Technical Primer on Climate Change in the Philippines

By the Manila Observatory for the Congressional Commission on Science & Technology and Engineering (COMSTE)

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Introduction

Anyone with a stake in the earth's weather or its resources will by now have seen or heard of the many changes that have been taking place on the planet. Images of devastating hurricanes, deadly heat waves, and crashing glaciers offered as signs of shifting climate have been impossible to ignore. Based on the millions all over the world who viewed the documentary *An Inconvenient Truth* since it was first released in 2005, the message of climate change has probably been received by every human with access to electricity.

The movie is only a public version of what many scientists have been saying since the first Intergovernmental Panel on Climate Change (IPCC) report in 1990. The threat of global warming has been known much earlier than that. Warnings about how the by-products of human activities can influence the weather have been raised throughout the 20th century, but only during the closing of the last millennium did enough striking images of disasters begin to accompany scientists' graphs and maps. By the time the fourth IPCC report was released in 2007, climate change had already become a global public agenda.

The science behind global warming is clear: emissions of CO_2 and other greenhouse gases from

human activities absorb heat emitted by the earth's surface, causing the lower atmosphere and surface to warm up. Mean global temperature is at its highest in human history **(Figure 1)**, and only the unprecedented levels of greenhouse gases in the atmosphere emitted by fossil fuel combustion provide a satisfactory explanation. New scientific results continually reinforce this relationship and provide more detail on its consequences.

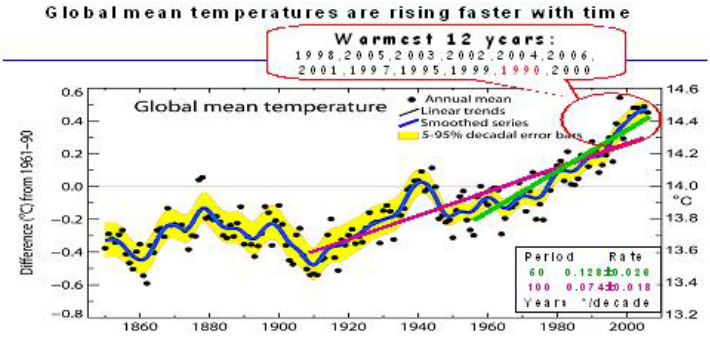


Figure 1: Global mean temperature showing the warmest 12years occurring in the last two decades of the 20th century.

Despite our good understanding of the causes of warming, its effects on specific regions of the world continue to be uncertain. The Philippines is among these regions. A quick search of the entire Fourth Assessment Report (AR4) of the IPCC finds only one mention of the Philippines in the text. To provide detail on the country, it will be necessary to inspect the many maps in the report and seek out

findings that are relevant to this part of the world. It will also be necessary to look beyond AR4 and gather what we do know about climate change from local scientists who specialize in the components likely to be affected.

The science of global warming will not be reviewed here since this topic is adequately discussed in the IPCC documents. It will also not cover skeptics' positions questioning the reality of human-induced climate change, since such doubt is no longer shared by scientists in the mainstream. However, this report will discuss what we can say with some certainty will happen to the Philippines as climate change progresses, and what appropriate courses of action must be taken to address its adverse effects. More important, it will also present the many unknowns and uncertainties in future Philippine conditions which should be weighed when selecting responses that will make the best use of our limited resources.

Making a 100-Year Climate Forecast

One key source of uncertainty lies with the methods used to forecast future conditions. For this reason, it is important to understand these techniques and their limitations.

Although the mean temperature of the earth is projected to rise, the exact changes in local conditions are not clear. Just as topography, location, land use, and many other factors influence local day-to-day weather, they also complicate the manner in which global warming will affect a specific province or municipality. In predicting these local effects, two main tools are used to look into what the climate in the future will be like. The first method looks to the past while the second surveys the future.

The first method makes use of statistics to draw trends from historical records, and project such trends into the future. Because this approach uses data gathered in the past, it forms the strongest basis for what scientists now know about the changing climate. The main drawback with this approach is that such data must be available. This is a problem for many places in the Philippines that are not covered in the network of weather stations in the

country. Data from these stations also vary in length and completeness. The other drawback, which is difficult to account for, is that data quality can change when monitoring instruments are not maintained or are upgraded.

The second method for assessing local climate change is called *downscaling*. This method makes use of predictions generated by global climate models (GCMs), which are essentially computer programs used to forecast daily weather but engaged instead to foretell conditions decades into the future. Figure 2 shows an example of GCM outputs for projected increase in temperatures for the Philippines by 2020 and 2050 under the A2 scenario from the Commonwealth Scientific and Industrial Research Organisation of Australia (CSIRO). Notice that the CSIRO model results are coarse with the projected warming covering broad regions of the country. There is no information on temperature changes at a more regional or local scale. Because the outputs of such models are still too coarse in time and space to be useful for local planning, climate scientists must use downscaling to interpolate between the coarse results to provide detail and focus on specific locations while making sure that results remain consistent with how the atmosphere should behave. Downscaled GCM results are currently used in many applications, but they suffer from the same errors inherent in any weather forecast. To try to minimize the influence

of (but not eliminate) these errors, results of several models are usually consolidated to yield the formal composite result.

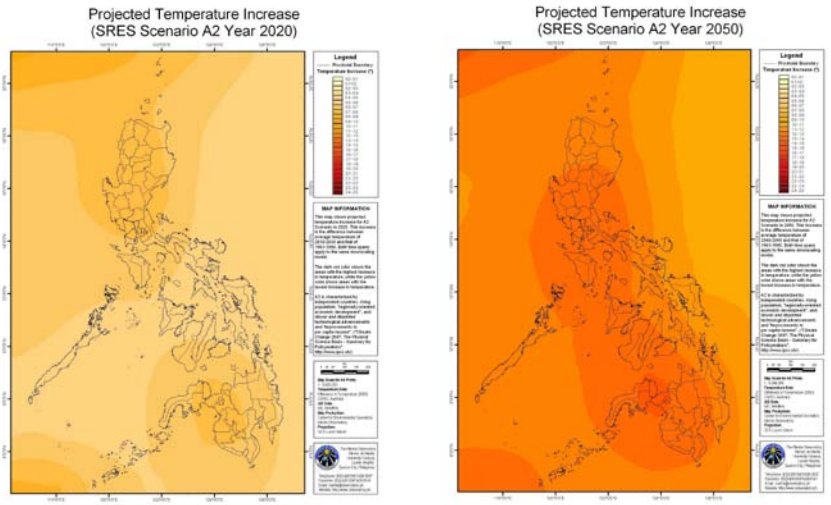


Figure 2. Projected increase in temperatures for the Philippines under the A2 scenario of the CSIRO GCM.

When model results agree among themselves and with the historical trend, confidence can be placed on their predictions. But there is never perfect agreement, and until we are able to conduct experiments with the atmosphere the same way with any other subject, they will remain the only tools available for understanding climate change.

Dealing with Uncertainty

When interpreting the implications of climate predictions, uncertainty is always present, and even more so in the Philippines. Long-term data of any kind is rare, and a lack of research plagues many sectors. Climate change has only recently become the agenda of the few local scientists with their meager resources. There has been a tendency to fill this gap by extending the results of studies from other countries to the Philippines, but without a true understanding of the limitations of this approach and the uniqueness of our conditions, we run the risk of adopting solutions that will not work here.

