

CLIMATE CHANGE VULNERABILITY AND ADAPTATION IN ASIA AND THE PACIFIC: WORKSHOP SUMMARY

L. AMADORE,¹ W.C. BOLHOFFER,² R. V. CRUZ³
R.B. FEIR,⁴ C.A. FREYSINGER,⁵ S. GULL,⁶ K.F. JALAL⁷
A. IGLESIAS,⁸ A. JOSE,¹ S. LEATHERMAN,⁹ S. LENHART¹⁰
S. MUKHERJEE,⁷ J.B. SMITH,¹⁰ and J. WISNIEWSKI¹¹

¹ PAGASA, Philippines

² U.S. National Oceanic and Atmospheric Administration, U.S.A.

³ University of Los Baños, Philippines

⁴ NAMIRA, Philippines

⁵ Camber Corporation, U.S.A.

⁶ U.S. Country Studies Program, U.S.A.

⁷ Asian Development Bank, Philippines

⁸ Instituto Nacional de Investigaciones Agrarias, Madrid, Spain

⁹ University of Maryland, U.S.A.

¹⁰ Hagler Bailly Consulting, Inc., U.S.A.

¹¹ Wisniewski and Associates, U.S.A.

Abstract. The Regional Workshop on Climate Change Vulnerability and Adaptation Assessment in Asia and the Pacific met to present and discuss assessments of vulnerability and adaptation to climate change in agriculture, forests, coastal resources, and water resources. Discussions were held in breakout and plenary sessions about the state of the science for vulnerability and adaptation assessment, conclusions that can be drawn about the vulnerability of the region to climate change, and where future research efforts should be directed. The workshop concluded that sea level rise is of greatest concern to island and coastal nations in the region, climate change will have a significant effect on agriculture, water resources are sensitive to changes in average climate conditions and to tropical monsoons and cyclones, and forests could be significantly affected by climate change. The workshop recommended that efforts to improve general circulation models continue and that countries in the region cooperate on the analyses of vulnerability and addressing adaptation measures. The workshop also concluded that results of vulnerability and adaptation assessments should be presented to policy makers and the public and that assessments continue to be undertaken to improve our understanding of the issue.

Key words: Asia, Pacific island nations, adaptation, agriculture, forest, coastal resources, water resources, sea level rise, national action plans

1. Introduction

Ranging from the boreal expanse of Siberia to tropical river deltas subject to tropical storms to small islands whose very existence is threatened by sea level rise, the Asia and Pacific region includes a breadth of ecosystems and socioeconomic systems vulnerable to climate change. With over three-fifths of the world's population, natural resources in many parts of the vast continent, archipelagos, and islands are already under stress.

At the Regional Workshop on Climate Change Vulnerability and Adaptation in Asia and the Pacific, recent studies on climate change vulnerability and adaptation were presented and reviewed. Research needs, further technical assistance on vulnerability and adaptation, and preparation of national communications that are required for all signatories of the U.N. Framework Convention on Climate Change were also discussed. How the region can address adaptation and develop national action plans on climate change was also discussed.

2. Agriculture

2.1 CONCLUSIONS ABOUT VULNERABILITY

Agriculture is a key economic sector in the region and accounts for a high portion of the national GDPs. For example, 20% of Thailand's GDP is in agriculture. Substantial foreign exchange earnings are derived from exports of agricultural products, (e.g., 70% in the Philippines) and agriculture employs over 50% of the labor force in most countries (60% in Thailand). The region faces increasing population, spread of urbanization, lack of adequate water resources, and environmental pollution, which may hinder growth of the region's future agricultural productivity.

South and Southeast Asia are vulnerable to many environmental hazards, including frequent floods, droughts, cyclones, and storm surges that damage life, property, and agricultural production (e.g., Bangladesh is especially vulnerable). El Niño-Southern Oscillation (ENSO) events play a key role in determining yearly agricultural production across the entire region of South and Southeast Asia.

