socio-economic activities from the lowland urban centres to picturesque mountain areas facilitated this on-going transformation that brings in considerable migration.

Given this context, the ICIMOD have identified some technologies on how mountain ecosystems be made more adapted to climate change with due consideration of its fragility, marginality, inaccessibility and richness of ecosystem services. As shown in Figure 7, these technologies have been categorised into water conservation management, soil conservation and renewable energy related adaptation actions. Though most of these efforts are concentrated in countries in South Asia, much could be learned and be applied in the specific context of some mountain areas in Southeast Asia.


*Figure 8. Adaptation technologies for mountain ecosystems.*

As identified by ICIMOD, specific types of adaptation technologies under water conservation management include low cost conservation ponds, drip irrigation, sprinkler irrigation, roof water harvesting, underground cisterns, and spring restoration. On the other hand, those for soil conservation and soil fertility management include black plastic composting, vermicomposting, and planting contour hedgerows with nitrogen-fixing plants. Renewable energy technologies include biogas plants and solar-based technologies for sustainable energy management. All of these approaches have led to considerable improvements in water and land productivity, have enhanced the livelihoods of mountain farmers, and reduced workloads, especially for women (ICIMOD 2011).

In the near future, more specific analysis and documentation particularly on the case of the mountain ecosystems in the Southeast Asian region would be necessary to really ascertain its peculiar conditions to which adaptation planning and implementation must be based upon. Along with this concern is the mainstreaming of climate change concerns on a number of development trajectories among mountain ecosystems such as mass tourism, ecotourism, and high-value crops production, etc.

## 3.4 Coastal Ecosystems

Of particular interest is the vulnerable coastal ecosystems of the Southeast Asian region as many of these countries have strong association to the oceanic ecosystem. Majority of the urban centres are in coastal ecosystems as such population and socio-economic activities are likewise concentrated in the coastal areas. IPCC (2007) raised that the coastal zone is perhaps the most vulnerable region to climate-related hazards such as storm surges and erosion.

IPCC (2007) further related that in many places, technology has been instrumental in reducing society's vulnerability to anticipated impacts of climate change in three basic ways: ***Protect***--reduce the risk of the event by decreasing its probability of occurrence; ***Retreat***--reduce the risk of the event by limiting its potential effects; and, ***Accommodate***--increase society's ability to cope with the effects of the event. This is related to the study of Klein et al. (2001) claiming that there are many different technologies exist to adapt to natural coastal hazards that could reduce vulnerability to climate change in coastal zones. These include technologies to develop information and awareness for adaptation in coastal zones, to plan and design adaptation strategies, to implement them, and to monitor and evaluate their performance, among others (Klein et al. 2001).

Just like the mountain ecosystems, a more in-depth analysis on the adaptation technologies applied in the Southeast Asian situation is needed to provide a suite of potential adaptation measures that any local government units or communities could consider. Specific examples of commonly used adaptation technologies are provided in Table 9 below.

*Table 9. Adaptation technologies in mountain ecosystems in Southeast Asian countries.*

| | Hard technologies | Soft technologies | Org technologies |
|---|---|---|---|
| Coastal Ecosystems | • Engineering technologies such as dykes, seawalls, etc. | • Incorporation of climate change adaptation and disaster risk reduction and management in various planning mechanisms such as the Comprehensive Land-Use plan (CLUP) | • Issuance of regulatory standards<br>• Creation of consultative bodies and monitoring committees<br>• Capability enhancement of personnel in weather stations/ and management boards<br>• Enhanced early warning systems in tandem with a working decision support system<br>• Support to fishermen alliance and management councils, etc |

# 4.0 CONCLUSION AND GAP ANALYSIS

This paper provides analysis of the broad trends of climate change adaptation in the Southeast Asian region and at the national levels particularly in terms of policies, strategies, institutions, and in general approaches in mainstreaming adaptation at the national and local levels. It likewise looks into the implementation of adaptation technology in support of climate change adaptation efforts as well as the identification of key gaps and challenges.