The succeeding sections will tackle many aspects of the impacts of climate change based on a critical review of the available relevant research findings. For those impacts that are certain, significant and adverse, the solutions will often be straightforward even if not necessarily easy. But there will also be many uncertainties, whether in the nature, magnitude, or probability of future scenarios. For these, it may be considered prudent to stop and wait. This is the opinion of many conservative policymakers in the U.S. who demand more definite proof before committing their country to spending billions to prepare for climate change.

Like many other countries, the Philippines chose not to take this stance, and for good reason. First, there is no such thing as definite proof, such as a phenomenon unmistakably caused by humans that announces the start of global warming. The series of powerful Atlantic hurricanes in 2005 constitute a possible sign, but such anomalous weather events can be explained by natural variability. The reality is that there is really no clear boundary where this natural variability ends and where the effects of human impact begins.

Second, by the time we recognize that climate change is upon us, it may be too late for the easy solutions. Any measure will take time to plan, fund, and implement. The good news is that the Philippines has been allowed this window with which to work these solutions. To wait is to miss this opportunity to act.

The Changing Philippines

Weather-related disasters are not new to the Philippines. Tropical cyclones, storm surges, floods and drought are part of our history and culture. They are so frequent that we have come to take for granted the many ways we have learned to cope with them. Indeed, even if these phenomena become more frequent, they will not bring anything we have not recovered from before. Why then should we be concerned about climate change?

The concern comes from the fact that the Philippines is also changing. What climate change poses is heightened *risk* of disasters, which is the true measure of its impact. Risk is proportional to the magnitude of an event or hazard, but is much more than that. It incorporates the number of people that actually suffer its effects. A moderate tremor in a city entails more risk than a strong earthquake in a farming municipality simply because more people are exposed to the hazard in a city.

Risk also includes the capacity of the exposed population to recover. An earthquake in an urban area will cause more harm to poor residents than to the wealthy who can afford to rebuild their homes, even if both groups experience the same earthquake. An event with the highest magnitude of risk or

human impact is therefore one which causes severe distress to a largest number of disadvantaged people.

When the effects of climate change are measured in such terms, the reason for concern becomes easier to understand. Climate change will increase the magnitude and frequency of weather hazards to an unknown degree, but the rise in exposed and vulnerable populations is assured. Exposure escalates as more people build homes along coastlines, riverbanks, mountainsides and flood plains. Poverty, ignorance of the hazards, and poor implementation of zoning laws brought them there, while continued migration and births increase their numbers. When a disaster strikes, the social costs of recovery will depend on this subset of the Philippine population. Even if climate change spares us and the hazards stay the same, the upward trends in exposure and vulnerability constitute sufficient reasons to be concerned about our future.

Direct Effects of Climate Change

Sea Level Rise

Perhaps the most visible effect of a warmer climate on the Philippines will be the rise in sea levels. As the oceans expand due to the increase in temperature, and as mountain glaciers melt and drain into the oceans, some islands and many coastal areas are feared might disappear with the rising waters. For a country like the Philippines, even a small rise in mean sea level will mean profound economic loss and social displacement.

In study after study, signs of sea level rise have been detected from tide gauges installed in several major ports in the country., Manila invariably registers the steepest rise. The UK Climate Research Unit (CRU) analysis of records in Manila and Legaspi gives evidence that the upswing started in the 1970s. However, geologists remind us that not all of the recorded rise is due to the changing ocean. In both stations, ground subsidence possibly due to groundwater extraction may also be to blame.

The problem with assessing the actual effects of sea level rise in the Philippines is that it is not yet clear how much will actually take place. The AR4 notes that if the influences of the two key factors, thermal

expansion and melting glaciers, are quantified over the last 50 years, they will not be enough to account for the observed rise. Ocean circulation, air-sea interactions, ocean chemistry and winds all introduce uncertainties that limit predictions of global sea level rise to “modest confidence.”

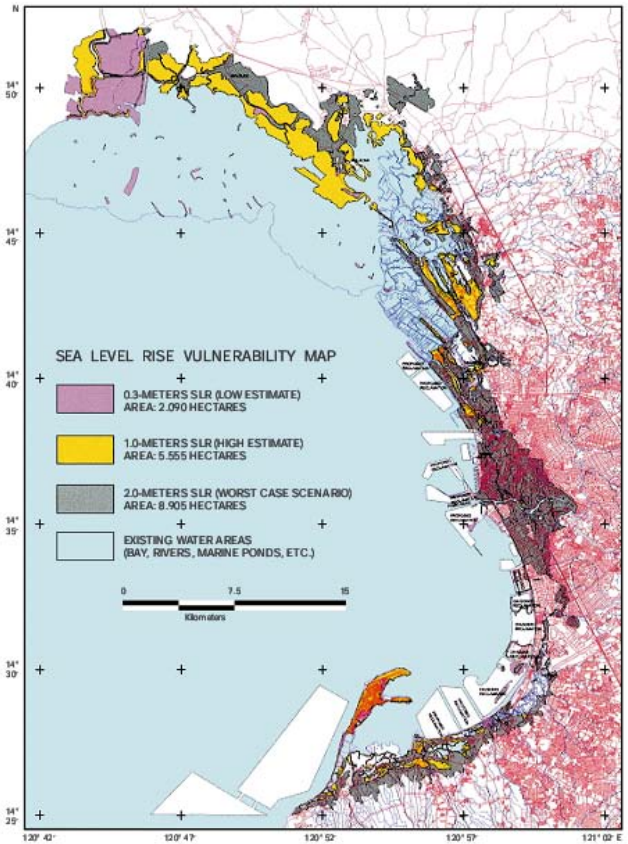


Figure 3: Impacts of 1m Sea level rise (Perez et al, 1999)

Assessing the impacts of sea level rise is currently based on mapping how the coastline will be pushed back for every meter the ocean rises. Low-lying coastlines with gentle slopes will suffer greater loss of land than those with steep topography. Using this approach, a PAGASA-led study calculated that a 1-meter rise in 2025 (Perez et al, 1999) will inundate more than 5,000 hectares and displace more than 2 million people, more than half of whom will be in Manila (Figure 3, Table 1). The impact can also be magnified during storm surges when strong winds push ocean waters deep inland, and, over a shorter but no less destructive period, during a tsunami.

The results of this simple analysis are alarming because 1 meter of sea level rise in Manila Bay is possible with the combined effects of siltation, surface subsidence, and land reclamation. The direct loss of coastal areas will naturally have far-reaching downstream effects on ecosystems, agriculture, and other resources. Since in an archipelagic country, the costs of solving through infrastructure even a moderate threat of coastal inundation will be prohibitive, other approaches must be found to prepare for this impact.

Table 1. Number of people that will be potentially affected by sea level rise in Cavite, Metro Manila and Bulacan (Perez et al., 1999).

Place	1990	1995	2025
The Philippines	62 049 000	68 614 000	143 096 245
Cavite	230 506	257 706	658 762
Metro Manila	429 600	510 794	1 443 228
Bulacan	130 000	140 790	227 166
		Total:	2 329 156

Temperature

As a tropical country, the Philippines has a climate that makes the daily weather forecast often a superfluous exercise. Anywhere in the country, hourly temperatures rarely deviate more than 5 degrees Celsius from the annual mean, and its warm temperatures are always accompanied by high humidity even in the driest months. This steadiness in temperatures is due to all the waters surrounding the islands that form the archipelago, and it is unlikely to be different in the future.