Many climate change impact studies have been conducted in various regions of South, Southeast, and East Asia. However, the impact of climate change on crop production remains uncertain not only because of uncertainties in climate projections, but also because of the lack of understanding of key processes in crop production, such as the direct effects of CO₂ and the complex interactions with water resources. Despite these significant uncertainties, and the limitation of the modeling studies outlined above, several conclusions can be made:

- Crop yields and productivity changes will vary considerable across regions. Thus, the pattern of agricultural production is likely to change across the region. Based on crop impact studies using 2×CO₂ equilibrium GCM scenarios, lower latitude countries have been shown to be more negatively affected. Nevertheless, crop yield simulation results vary widely (e.g., ±20% changes in yield) for specific countries sites across studies, and GCM scenarios.
- Vulnerability to climate change depends not only on physical and biological response but also on socioeconomic characteristics. Low income populations depending on isolated agricultural systems, especially dryland systems in semi-arid and arid regions, are particularly vulnerable. Many of these at-risk populations are found in South and Southeast Asia.
- Although global studies suggest that agricultural production appears to be sustainable under climate change as expressed by GCMs under doubled CO₂, the regions of South and Southeast Asia appear to be among the most vulnerable, and East Asia appears to be relatively less vulnerable. Furthermore, global studies have shown that incremental additional costs of agricultural production and additional risk of hunger under climate change, which could create a serious burden for some developing countries in the region.

Because of the key role that ENSO events play in determining yearly agricultural production in South and Southeast Asia, changes in ENSO frequency and severity would be likely to affect the agriculture of these regions.

2.2 SUITABILITY OF ADAPTATION MEASURES

Adaptation to climate change is likely in areas that are currently less climatically stressed; the extent depends on the affordability of adaptive measures, access to technology, and biophysical constraints such as land and water resource availability, soil characteristics, genetic diversity for crop breeding (e.g., crucial development of heat-resistant rice cultivars), and topography.

Many existing agricultural and resource policies are likely to discourage effective adaptation, and are a source of current land degradation and resource misuse.

2.3 FUTURE RESEARCH NEEDS

The assessment of the direct effects of CO₂ on crop production remains a crucial research question. Although many experiments have confirmed the beneficial effect of CO₂ on the mean response of crops (+30% for C₃ crops, including rice), variation in responsiveness between plant species and ecosystems persists. Response depends on available nutrients, species, cultivar, temperature, and other stressors, as well as differences in the experimental technique.

Development and broad application of integrated agricultural modeling efforts (those that consider interactions of biophysical and socioeconomic factors), and modeling approaches particularly applicable at the regional scale, warrant increased attention. Inclusion of multiple joint effects may change significantly the current “mean” estimate of impacts.

3. Forest Resources

3.1 ASSESSMENT METHODS

The suitability of current assessment methods to address vulnerability and adaptation to climate change in forests was discussed. The uncertainty in climate change scenarios should be carried through into these vulnerability assessments for the forest sector. For example, results may be presented as a range of potential impacts.

The current assessment methodologies generally do not consider how changes in water use efficiency resulting from increased atmospheric concentrations of CO₂ may influence the distribution of vegetation, particularly in the case of decreasing soil moisture, nor do they incorporate factors such as pests, fire regimes, or seasonality. Further refinement of the methodologies is needed to incorporate these factors. More sophisticated models are available and could be used to refine forest vulnerability assessments.

Modeling techniques that use climatic indices to predict the distributions of vegetation zones do not address dynamic or transient responses. Paleoclimate research could be one of the most promising methods for estimating how quickly vegetation could migrate. Paleoreconstruction research from Russia indicates that an increase in precipitation may allow for the expansion of forests on the plains and in the mountains, and that larch forests have migrated relatively quickly and can withstand a wide range of temperature fluctuations.

Additionally, none of the studies presented discussed nonclimate factors such as deforestation despite the significance of such influences on forest vulnerability. Potential changes in land use and socioeconomic conditions are difficult to estimate for the relevant time period. For example, there is significant uncertainty about future rates of deforestation and habitat fragmentation.