A considerable effort in terms of national policies and adaptation strategies have been documented in this study indicating that most of the Southeast Asian countries have made the necessary initial efforts towards climate change adaptation. While the existence of several institutional set-up and arrangements across these countries signify the presence of requisite organizational structure for climate change adaptation action, it is apparent that the varying combinations of these efforts indicate the peculiar condition of their area as well as the differences in the level of their capacity to adapt and the available resources. Thus, it is understandable that instead of adaptation agenda being determined by external agents, support for adaptation efforts must be biased on adaptation actions determined by the recipients themselves. It must clearly be needs based and must maximise their inherent strength. At the regional level, while several efforts have been initiated by international organizations and multi-lateral agencies, necessary support for the achievement of more strengthened regional adaptation programme across Southeast Asia would be needed for the realization of common but differentiated action that would pave the way for mutual support and learning.

Analysis on the current trends on implementation of adaptation points to the importance of technological innovation in the important sectors of agriculture, water, mountains and coastal ecosystems. Across Southeast Asia, several adaptation strategies for each of these sectors have been implemented autonomously or through government and private organizations' support. Knowing that agriculture remains a critical sector to which many of the economies in the region are dependent upon, the value of employing technologies in the different facets of agriculture could not be underestimated. Simultaneously, there is an urgent need to invest on technologies that enhance communities' ability to reduce the vulnerability of its water resources to climate change. In the immediate future, water issues would once again become a shoo-in in adaptation discussion. On the other hand, additional support is likewise needed to strengthen our understanding of how mountain ecosystems be made more adapted to climate change. At current rate, these mountain ecosystems despite its importance to many marginal communities have not received much investment so far. The same could be asked in the case of many coastal ecosystems of Southeast Asia where urban and socio-economic activities concentrate.

Table 10 below summarises the key points of this report. Several enabling mechanisms related to strategies and policies that serve as the driving factors namely, a) the responsiveness of the Southeast Asian countries to international agreements related to climate change in general and climate change adaptation in particular, b) ongoing efforts to mainstream adaptation targets to national and local devel-

opment planning, and c) growing public awareness on climate change impacts that comes along with increasing receptivity to the need to implement and support climate change adaptation efforts.

On the other hand, additional investments are necessary on research and development programmes to engender specific projects that would look into the intricacies of climate change impacts and how it would be better managed down at the country and local contexts. Since returns on investments of research projects are more often relatively slow, the need of fast-tracking results and its utility to decision-making would improve the timing and delivery of science and evidence-based adaptation efforts. Needless to say, timing is important in achieving a strengthened climate change adaptation programme. On top of ensuring, the research programmes must result to the fruitful delivery of practical technologies for climate change adaptation. These need to be recipient-friendly, affordable and easy to apply.

*Table 10. SWOT analysis of strategies, policies and adaptation technologies.*

| | **Enabling Mechanisms** | **Barriers/Constraints** |
|---|---|---|
| **Strategies and Policies** | **STRENGTHS**<br>• Countries are responsive to international commitments on climate change adaptation<br>• Mainstreaming of climate change adaptation are actively being implemented by Southeast Asian countries<br>• Increasing awareness on climate change impacts and the need for adaptation | **WEAKNESSES**<br>• Slow pacing of adaptation research relative to the need in policy and adaptation implementation<br>• Uncoordinated actions across different government levels, different sectors, and stakeholders<br>• Ability to clearly sync adaptation efforts regionally without losing touch of national and local targets |
| **Technology for Adaptation** | **OPPORTUNITIES**<br>• The need to implement climate change adaptation could be used as a platform for improved governance set-up and mechanisms<br>• Adaptation financing<br>• Mutual learning and strengthened cooperation<br>• Scaling up | **THREATS**<br>• Financial resources<br>• Conflicts<br>• Non-participation<br>• Uncertainty in relation to Irreversible effects of climate change<br>• Diffusion and adoption of climate change adaptation technology is a challenge |

Interestingly, climate change adaptation efforts could be utilised by the government to renew its commitment and put in place reforms for an improved governance set-up and in institutionalizing necessary mechanisms such as adaptation financing, among others. While political will among government leaders would be necessary in realizing this, this presents opportunities for engendering clear reforms that would not just achieve adaptation targets but would likewise produce developmental dividends. While implementing this at the national level would take longer period of time, this is highly achievable at the local level. Instituting necessary support mechanisms and appropriate incentive systems would be need on this respect. Additionally, massive capacity building and awareness among officials and their support staff is necessary to make this a possibility.