Still, future temperatures in the Philippines have been the subject of some studies. Extracted data from the gridded global database of the IPCC Data Distribution center and the UK Climate Research Unit (CRU) show a definite increase in the average surface (land and ocean) temperatures over the

Philippines since the 1980s (Figure 4). This result is also found in a report released by the CRU in 1999. The authors of the report also found that local ocean temperatures peaked in 1998, following a global pattern. By the time the report was released, annual temperatures were already 0.5°C above the 1961-1990 mean.

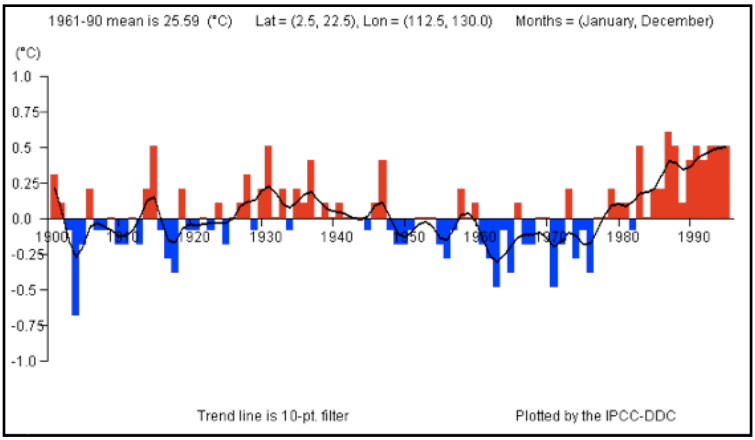


Figure 4. Average surface temperatures over the Philippines show a definite warming since the 1980s. (Data extracted from the gridded global database of the IPCC-DDC and CRU.)

The CRU also used GCM results to project land temperatures in the Philippines up to 80 years into the future under four different CO_2 emission scenarios. Although their forecasts remained coarse

(only four points represented the country), they found increases ranging from 1.0°C to 3.5°C in mean temperature. The projected warming by the CSIRO GCM in Figure xxx is consistent with these results.

Research work at the Manila Observatory shows that downscaling the GCM output of the ECHAM5 model of the Max Planck Institute for Meteorology (Germany) using the Regional Climate Model 3 (RegCM3) of the International Center for Theoretical Physics (ICTP) gives a similar range in increase in temperatures by 2020 and 2050 over the Philippines for the A1B IPCC scenario (Figure 5). More importantly, the downscaled results give more details on regions in the country that may experience higher increases in temperature. Mindanao and Southern Visayas, for example, are projected to be warmer in 2020 and 2050 compared to Luzon. Zamboanga Peninsula in particular will have the highest increase in temperature. It is important to remember though that as mentioned earlier, several models and scenarios should be considered to minimize the errors and uncertainties in the climate projections and to provide as well a range of possible climate scenarios for the future.

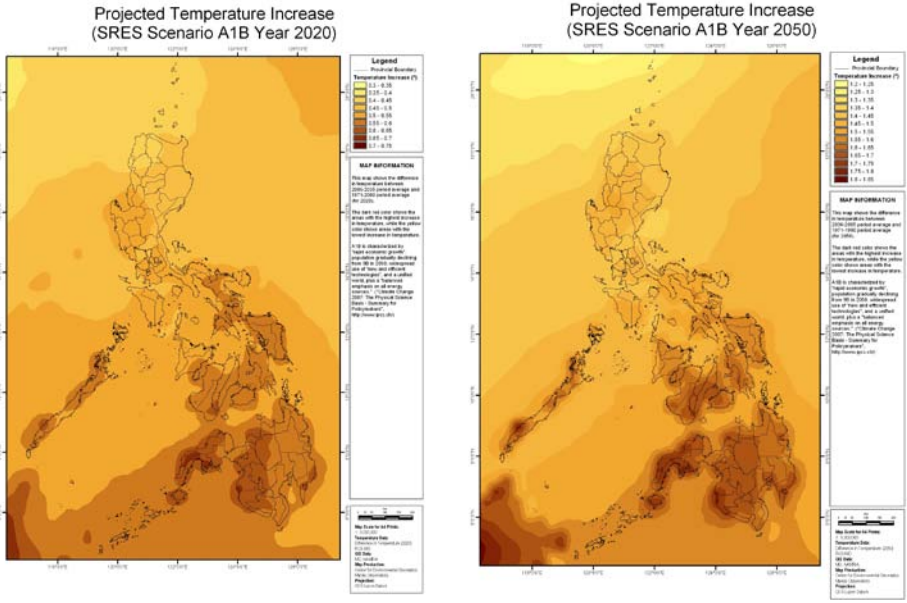


Figure 5. Downscaled projected increase in temperatures for the A1B scenario for 2020 and 2050 using RegCM3 to downscale the GCM ECHAM5 output. Darker colors denote greater increase in temperature. (Manila Observatory)

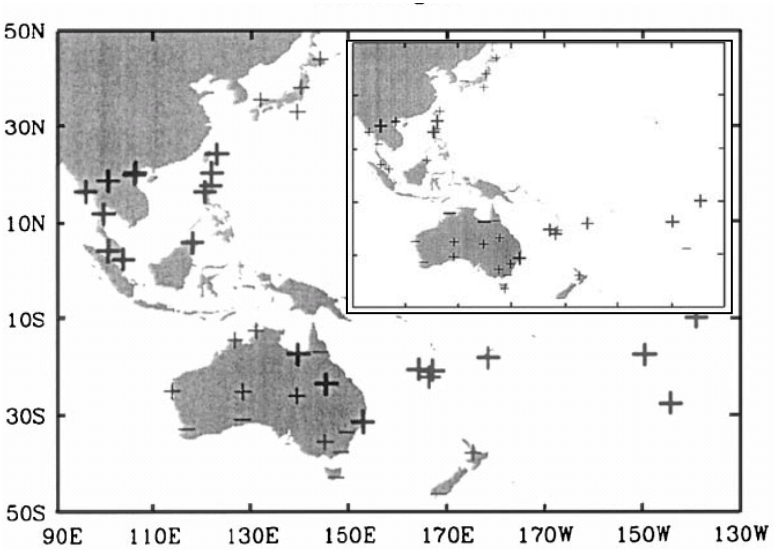


Figure 6. More frequent warmer days and nights in all stations for the Philippines as denoted by the plus sign (Manton et al., 2001).

Another study published in 2001 by M. J. Manton and a long list of co-authors compiled historical rainfall and temperature data from 1961 to 1998 in the Asia-Pacific region to look for trends. Unlike the CRU report which analyzed averages, Manton *et al.* looked at minimum and maximum temperatures. The authors defined four indices of extreme temperature and found that all four consistently pointed to more frequent warmer days and nights in all the stations from the Philippines (Figure 6). This report is significant because agriculture is more sensitive to such temperature extremes.

A limitation of these studies is that part of the observed warming can be attributed not to a global trend but to the well-known Urban Heat Island phenomenon. This refers to the *localized* warming arising from the removal of natural surfaces such as vegetation and moist soil and their replacement with artificial materials such as concrete and metal roofs that warm up much more easily. This is particularly true for the Philippines where weather data gathering has traditionally been in populated areas likely to experience urbanization. The study by Manton et al., however, shows that night time temperatures are also increasing and hence this cannot be attributed to urban heating, which

happens more during daytime. But more importantly, as will be shown later, identifying the appropriate responses to the consequences of the observed warming is more urgent than finding its main cause.