3.2 CONCLUSIONS ABOUT VULNERABILITY

Although the research presented is too limited to draw many general conclusions about the vulnerability of forests in the Asia Pacific region, a number of findings can be highlighted:

- Adding to the research on the vulnerability of lower latitude countries, the results of research from Thailand indicate that the potential impact on tropical forests may be significant. Under climate change scenarios generated by the United Kingdom Meteorological Office and the

Goddard Institute of Space Science general circulation models, the area of subtropical forests is estimated to decline from 50% of forest cover to either 20% or 12% depending on the model, and the area of tropical forests is estimated to increase from 45% of forest cover to 80%. This analysis suggests that global climate change will have a profound effect on the future distribution, productivity, and health of Thailand's forests.

- Research in the Russian Federation focused on larch forests (*Larix russica* and *Larix gmelinii*), which are the most widely distributed coniferous forests in the world. The major vulnerability factors for larch forest are fires and damage caused by insects. The frequency of these vulnerability factors is likely to increase with global warming; however, these forests may also benefit from soil nutrition improvements due to permafrost melting.
- Research in Mongolia estimated a shift to warmer and drier conditions, which would be consistent with other research predicting midcontinental drying. The Gobi Desert would change from warm temperate desert to warm temperate desert scrub and the cool temperate desert scrub would be replaced by warm temperate throne steppe. The area of cool temperate desert scrub would also expand to the Khangai mountains, supplanting forest areas.
- An equation relating Precipitation Effectiveness Indices (PEP) and net primary productivity was constructed for a study in the state of Kerala, India. Using this approach, it was estimated that due to the depletion of soil moisture estimated by GCMs [United Kingdom Meteorological Office, Commonwealth Scientific and Industrial Research Organisation (CSIRO), and Max Planck Institute], the productivity of teak plantations would decline from $5.40 \text{ m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$ to $5.07 \text{ m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$ and the productivity of moist deciduous forests would decline from $1.8 \text{ m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$ to $1.5 \text{ m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$.

3.3 SUITABILITY OF ADAPTATION MEASURES

Adaptation assessments should proceed, despite the need for further research on vulnerability to climate change. At the same time, the difficulties in obtaining the data necessary to evaluate various forests management practices should be recognized.

Some of the research presented provides insight into the potential for forests to adapt to climate conditions. For example, research in the Russian Federation indicates that morphological and physiological features of *Larix gmelinii* (larch) allow this species to withstand a range of air temperature fluctuations of more than 100°C and that one of the major ways of adaptation to unfavorable soil conditions is provided by a specific feature of root formation.

Work on vulnerability of forests to climate change could be integrated with vulnerability assessments from other sectors to identify socioeconomic activities or aspects of the biodiversity that are vulnerable to climate change. This type of research could provide information on the importance of various vulnerabilities that is necessary to begin developing policy strategies and options. For example, maps of changes in forest vegetation may be overlaid with maps of potential biodiversity to identify areas that are particularly vulnerable. These areas can then be the focus of an assessment of local management practices.

3.4 INTEGRATION OF VULNERABILITY AND ADAPTATION ASSESSMENTS INTO NATIONAL COMMUNICATIONS

The focuses of each country's national plan for the forest sector in the Asia Pacific region are extremely diverse, ranging from Malaysia, with large forests that are not yet managed, to

Thailand, with large areas of forest that are already being managed, to the Philippines, with limited forest resources remaining. Some of the countries (Philippines, Thailand) already have national forestry plans, which include the importance of influencing the forest planning process to include climate change. For example, climate change vulnerability research could be valuable to the current reforestation project in Thailand. Also, Russia, which has focused on forests as one of its most important sectors, has completed a comprehensive national communication.

3.5 REGIONAL COLLABORATION AND TECHNICAL ASSISTANCE

The vulnerability of the region is diverse and the most relevant options for adaptation will vary; however, there is a great benefit in collaborating in efforts to improve assessment methods. While it is valuable to use outside technical assistance, it is also important to do what is feasible within each country using existing capacity and resources.