The need of a strengthened climate change adaptation programme also brings in an opportunity for a more solid regional cooperation among the Southeast Asian countries. Among others, this is primarily needed for the setting up of the sufficient and sustainable financial mechanisms for adaptation, potential for mutual learning and meaningful cooperation that could hasten scaling of projects both at the regional and country-levels. On the other hand, various additional barriers for the achievement of a strengthened climate change adaptation programme in the Southeast Asian region include insufficiency of financial, technical and other resources, conflicting interests that would result to non-participation or overlapping efforts, and the uncertainty in relation climate projection as well as the irreversibility effects of climate change. Also, diffusion and adoption of climate change adaptation technology is a challenge as this need reliable pilot-testing and would need considerable period of time before being generally adopted. As such, the need to leverage public funds from various sources such as international funding organizations and the private sector would be instrumental.

# REFERENCES

Adaptation Knowledge Platform (AKP). 2011. The Desktop Study on the Assessment of Capacity Gaps and Needs of Southeast Asia Countries in Addressing Impacts, Vulnerability and Adaptation to Climate Variability and Climate Change. Asian Institute of Technology-UNEP

Asian Development Bank. 2009. The economics of Climate Change in Southeast Asia: A regional review. Available online at http.www.adb.org/sites/default/files/economics-climate-change-se-asia.pdf

Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Eds. (2008) IPCC: Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva, 210 pp

Christiansen, L., A. Olhoff and S. Trærup (eds.): Technologies for Adaptation: Perspectives and Practical Experiences, UNEP Risø Centre, Roskilde, 2011

Clements, R., J, Haggar, A. Quezada, and J. Torrer. 2011. Technologies for Climate Change Adaptation – Agriculture Secture. X. Zhu (Ed.). UNEP Risoe Centre

Convention on Biological Diversity Subsidiary Body on Scientific, Technical and Technological Advice. Mountain Biological Diversity, Eighth Meeting, Montreal, 10-14 March, 2003.; World Health Organization (WHO) Regional Office for South-East Asia. 2006. Chapter 2: Introduction to Mountain Regions. In: Human Health Impacts from Climate Variability and Climate Change in the Hindu Kush-Himalaya Region: A Report of an Interregional Workshop, India; Swiss Agency for Development and Cooperation (SDC), Mountain Partnership, CDE University of Bern. 2012. Why Mountains Matter in Global Sustainable Development

Cruz, R.V., H. Harasawa, M. Lal, S. Wu, Y. Anokhin, B. Punsalmaa, Y. Honda, M. Jafari, C. Li, N. Huu Niinh. 2007. Asia, In Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the 4th Assessment Report of IPCC. M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der linden, C.E. and Hanson (eds.) Cambridge University Press, Cambridge, UK

Elliot, M., Armstrong, A., Lobuglio, J. and Bartram, J. (2011). Technologies for Climate Change Adaptation—The Water Sector. T. De Lopez (Ed.). Roskilde: UNEP Risoe Centre

FAO. 2008. Climate change adaptation and mitigation in the food and agriculture sector. Technical Background Document from the Expert Consultation held on 5-7 March 2008. FAO, Rome

ICIMOD. 2010. Mountains of the world—Ecosystem Services in a Time of Global and Climate Change: Seizing Opportunities-Meeting Challenges

IPCC (2007) Summary for Policymakers. In: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 7-22

Klein R. J.T., R.J. Nicholls, S. Ragoonaden, M. Capobianco, J. Aston and E. N. Buckley. 2001. Technological Options for Adaptation to Climate Change in Coastal Zones. Journal of Coastal Research Vol 17 (3), p 531-543

Smit, B. and M.W. Skinner. Adaptation Options in Agriculture to Climate Change: a typology. Mitigation and Adaptation Strategies for Global Change, Vol 7, p85-114

Snidvongs, A. 2006. Final Technical Report AIACC AS07. Southeast Asian Regional Vulnerability to Changing Water Resources and Extreme Hydrological Event Due to Climate Change. SEA START RC Technical Report No. 15, pp 142. Bangkok

World Bank. 2011. World Development Indicators online database, http://data.worldbank.org/indicators

Yusuf, A.A. and H.A. Francisco. 2009. Climate Change Vulnerability Mapping for Southeast Asia, IDRC-SIDA-EEPSEA-CIDA

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