Rainfall

Compared to temperature, rainfall is a more critical weather parameter with more direct effects on Philippine conditions. Indeed, any concern about the impacts of climate change on the Philippines should be focused on how it will influence mean and extreme rainfall. A likely increase is what the AR4 forecasts for precipitation over Southeast Asia, but this does not provide enough detail for the Philippines.

The 1999 CRU report's analysis of historical Philippine rainfall indicated a general decreasing trend in total precipitation for the entire country. Modeling 50 years into the future, CRU showed two key results: an increase in June-to-August precipitation under all scenarios, but a decrease between December to February under the high-CO_2 emission scenario. How these seasonal changes affect the four climate types in the country is still to be studied.

The downscaled climate results of the ECHAM5 model under the A1B scenario from the Manila Observatory projects decreases in rainfall by 2020 in most parts of the Philippines except for Luzon where there is either an increase or no change in rainfall (Figure 7). By 2050, Visayas and Mindanao will be drier than normal as well as most of the western part of Luzon. It is emphasized here again, especially since rainfall is highly variable and one of the more difficult variables to forecast, that a multiple model and multiple scenario analysis is needed to produce a composite rainfall change projection for the future.

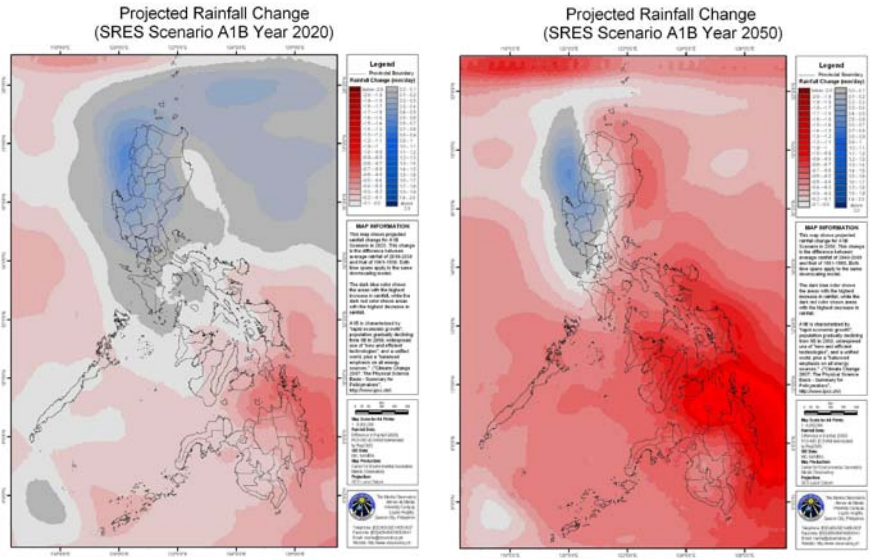


Figure 7. Downscaled projected changes in rainfall for the A1B scenario for 2020 and 2050 using RegCM3 to downscale the GCM ECHAM5 output. Red denote decrease in rainfall amounts while grey and blue denote no change or increase in rainfall, respectively.

The CRU's comparison of mean rainfall between decades is a clear-cut method used to detect signs of climate change. A risk with this method arises from the higher number of El Niño events during the last quarter of the last century. Since an El Niño is associated with rainfall deficits in many parts of the Philippines, the CRU result may have little to do with climate change. To remove the influence of El Niño events in the trend, work done at the Manila Observatory separated the comparisons of rainfall between 1951 to 1975 and 1976 to 2000 among El

Niño, La Niña and normal episodes. Comparing past and recent composite La Niña events yielded a strong positive increase in rainfall over the Visayas, while a comparison of normal conditions found a reduction in the entire country that is most pronounced over eastern Luzon. Overall, the general trend in rainfall appears to be a decrease over Luzon and Mindanao, and an increase over the Visayas (Figure 8).

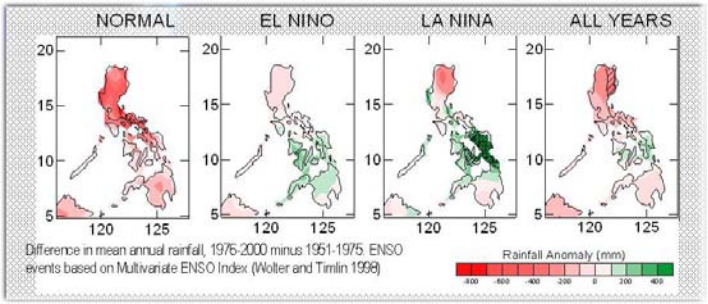


Figure 8. Changes in mean annual rainfall in the Philippines, 1976-2000 minus 1951-1975.

The Manton study provides additional detail about the trends in rainfall between 1961 to 1998 (Figure 9).. The first is a decrease in the number of days with measurable rain. This may explain the overall reduction in total precipitation noted earlier. More notable is other findings showing the general positive trend in the percentage of annual total rainfall contributed by extreme rainfall events (defined as daily rainfall above the 99th percentile). In ordinary terms, these results mean that while wet

days have become fewer, rains during these wet days tend to be heavier than usual. If these results are extrapolated into the future, they foretell two extremes *both* becoming more pronounced: drought and deluge.

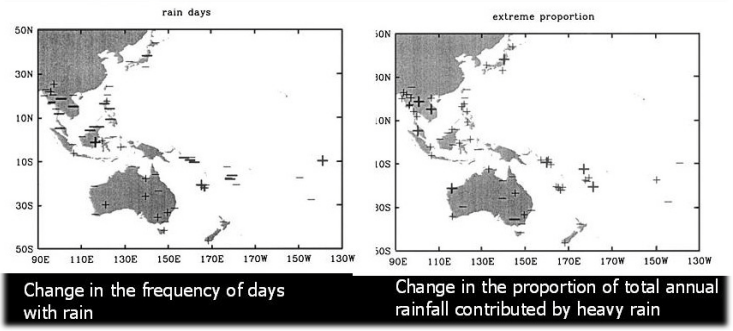


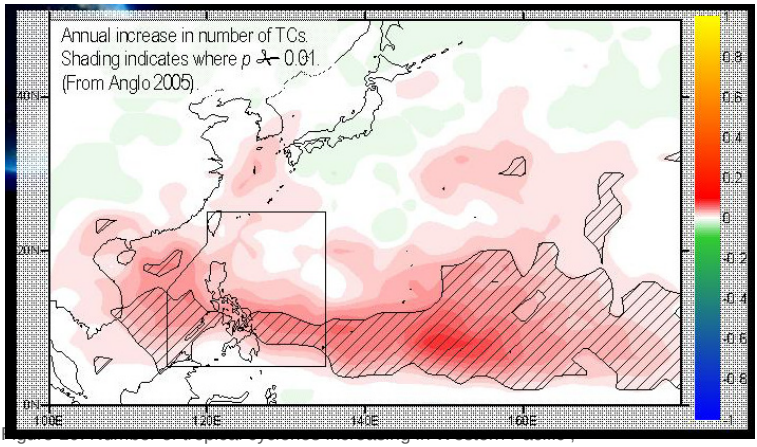
Figure 9. Changes in regional rainfall extremes, 1961-1998 (Manton et al, 2001)

These studies form part of a larger body of research that looks at three large-scale systems that influence Philippine rainfall: the El Niño-Southern Oscillation (ENSO) phenomenon, the Asian monsoon, and the Pacific Decadal Oscillation. Scientists believe these systems modulate through yet poorly understood connections how global climate disturbs long-term regional variability in local rainfall. Weather prediction will radically improve when these connections are understood, but for now our decisions for the future must be based on the broad warnings these studies provide.