In addition, acid deposition is a significant problem in the region, and it will require regional efforts to implement mitigation strategies and improve the overall situation/impacts.

3.6 FUTURE RESEARCH NEEDS

Future research needs include improved techniques for downscaling methods to a regional level, development of growth functions, collection of data on management practices, and incorporation of land use and socioeconomic conditions into the analysis.

4. Coastal Resources

4.1 ASSESSMENT METHODS

The Bruun rule, which estimates the amount of beach erosion for a given level of sea level rise, is being used worldwide to determine the amount of erosion in anticipating a response to a given sea level rise. There are real limitations in its application to many island states bounded by coral reef flats. The depth of closure (which measures the active part of the beach) varies by location. Without this critical parameter, the Bruun rule calculations are nearly meaningless. Also, there has been some attempt to use the Bruun rule along muddy shorelines such as Bangladesh. Here, the formulation loses all physical meaning because the equation is based on the equilibrium profile of a sandy beach. Clearly, more basic scientific research, including long-term beach profiling, is necessary to better model sedimentary dynamics in these environmental settings.

Beach erosion and inundation are controlled by relative sea level rise, which is the combination of eustatic (global) and local (uplift or land subsidence) components. Therefore, tide gauges are necessary throughout the Pacific Ocean because a gauge in one country may have little relationship to the actual sea level changes in another.

The seven-step common methodology of the IPCC is being used by most countries in their vulnerability analyses. This should be considered a very coarse, first-order approach as today's conditions are merely projected into the distant future when a 1 m sea level rise will be realized. This static approach is not very useful for planners who work on 5 to 10 year time horizons. What is needed is a dynamic approach where this big jump is broken down into smaller steps on a decadal basis. For example, beach nourishment can be used against sea level rise induced erosion, but typically such calculations are made for the baseline, 0.5 m, and 1.0 m scenarios.

In actuality, beach nourishment projects rarely last more than 20 years, and most require renourishment in 5 to 10 years.

4.2 CONCLUSIONS ABOUT VULNERABILITY

Accelerated sea level rise is one of the most certain outcomes of global warming. It is of great concern to Pacific island and coastal nations in Asia because most have long shorelines and major population centers located on low-lying areas susceptible to erosion, inundation, and storm surge flooding. Other coastal impacts include salt-water intrusion, which is a particular problem for coral reef atolls such as the Marshall Islands.

In addition to sea level rise is the potential for more frequent or severe tropical storms if the earth warms. Typhoons are a serious problem throughout most of Asia, causing massive destruction and loss of life where they make landfall. Especially impacted are Vietnam, South China, Hong Kong, Philippines, parts of Australia, India, and Bangladesh. Interestingly, only about 1% of global cyclones hit Bangladesh, yet almost 50% of global deaths from cyclones happen in Bangladesh. If climate change alters cyclonic size, frequency, track, etc., only slightly, then the impact could still be enormously important to Bangladesh because of its high sensitivity to these extreme events. The dual threat of sea level rise and storm surge flooding looms large in vulnerability and adaptation analyses for Bangladesh as well as for a number of other coastal nations.

4.3 SUITABILITY OF ADAPTATION MEASURES

Shoreline stabilization has been used widely to counter ongoing beach erosion, which is a worldwide problem. But many of these projects have been ill-conceived, often causing as much or more damage than proposed benefits. Hard shoreline engineering in the form of seawalls and rock groins/jetties have been oversold as a panacea to coastal erosion problems. The consequences are all too clear in places like Sri Lanka, where beautiful white sandy beaches have been squeezed out of existence. Seawalls also encourage unwise development practices by allowing hotels and infrastructure to be constructed too close to an eroding shore. Building setbacks must be instituted to provide the buffer size needed under existing conditions as well as to provide a measure of protection as the seas rise and beach erosion rates accelerate in the coming decades.