Tropical Cyclones

Changes in typhoon activity are inherently difficult to ascertain owing to the many factors that influence their formation. Among these factors is sea surface temperature (SST): tropical cyclones do not form where SSTs are below 27°C. Warm waters supply the masses of water vapor which, through their condensation, contain the energy needed to power the cyclone. A reasonable conjecture is that climate change will warm up the ocean and enhance the strength, frequency and range of tropical cyclones.

In 2005, the Manila Observatory analyzed trends in tropical cyclone activity in the Western Pacific, particularly those entering the Philippine Area of Responsibility (PAR), to determine whether rising SSTs did have an influence. The MO study detected a small but steady increase in the number of disturbances entering the PAR. More important, this increase was most pronounced over the Visayas (Figure 10), the same general location where an increase in rainfall has been recorded.



significantly in the Philippines over the Visayas region (Anglo 2005)

The question whether global warming was enhancing the strength of tropical cyclones was addressed in two recent studies (Emanuel 2005, Webster et al 2005). Both found a significant increase in the maximum velocities of both Pacific and Atlantic Ocean disturbances that was correlated with the rise in sea surface temperatures. Other climate scientists however cautioned that any such increase may not be due to climate change, but are explained either by natural long-term variability or by improvements in technology used to monitor disturbances. This objection may be more valid in the Western Pacific, where the dramatic increase in data acquisition during the advent of the satellite age began to offset its large gaps in weather station coverage.

For the Philippines, settling this debate is of secondary importance because the increase in damage wrought by typhoons depends less on their enhanced strength and more on the heightened exposure and vulnerability of the population. The enhanced potential for heavy rain combined with strong winds from more frequent typhoon crossings implies an increased risk for flooding, landslides, and lahar events. After the 2005 Oriental Mindoro inundation, the February 2006 Leyte landslide, and the December 2006 Albay lahar event, no further reminders of the downstream consequences of extreme weather are necessary.

Combining what we know about temperature, rainfall, and tropical cyclones, what we have so far amounts to a low-resolution conceptual image of the anomalies in weather that climate change will likely cause. The only definite conclusion we can draw from them is that the preparations that the residents of Luzon should undertake may have to be different from those in Visayas and Mindanao. Impact and responses may also vary among the climate types of the country.

Social and Ecological Effects of Climate Change

Public Health

The waters surrounding the archipelago serve to protect the Filipino population from one of the most feared effects of global warming: extreme heat waves that can kill the old and weak. It may also be taken as comforting news that the global spread of disease is expected to originate from tropical regions towards countries that warm up, and not in the opposite direction. The effect of climate change on public health in the Philippines will be more indirect, and will come in several ways.

The general outlook is that the displacement of families living in disaster-prone areas will be a public health challenge that will become more frequent. Based on the rainfall data, it is the eastern Visayas that appears to be at risk. Elsewhere, losses in agriculture, fisheries and other livelihoods will result in hunger and poor health. Any decline in groundwater yield will heighten water-related disputes and expose people to water-borne diseases such as cholera and typhoid fever. Sadly, all these are old problems that have long burdened local government services in the Philippines.

International health agencies predict the more specific impacts on global public health to be through alterations in the range and seasonality of

mosquito-borne diseases such as malaria and dengue. Because the vectors for such diseases are already present nearly everywhere in the country, in this aspect, climate change may have moderate impacts on the Philippines. However, if these diseases do infect more people globally, the possibility for them to mutate into more virulent forms also increases. But this does not change the need to continue the efforts to remove the breeding grounds of the mosquito vectors.

Additional research is therefore needed to identify new health risks that may arise from climate change. For now, protecting the public from the effects of global warming calls for preventing it from exacerbating existing problems.

Energy

Understanding the impacts of climate change on the energy sector requires a review of Philippine energy policy and of how this energy is used. This policy aims for self-sufficiency by maximizing the use of local energy resources and avoiding the need for imported coal or oil. For this reason, as an operating policy, all available hydroelectric and geothermal power capacity is always used, leaving the remaining demand to be filled by other sources. Even with this policy, hydropower currently

accounts for less than 10 percent of the total national capacity.

Hydropower capacity is of course dependent on the amount of rainfall during a season. But as discussed earlier, climate change analysis based on historical data indicates increase in rainfall in the Visayas and reduction in Luzon and Mindanao. What is upsetting is that the Visayas region has virtually no major dams, whereas Luzon and Mindanao rely heavily on them not only for electricity but also for irrigation. More importantly, the historical trend of rainfall decrease in Mindanao is consistent with the downscaled rainfall projections, although under only one scenario and one GCM, that also indicate drier conditions for the region where most of the country's hydropower plants are located.

The sensitivity of hydropower to rainfall was illustrated during a drought in 2003 which drastically reduced water levels in Lake Lanao. Power outages in Mindanao lasted several hours, causing businesses to turn to costly and pollutive diesel-fired generators. Luzon's other power plants cushion its energy supply from the effects of drought, and similar investments must be made in Mindanao if this scenario is to be avoided in the future.

Also relevant is the fact that much of the Philippines' domestic energy use is taken up by

indoor air-conditioning.. Since all projections of climate change point to warmer temperatures, it is nearly certain that this will magnify future energy demand beyond normal economic and population growth.

The net result is that global warming will raise the country's expenditure for imported fuel. Unless renewable energy resources are developed in keeping with the aim of exploiting local sources, the only other alternative is to live with power shortages.

Fortunately, investments in wind, solar and biomass power are booming locally, which may lessen this impact. Renewable energy remains more costly than conventional sources, but support from governments and funding agencies has removed this limitation. Climate change however creates another source of uncertainty for its prospects: any increase in rainfall and cloudiness may diminish the potential for solar power. The influence on biomass energy potential, which may or may not be favored by these weather changes, is unknown.

Forests and Terrestrial Ecosystems

During occurrences of floods and landslides, the focus on human and social costs always relegates to the background the damage wrought on ecosystems.

Little attention is given to the loss of habitats and the resident wildlife. The reality is that the increased frequency of such calamities constitutes an additional threat to the health and survival of the Philippines' natural wealth.

Classified among the world's biodiversity hotspots, Philippine forests serve host to a large variety of plant and animal species. Of the one thousand known terrestrial vertebrates living among the islands, endemicity is 57 percent, a figure higher than in the Amazon basin (Heaney 1998). The 13,500 species of native flora constitute 5 percent of the global total, but a substantial number is believed to remain unidentified. Upland forests also support a third of the total population of the Philippines, among whom are its poorest.

There have been very few studies on how climate change can alter local ecosystems. One such study by Lasco et al calculated how the character of Philippine forests can change if mean temperature and rainfall were to be altered by global warming. By imposing the changes in these two meteorological parameters predicted by several global climate models into a simple ecosystem model, his results showed that the present fraction of dry forests can decrease in favor of wetter types of forests if the country receives more precipitation in the future. However, not all GCMs predict a surplus of rain. Observed rainfall trends point to a

decrease in northern Luzon and parts of Mindanao and downscaled climate projections also show drier conditions in most regions of the country. In these deficit areas the size of dry forests will expectedly decrease, but because such dry forests are easier to convert to farms and other uses, and are more fragile under fire, wind and rain, the decline in overall forest cover may take place faster.

As serious is the danger of climate change to Philippine forests and wildlife, the dismal fact is that human activities will likely continue to be the more damaging factor. Since 1900, logging and conversion reduced forest cover from 20 million hectares to less than 7 million hectares in 100 years. With or without climate change, this decline would have continued were it not for vigorous reforestation and forest protection efforts. Since 2004, the area of Philippine forests has been registering a small but steady rise. The future of Philippine forests and its remaining terrestrial biodiversity will depend on which human activity dominates.

The recent discovery of a new bat species in Mindoro was refreshing news, but to biologists, this finding contains a subtle reminder. If every effort to explore our forests continues to yield dramatic new discoveries, the possibility is high that there are still more in there waiting to be revealed by science. To fail to find these unknown species, or to consign

them to extinction, is not merely a sentimental or academic loss. It may also mean missing the opportunity to develop new medicines, materials, or even food.

Agriculture

Any inquiry into the potential adverse consequences of global warming not only to agriculture but to the Philippine economy in general need only to review the statistics on losses during droughts and typhoon crossings. From 1970 to 1990, 82.4 percent of total Philippine rice losses were attributed to typhoons, floods, and droughts (Lansigan et al., 2000). Recalling the earlier findings on the increasing frequency of days without rain and days with extreme rain, trouble lies ahead for local farmers as a consequence of weather anomalies caused by climate change.

But it will not be this simple. More detail on the future of agriculture may be drawn from the document Philippines Initial National Communications on Climate Change (PINCCC) in 1999. Summarizing model results and trend from other countries, the report warned of the loss of arable lands due to sea level rise and decreased soil fertility due to erosion. It also cited the effects of rising temperatures, which have since been reinforced by newer findings.

While mean temperatures are not expected to rise significantly owing to the country's geography, the problem is that any little change is likely to affect rice crops. Noting that minimum temperatures in Los Baños, Laguna have increased by more than 1°C between 1979 to 2003, Peng et al. (2004) of the International Rice Research Institute proceeded to investigate how this particular parameter could influence rice yield. Using field studies, they found that each 1°C rise can cause a decrease in yield by 10 percent.

Rising CO_2 levels makes the net effect of climate change slightly more complex. Plants do need CO_2 for photosynthesis, and as some laboratory and model results show a higher concentration of CO_2 in the atmosphere can enhance production. However, this improvement can only occur if *temperatures remain at the optimal level*. If conditions warm up by more than 2°C, no enhancement will take place, and CO_2 becomes detrimental as its concentration rises (Horie et al 2004). In addition, the benefits of higher CO_2 can only be obtained if nutrients are available (Baysa et al. 2003).s

There are other reasons tinkering with CO_2 concentrations is not good for rice farming. More CO_2 might help crops, but weeds tend to be better at exploiting favorable conditions. Insects and other pests may also find warmer temperatures more

hospitable. If CO_2 levels do rise, its outcome is more likely to be an increase in farm inputs such as herbicides and pesticides if yields are to be maintained.

Increased CO_2 favors crops like rice and wheat which are able to efficiently store the additional carbon, but models show that this added carbon will be used by these plants to build more leaves and stalks, not edible grain.

Besides altering temperature, climate change may cause extreme rainfall events that will exacerbate the old problems of soil erosion and loss of fertility, twin problems that have reduced the size and productivity of farmland. Studies in Mindanao show the causes to be largely preventable, such as wasteful use of fertilizers and poor soil management.

Induced rainfall anomalies can also amount to dissembling a delicate balance in agriculture. First, if global warming magnifies the variability in rainfall, soil will suffer from the extremes of desiccation and water logging. Second, the increase in mean rainfall over selected parts of the Philippines may be a good thing, but rain is welcome only if it falls in right amounts on the correct months of the year when plants need them. Given how finely tuned the life stages of crops are to the timing of rain, any shift will only be favorable if farmers can adapt to it. This means

breeding new crop varieties, embracing modern farming technology, and finding the resources to help farmers get access to them.

The challenges to the agricultural sector are not merely those created by global warming, but of self-sufficiency in the face of rapid population growth and the loss of farmland. Climate change poses to farmers the difficult but not infeasible task of producing more with less.

Water Resources

Other than sea level rise, the greatest worry over climate change is how it will disrupt the supply of freshwater. Much has been said about how this supply is threatened by shifts in the global weather systems that bring rain to the habitable portions of the planet. However, the fear goes beyond parched farmlands and dry faucets, but of heightened tension among countries over water resources. History is full of accounts of big and small wars fought over control of rivers and wells even when global population was a fraction of what it is now. With global warming, scientists warn of a resurgence and expansion of longstanding quarrels in Africa and Asia over this resource.

With no neighbors sharing its boundary, the Philippines has been spared from such conflicts. Its

geography has also ensured enough rain will fall on every patch of its territory. PAGASA's station records show that any empty swimming pool in the Philippines will receive at least a meter of water after a year: only in General Santos City will there be less. Much of this water just evaporates or flows back into the ocean, but some is held in rivers, dams and aquifers, available for use in our homes, farms, factories and power plants.

Estimates of this total available water vary, from 146 billion cubic meters (BCM) per year according to the latest values from the National Water Resources Board (NWRB), to 480 BCM from the World Resources Institute. This uncertainty is huge, but even the lowest estimate still gives about 5 cubic meters to each of the country's 85 million people daily, or five times the minimum amount considered adequate.

These data hardly depict the country's water situation. First, they say nothing about how this water is distributed among the population. The World Bank states that about one of every five Filipinos has no direct access to clean water, a figure that is actually worse today than in the 1990s because the development of supply infrastructure has lagged behind population growth. For this sector of the population, water must come from rivers, lakes and shallow wells which are prone to contamination. Such widespread lack of access to

clean water explains why diarrhea remains a leading cause of illness in the country (though mercifully, other waterborne diseases like typhoid fever and cholera have been rare). This same sector will also be among the worst victims of climate change if the predicted lengthening of rainless days render these water sources unreliable.

Second, the uneven distribution of water also applies to farms. Of the more than three million hectares of agricultural areas that could benefit from irrigation, 56 percent must depend on seasonal rainfall while waiting for new dams to be built. This lack of storage infrastructure leaves the Philippines' agrarian economy highly sensitive to droughts and floods. As these anomalies become more pronounced, so does the need for these dams and irrigation systems.

Sea level rise has had a disquieting connection with freshwater generation for a long time. As is well known, the apparent sinking of many coastal areas can be caused by too much extraction of groundwater. Equally well known is the phenomenon of salinity intrusion, wherein water from wells gradually turns salty and undrinkable as the ocean pushes into overused aquifers. If climate change does cause sea levels to rise dramatically, even aquifers that have been sustainably utilized can suffer the same fate.

Sea level rise can also affect surface waters. As ocean levels rise, saltwater backflow into some rivers will penetrate deeper inland, limiting their use as a source of freshwater. Uniquely vulnerable to this effect is the Laguna de Bay, the largest lake in the Philippines and envisioned to be the future source of domestic water for the growing population of Metro Manila. At present, extreme high tides in Manila Bay occasionally mixes seawater into the lake through Pasig River backflow. These brief infusions of sea water are actually welcomed by fishers in the lake because they clear the water of algae, thereby enhancing photosynthetic activity and overall productivity. It is not clear how these stakeholders will receive the lake's further salinization in the coming decades, but others will lament the loss of the lake's importance in irrigation and its promise as a source of drinking water.