5. Water Resources

5.1 ASSESSMENT METHODS

Assessing the true vulnerability of water resources is difficult, especially given the uncertainties about regional climate change and the complex nature of modeling runoff. The scale of GCMs is far more coarse than the scale of processes that affect runoff. Although the resolution of the GCMs has been improved, they are still at too coarse a scale to resolve such important features as mountains. Limited area models (which model regional climate) are a promising development. In the workshop it was noted that some of the GCMs made available by the U.S. Country Studies Program (CSP), such as the Canadian Climate Centre Model and the Geophysical Fluid Dynamics Laboratory, show peak precipitation in July and August, similar to observed peaks. Runoff is a highly complex nonlinear process that is difficult to model.

Simple runoff models are relatively easy to use, but they leave out many features of water resource systems such as daily events. Estimates that assume that use of water per capita or per unit of GNP will stay the same ignore the potential effect of new technologies and management practices.

In spite of the limitations of methods to assess the affects of climate change on water resources, it is important to conduct vulnerability and adaptation assessments with the best tools available in order to inform policy makers about the potential risks from climate change. The best information on future climate change in Asia and the Pacific comes from GCMs, and the best information on how climate change will affect water supplies comes from the use of GCM-based scenarios with runoff models to assess the sensitivity of water supplies. Such studies should be conducted at the river basin level, which is most relevant to decision making on water resource management. Policy makers should be presented the results of assessments such as those discussed here, but should also be clearly made aware of the limitations of this type of analysis.

5.2 CONCLUSIONS ABOUT VULNERABILITY TO CLIMATE CHANGE

Water resources in many parts of Asia and the Pacific are quite vulnerable to climate change. Although there are many uncertainties concerning regional climate change and how it will affect water supplies and demand, it seems highly likely that climate change will result in significant changes in water supplies and demand. These changes could cause many problems, particularly in areas with high populations or limited water supplies. Changes in climate variability, particularly in storm tracks and ENSO events, could have an even greater effect on water supplies than mean climate changes.

The nature of many of the vulnerabilities of water resources in Asia and the Pacific is unique to the region. These unique vulnerabilities, particularly in South and Southeast Asia and the Pacific islands, stem from the combination of unique topography and current vulnerability to tropical cyclones. In Nepal, for example, runoff is strongly affected by the Himalayas and the presence of tropical monsoons and tropical cyclones. A recent and rare tropical cyclone in November dumped over 500 mm of precipitation in less than a day. Archipelagos such as the Philippines have no snow and therefore are highly dependent on rainfall. Changes in rainfall patterns can have a significant effect on water supplies. Atolls in the Pacific are very sensitive to precipitation patterns and changes in storm tracks; they capture rainwater in cisterns and rely on a below ground lens of fresh water that rides on salt water as a reserve source of water. Reductions in precipitation and sea level could diminish this fresh water lens.

Water resources in the region may be vulnerable to increases in demand from population growth and industrialization because they are already strained in many parts of the region. Asia has three-fifths of the world population and projections are for population to increase significantly over the next century. For example, the World Bank projects that the population of the Philippines will increase from 69 million in 1990 to 160 million in 2075. Industrialization could also result in increased demand for water. The Philippines government projects that demand for water will triple over the next half century. Not only could this strain water supplies, but water quality could also suffer. Climate change would be an additional stress on water resources in the region.

5.3 ADAPTATION MEASURES

The concern about potential climate change impacts on water resources is great enough to justify addressing adaptation in water resource management decisions. Climate change could have a very significant effect on the availability and quality of water supplies in Asia and the Pacific. In addition, the demand for water for uses such as agriculture could also increase because of climate change. Policy makers should consider climate change when making decisions about construction of water resource infrastructure and developing water management systems. The difficulty in addressing climate change is that the direction of change is uncertain. For most if not all areas, we do not know whether climate change will increase or decrease water supplies. Nonetheless, it is likely that water supplies will be changed. Water supply systems can be made more robust if their storage capacity is increased or if adjacent basins are linked so there can be interbasin transfers. Use of market prices for water can reduce inefficient use of this precious resource and enable water users to quickly respond to changes in water supply conditions. Small islands and atolls may need to plan relief efforts or evacuations in case water supplies are reduced.