A more definite positive outcome of climate change may be expected in those locations where mean rainfall may increase, specifically over the central Philippines based on historical trend or over central Luzon in 2020 based on downscaled climate projections. Except during periods of extreme rain, productivity and quality of life in these places will probably not suffer and may indeed benefit from the improved availability of the resource. However, the opportunity this scenario offers to farms, industries and people in general and will go to waste unless

the infrastructure to take advantage of the water is put in place.

The need for freshwater illustrates how adapting to climate change will entail not only mitigating its effects but also exploiting its benefits. However , both measures will require careful scientific planning and major funding commitments.

Marine Resources

The marine resources sector is one in which nature has provided distinct warning indicators of the potential impacts of climate change. These warnings came in 1998 when an El Niño brought record high ocean temperatures to the Western Pacific and the South China Sea that lingered for several months. The event was extensively investigated, and created a wealth of data that illustrate what might happen if such warming persisted for years or decades.

The most dramatic of these impacts is coral reef bleaching, so-called for the chalky appearance corals take when they die. Temperature was among the critical factors in the 1998 bleaching event, but CO_2 can cause a similar result, as described by Kleypas et al. in 1999. As CO_2 in the atmosphere rises, so does the amount absorbed by the ocean. This added CO_2 forms carbonic acid, which

acidifies seawater and disturbs the chemistry of calcium carbonate. This carbon compound happens to be the key component in the structures of coral and plankton and the exoskeleton of mollusks. In essence, CO_2 increase makes it difficult for these marine organisms to accumulate calcium carbonate, making them weak and limiting their growth. Together with rising temperatures, this phenomenon may negate the efforts to protect our remaining reefs. The destruction of reefs will reduce marine biodiversity, which diversity is critically important for the ecological balance and productivity of marine resources.

The impact on marine resources has both deep ecological and social dimensions. Well before climate change was recognized, Filipino fishers and their families have been suffering dwindling incomes due to overfishing, heavy competition, pollution and destructive fishing practices. Recognizing these threats to small operators, many local governments strengthened their capacities to enforce regulations with some success. However, most marine scientists believe it is unlikely for fisheries, whether near coastal waters or in the deep sea, to reverse its decline. If so, the best long-term response to help fish stocks *and* improve the welfare of local fishers is for the latter to turn to other livelihoods.

Responding to Climate Change

Given what we know so far about the potential effects of climate change to the Philippines, what actions will be necessary? There has been no shortage of answers to this question. What this study attempts to do in the following section is to assess each of the usual proposals and to evaluate their urgency in terms of the magnitude of their benefits, the coverage of the impact they aim to address, and the cost of implementing them.

Mitigating GHG Emissions

In 1994, the Asian Development Bank published the first official estimate of total GHG emissions of the Philippines. This total was found to be equivalent to just above 100 thousand tons of CO_2. This number obviously has little meaning except when weighed against the emissions of other countries. When such a comparison is made, this total emerges as a small contribution to the total global anthropogenic CO_2 load. If this total is a measure of responsibility for global warming, on an absolute magnitude and per capita basis, the Philippines can still be considered to be on the low-end of greenhouse gas emitters in the world.

CO_2 is not a pollutant that harms most seriously those who emit it most, nor will global warming spare those who produce it least. The nature of the problem is that even if the Philippines were to shut down all its coal-fired power plants, it would amount to a noble but hollow gesture unless developed countries do the same. The collective goal to reduce CO_2 emissions must take into account the differentiated responsibilities of the countries.

This of course does not mean that the Philippines should exert no effort to reduce its use of fossil fuels. There are very good reasons to minimize oil imports, not the least of which are to avoid oil spills, reduce air pollution, or to save on foreign exchange. But it does suggest that any such effort be taken without causing shortages or making energy too expensive. Indeed, if coal and oil consumption is to be reduced, it should be for its practical and economic benefits, not just CO_2 mitigation. Such a co-benefit approach is deemed appropriate for developing countries such as ours who are not principally responsible for creating the problem in the first place.

What mitigation measures should then be taken? On the supply-side of energy management, we should consider replacing old, inefficient and pollutive power plants with cleaner renewable energy (RE) sources. Because some of these RE plants rely on

intermittent resources which are dependent on climate (e.g. sun and wind), the Philippines should consider employing steady sources of power such as biofuels. The economics of biofuel production must be carefully weighed vis a vis the ecological benefits of this alternative fuel. The long-term strategic objective must take into account reducing dependence on overseas fossil fuel and increasing the use of local energy resources which are deemed underutilized to this day.

On the demand-side of energy management, reducing energy consumption at every level remains desirable, and providing simple, sound advice to power consumers will have widespread benefit. Such advice must take advantage of data from the Philippines.

For instance, proponents of energy conservation should note that half of the country's CO_2 emissions come from energy use. Of this fraction, 38 percent is emitted by power plants that supply the grid. The bulk of this electricity is in turn used for a single purpose: air conditioning in homes and offices. Instead of sending broad trite messages exhorting the general public to save on electricity, a focused program calling for designing better buildings and installing more efficient appliances will be more effective at minimizing power usage.

Another major source of CO2 in the atmosphere is the transport sector. On the supply-side, the country should devise and implement policies that encourage the production and deployment of fuel-efficient vehicles, urban planning that promotes public transport and reduced car use, alternative modes of transport (e.g. river transport), road and traffic management, among others. The demand-side of clean transport management should empower the consumer to patronize clean public transport, reduce dependence on inefficient modes of mobility (such as the two-stroke tricycle for highly dense urban centers), choose fuel-efficient vehicles, and the like.

GHG mitigation is an option, but only if it can be carried out cost-effectively, and for the appropriate reasons. On the other hand, adaptation measures are not cost-free, but they will pay off in many ways.

Adaptation

The following facts were established earlier: (i) the impacts of climate change on the Philippines remain uncertain, and (ii) our emissions indicate minimal responsibility for global warming. If these should be among the bases of our decisions, is the correct response then just to wait it out until the uncertainties are resolved or our emissions become significant?

The answer is, of course, no. Rather than defer our decisions, uncertainty should instead shape them. Uncertainty prompts us to tread carefully, but not to stop and wait, nor to merely follow the paths of others. In the face of doubt, the best response is to look for solutions that have corollary dividends, often called *co-benefits*, that address other existing problems. Climate change brings with it a cascade of challenges; the best solutions for the Philippines should also have myriad downstream benefits.

Based on the principle of co-benefits, any solution should be adopted only if:

(i) Reduction entails other desired outcomes,
(ii) It is useful even if no impact of climate change is seen, and
(iii) It entails no unnecessary sacrifices.

This means that in aiming to reduce our greenhouse gas emissions, the solutions we commit to must also maximize other benefits such as clean air or lower energy costs, and must not jeopardize our economic growth. The types of actions that will satisfy these criteria are those geared towards adaptation.

Build effective dams and water impoundment systems. , big and small, for irrigation, power generation, flood control, and drinking water storage. Costs will be huge, and the displacement of homes is very likely. It will also be unpopular

among some environmental groups, who believe the ecological impacts of all but the smallest dams are just too high. The best efforts should be taken to address these concerns, but they should not prevent effective water impoundment systems from being built.