5.4 FUTURE RESEARCH NEEDS

Future analyses of climate change and water resources should address the likelihood of how well water resource development projects will cope with climate change. There are many plans to further develop water resource supplies in many parts of the region. These development projects should be assessed as to their capability to meet objectives under scenarios of climate change. The scenarios should incorporate changes in climate variability, particularly the timing of the monsoon and the location and timing of tropical cyclones. If the capability is compromised by climate change, analysis should be conducted on what reasonable and cost-effective modifications can be made to reduce vulnerability by increasing robustness and resiliency of water management systems.

6. National Action Plans

6.1 VULNERABILITY AND ADAPTATION SECTORS TO BE ADDRESSED

In the Philippines, the sectors that will be included in its national action plan are agriculture, water resources, coastal resources, forestry and biodiversity, health and human settlements, energy/transportation and industry, and adaptation technology assessment.

Micronesia's national action plan will address coastal resources (including marine biodiversity), fisheries (subsistence and offshore foreign fleets), fresh water resources, agriculture, forestry and biodiversity, and socioeconomic factors, including tourism and human settlement.

Indonesia is participating in the ADB sponsored study called Least-Cost Greenhouse Gas Abatement Strategy for Asia (ALGAS). At the time of the workshop, Indonesia was conducting its vulnerability and adaptation analysis, as well as identification of mitigation measures. When these phases are complete, work will begin on Indonesia's national action plan.

6.2 HOW ADAPTATION MEASURES MAY BE SELECTED

First and foremost, a country can select adaptation measures that make sense on their own regardless of climate change, which can be called “no regrets” measures. One example is using market-based systems to allocate water supplies, which results in less wasteful uses of water under current climate and enables water users to more efficiently adapt to climate change.

Policy makers tend to take a short-term view of issues affecting their countries. One response to this problem may be to include climate change considerations in the design of long-term infrastructure projects. Also, agricultural research, with 5- to 10-year time horizons, may be another appropriate arena to encourage policy makers’ consideration of climate change.

6.3 GOVERNMENTAL ORGANIZATIONAL STRUCTURE FOR DEVELOPING NATIONAL ACTION PLANS

The approaches for the countries that are developing their plans are as follows:

- In the Philippines, the Inter-Agency Committee on Climate Change (IACCC) was created in 1992 to address the issues of climate change. It is co-chaired by the Department of Science and Technology and the Department of Environment and Natural Resources. Membership includes several agencies, and is being expanded to include Transportation as well as agencies with responsibility for cultural resources. The IACCC reports directly to the Philippine Council for Sustainable Development (PCSD), which comprises 14 agencies and seven NGOs. PCSD’s main responsibility is to implement the Philippine Strategy for Sustainable Development (Agenda 21), and the council uses consensus-building in its operations. The PCSD reports directly to the President of the Philippines.
- In Micronesia, the U.S.-sponsored Country Study precipitated the formation of the Presidential Council on Environmental Management and Sustainable Development in 1995. The interdepartmental council, representing the four Micronesian states, meets monthly, and is chaired by the Vice President. In the absence of an environmental agency in Micronesia, the council takes on the role of coordinating across sectors, following up on UNFCCC commitments, and ensuring compliance with environmental provisions of other treaties that Micronesia has signed. Sustainable development councils are now being formed. It is at this level that NGOs, private businesses, and municipalities will be involved in climate change activities in Micronesia.
- Indonesia has established a National Committee on Climate Change, with government agencies, NGOs, and universities as members. The Indonesian government recognizes that the output of scientific research can help with informed policy decisions, and does not try to influence the group’s deliberations. Each committee member has assigned responsibilities, which will be augmented upon the completion of the ALGAS project.

6.4 INTEGRATION WITH OTHER DEVELOPMENT PLANS

Several approaches for integrating national action plans with other development plans were discussed:

- In the Philippines, a number of ongoing and completed studies will need to be integrated with its national action plan, among them ALGAS, the Regional Study on Global Environmental Issues, and the EPA/IRRI Study on Global Impacts of Climate Change. With regard to mitigation measures involving alternative energy sources, coordination with the Philippine National Energy Plan will also be required.

- A problem cited by Micronesia is integration of the national action plan into other national development plans. National development plans, with their five-year time horizons, are already difficult for Micronesian policy makers to address. The time horizons of the vulnerability and adaptation analyses, 50 or 100 years, are too far in the future to be incorporated in such plans. Also, more immediate concerns push climate change further down the list of priorities.
- Indonesia views its national action plan in light of three positions. First, as a member of OPEC, Indonesia must ensure that its proposed measures do not contradict the wishes of fellow OPEC members. Second, Indonesia is a G-77 country, and so must also consider the aspirations of its fellow developing nations. Finally, Indonesia comprises 18,000 islands, and is a member of the Alliance of Small Island Nations. In this delicate position, Indonesia will be approaching its national action planning carefully. Nonetheless, Indonesia's national action planning is under way, and is being coordinated with U.S. CSP and USAID. It is being considered important to both sustainable development as well as continued economic growth.

6.5 RECOMMENDATIONS REGARDING CONTENT OF NATIONAL ACTION PLANS

In some of the panelists' opinions, the concept of "planning" still carries negative connotations in a region where market economies are dominant. Further, a national action plan carries the underlying assumption that the government can control the outcome of its policy actions.

A national action plan that looks broadly at vulnerability and adaptation should contain three sections:

- Vulnerability to climate change and potential adaptation measures; a plan based on several IPCC scenarios, with a focus on medium and long-term projects.
- GHG sources and sinks, a long-term GHG forecast under IPCC guidelines, and mitigation action plans.
- How the government will implement the action plan. This section would include recommendations such as legislative changes, emissions trading opportunities, or economic measures.

Climate change is one of a host of environmental problems affecting countries in the region. Each country will have to evaluate the tradeoffs between climate change actions and nearer-term needs (such as hunger, air and water pollution, energy demand).

Many countries still view climate change as a distant threat. For example, Indonesia's 200 million people, dealing with hunger and other pressing issues, may have difficulty incorporating climate change into their priorities; therefore, to be effective, a national action plan has to relate to the economic development plans across all sectors. Viewed in this manner, a national action plan is part of a country's total planning activity.

6.6 OPPORTUNITIES FOR REGIONAL COOPERATION

Regional cooperation is important, especially for countries that share water resources. Groups like the Association of Southeast Asian Nations (ASEAN) have environmental components, which national actions plans could build upon.

As countries move from technical studies to policies, more sharing of experience between the countries will be important to achieve results. In Africa, U.S. CSP countries started a newsletter

to communicate and share experiences, and the countries in Asia and the Pacific may want to follow their approach.

7. Workshop Conclusions

There are significant vulnerabilities to climate change in the Asia and Pacific region. The major conclusions of the Regional Workshop on Climate Change Vulnerability and Adaptation in Asia and the Pacific are as follows:

- **Sea level rise is of great concern to residents of Pacific islands and coastal nations in Asia.** Asia and the Pacific countries are particularly vulnerable to sea level rise because of the large number of people living on small islands, archipelagoes, and in river deltas such as the Ganges-Brahmaputra and Mekong. These areas are already affected by storm surge flooding and other related impacts. In addition, many major Asian and Pacific Island cities such as Manila, Jakarta, Shanghai, and Hong Kong are at sea level. Coastal reefs and mangroves are also threatened by rising seas and higher temperatures. Many vulnerable cities and countries are already taking steps to cope with rising sea levels and the potential for accelerated sea level rise. Although these measures may enable populations to continue to live in low-lying coastal areas, they will do so at an increased risk of coastal flooding. Future assessments of sea level rise should include analysis of human impacts on coastal ecosystems, shoreline stabilization, and storm surge flooding from tropical cyclones.
- **Changes in average climate conditions and climate variability will have a significant effect on crop yields in many parts of Asia and the Pacific.** Crop production in South Asia, Southeast Asia, and China appears to be more vulnerable to climate change than in Northeast Asia. Low income populations dependent on isolated agricultural systems are particularly vulnerable. This includes many areas dependent on rice production, populations dependent on production of tropical crops such as tea and coconuts, and regions with limited access to agricultural markets. Changes in climate variability will affect the reliability of agricultural and livestock production in the region. Increasing population could also place stress on agricultural production in the region. The extent of adaptation depends on the affordability of adaptive measures, access to technology, land and water resource availability, and genetic diversity of crop breeding. Many agricultural and other natural resource management policies discourage effective adaptation and lead to misuse of natural resources. The region has a rich history of farmer adaptations to a variety of climatic conditions, and this broad experience can be used to help adapt Asian and Pacific agriculture to the effects of climate change.
- **Water resources are very sensitive to climate change, and there are sensitivities unique to the region.** Water resources in this region, particularly in South and Southeast Asia and the islands, are very sensitive not only to changes in temperature and precipitation, but also to changes in tropical monsoons and cyclones. For example, runoff in Nepal is affected by snowcover, the southwest monsoon, and southwest cyclones, all of which are likely to be affected by climate change. In contrast, atolls depend on a lens of fresh water below the surface of the ground as a reserve supply. This lens will probably be reduced if rainfall declines. In addition, countries such as the Philippines may experience a large increase in population and GNP, which could further strain water resources. Climate change will be an additional, but important, stress. Consideration of climate change should be incorporated in the design of water resource projects, water development plans, and other related national action plans.

- **Forests in many parts of Asia and the Pacific could be significantly affected by climate change.** A large fraction of the forests of Asia and the Pacific will undergo a significant change in ecological life zones under climate change. For example, the results of research from Thailand indicate that the potential impacts of climate change on tropical forests could be significant. Research from Siberia shows that boreal forests could be both positively and negatively affected by climate change. Warmer temperatures could result in improvement of soil conditions, but also exceed thermal tolerances of many species and result in forest fires and pests. Future assessments of climate change impacts on forests should account for CO₂ fertilization and nonclimate factors such as changes in land use.

The following recommendations resulted from the workshop:

- **Efforts to improve general circulation models should continue.** The general circulation models (GCMs) show large differences in the direction and magnitude of climate change at a regional scale. Such differences make it difficult to get policy makers to accept the results of vulnerability analyses and address adaptation; therefore, efforts to improve the resolution and accuracy of the GCMs and to resolve differences concerning predictions of regional climate change are needed.
- **Asian and Pacific countries should cooperate on the analysis of climate vulnerability and adaptation.** Cooperation among countries in the region is needed because vulnerabilities are not confined to national boundaries. River basins such as the Ganges-Brahmaputra and Mekong are vulnerable to climate change and traverse national borders. In addition, many nations in the region share similar problems such as vulnerability to tropical cyclones and storm surges.
- **Asian and Pacific countries should address adaptation to climate change.** Adaptation measures designed to anticipate the potential effects of climate change can help offset many of the negative effects. Many countries are addressing adaptation through the development of national action plans on climate change. These plans will be developed in cooperation with natural resource and other agencies across governments, and should also be developed in consultation with key stakeholders and the public. These plans will feed into the writing of the national communications.

8. Summary

Many uncertainties remain about the vulnerability of the Asia and Pacific region to climate change, and much research on vulnerability and adaptation is needed. The assessments presented at this workshop indicate that climate change is of great concern to the region. The studies present a sound basis for addressing the mitigation of greenhouse emissions and the inevitable need to adapt to climate change. The results of these assessments need to be presented to policy makers and the general public. Assessments of vulnerability should continue in order to improve our understanding of the vulnerabilities of Asia and the Pacific to climate change and how the region can adapt to these changes.

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