Promote renewable energy. The excessive price of petroleum has resulted in the closure of major oil-fired power plants, and it is time to replace them with sources such as wind, solar energy and biomass. Few constraints remain in their adoption. These technologies can no longer be called experimental, and their widespread use has allowed enough competition among suppliers to reduce their prices. The Clean Development Mechanism, which is aimed at assisting developing countries find funds to adopt renewable energy in exchange for carbon credits, promises to remove the problem of funding. Renewable energy will not only diminish the need for imported fuel, but by producing power on a smaller, modular scale it may provide the benefits of electricity to remote locations.

Encourage clean transport. These actions need not be as innovative as those for energy. Proper engine maintenance for cleaner emissions and improved fuel efficiency has long been proven as a simple and cost-effective measure – if only this message reaches more drivers and operators in the public transportation sector. The expansion of various

modes of mass transport in Manila and other urban areas in the Philippines is reassuring, but it will require heavy financial commitment if the trend is to be sustained. Based on the crowds that patronize existing railway systems, transport planning officials should be able to tap the willingness of the commuting public to bear some of the cost of building new routes.

Develop new crops and farming technology. New crops that use less water and other inputs, resistant to drought and heavy downpours, will thrive in poor soil, and can work with altered rainfall schedules. Some varieties already exist, shelved only because popular varieties yield much more. Other crops may call for no less than miracles in genetic engineering. Also, promoting crop programming, the effective use of pesticides and fertilizers, organic agriculture, soil management and conservation., will modernize the industry and help farmers with their present problems .

Develop financial recovery mechanisms. Calamity funds and broad-based charity financial support are the usual financial mechanisms employed in the country to mitigate the risk of disasters. The Philippines should consider a more systematic way to distribute and transfer disaster risk via insurance and other mechanisms. The insurance industry has been remarkably instrumental in bringing to the mainstream the threat of climate change and the

need to manage its risks in developed countries. However, this has not yet been the case in the Philippines,

Protect fisheries, reduce pressure on marine resources. There is enough research on Philippine marine resources to be alarmed about the potential threats posed by climate change. All assessments point to the need to design, promote and, more important, enforce laws protecting marine biodiversity and fisheries from overexploitation and destructive activities. The even more difficult challenge is to seek alternative livelihoods for fishers to allow wild fish stocks to recover and reduce the numbers dependent on them.

Enforce forest protection. Like marine resources, direct human activities, not climate change, is the more serious threat to forests and terrestrial biodiversity. The solutions are therefore similar: strengthen enforcement of laws, and help those displaced by enforcement find other sources of income. Their ultimate goals are also the same, which is to find stable and safe livelihoods for the poorest of the population.

Prepare for disasters. When the Philippines gained the dubious reputation as a global leader in disasters, the country received some assistance to improve its preparedness and capacity to respond. Places recently affected by natural disasters as well as

communities with forward-looking leaders took advantage and initiated this effort. Preparedness involves conducting baseline studies, revising land use and development plans, conducting information drives and training programs, implementing warning systems, and building evacuation plans. It is unclear if its efforts will be sustained, or whether the initial enthusiasm will fade as rubble from the disaster is gradually cleared.

Use engineering. Protecting embankments and steep slopes from collapse, building drainage systems and preventing erosion both through vegetation and artificial structures are effective though expensive measures. These solutions can help if they are designed and built well. However, they should not create an undue sense of security, and should only be one of many layers of readiness.

Reduce exposure. The much more difficult and costly part is moving people away from risk areas and preventing them from returning. Compensation and assistance should be provided to displaced families (making the costs of relocation massive), but forced demolitions are still likely. Local and national leaders should recognize that for the riskiest locations, there is no way around this unpopular measure. In other less risky locations, officials may impose increased vigilance among residents until funds can be obtained for their relocation.

Reach out to the grassroots. Reducing vulnerability to climate change must include efforts to improve people's welfare through any possible means. Creating jobs, providing loans to open small businesses, offering livelihood training programs and giving scholarships all improve the capacity to recognize and avoid risk, and the ability to recover from disaster. Like most of the other recommendations these are not new, but they highlight the fact that the most effective responses to impending climate change involve meeting present shortcomings.

An advantage of the Philippines is that unlike other countries, none of these proposed measures entail sacrificing economic growth. Indeed, all these measures aim to preserve gains and minimize the losses from disasters.

Responsibility

For climate change, there is always a delay between a cause and its consequence. The effects we observe now are results of emissions from more than a century ago. If we wait for clear signs of climate change before we act, we will suffer first before our responses yield any benefit. It can also be too late or too costly to respond effectively.

The fact that the Philippines emits so little of greenhouse gases worldwide does not free its citizens of responsibilities in meeting the challenges of climate change. It only assigns different roles to different people. On the one hand, wealthy Filipinos,who consume the most energy and account for most of local emissions, are just as responsible for the problem as anyone else in the developed world. It does not exonerate them just because they are so few. Being more at fault than the average Filipino, they and the institutions they manage must therefore do more about the problem. by shrinking their footprint on the planet, or by helping others cope.

The poor, despite their having so little to do with climate change, must on the other hand accept that the burden of responding to climate change falls upon them heavily as it may mean abandoning lifestyles to reducing their exposure. The hope is that enough resources are made available to provide assistance to them, but the success of efforts to lessen their vulnerability still rests upon their own initiatives.

Not all basis of action is practical. Our roles as stewards of this planet enjoin us to limit our emissions no matter how small they are. Yet ethics cannot identify what works well. Science is needed to translate motivation into tangible results.

Trees and Cows

Perhaps the most common response to climate change has been to plant trees. Reforestation and forest protection create carbon sinks, which are reservoirs that carry away CO_2 from the atmosphere. Tree planting improves the landscape and is also a simple way to reduce the Urban Heat Island effect, still the main cause of warming in expanding cities.

But there has been a tendency to overstate the importance of planting trees in greenhouse gas mitigation at the expense of more meaningful actions. Consider the 1994 estimate of Philippine per capita CO_2 emissions of 900 kg per year. How many trees should each Filipino plant to offset this amount? According to Lasco and Pulhin (2003), a hectare of tropical forest in active growth can sequester between 1 and 15 tons of CO_2 every year by turning the carbon into wood and roots. Assuming there are a thousand trees in one hectare, a fast-growing species can absorb as much as 15 kilograms a year. This means that each person in the country should plant *at least* 60 such trees every year. Today the number currently needed should be about 100 trees per year.

It is doubtful that a participant in tree-planting ceremonies comes near this number, or that enough land can ever be found to hold these new trees. If, as is the fate of most young saplings in the wild, a

tree is consumed by an animal, cut down, burned, or dies naturally and decomposes, the CO_2 returns to the atmosphere and the effort is negated. Planting a few seedlings is thus but a symbolic effort if done with the aim of offsetting greenhouse gases; protesting the cutting of a few old trees in the city has the same inconsequential impact on climate change. If such protests prevent the implementation of a road widening project that can improve traffic flow and reduce fuel consumption, then the actions can even become counterproductive. To the extent that it makes people believe it compensates for driving an SUV or wasting energy, planting a tree should be delisted as a highlight of environmental celebrations.

Beyond the usual exhortations to save water, energy and other resources, what then can ordinary citizens do that they have not heard before? A more meaningful gesture, according to ecologists, is to eat less meat. There are two reasons this helps. First, to get energy from an animal rather than directly from plants is to add another layer in the process of getting energy from the sun, life's ultimate source. Conventional wisdom states that each layer (or trophic level) consumes or wastes 90 percent of the energy it receives from the layer below it, leaving only 10 percent to be transferred to the next trophic level. In other words, humans could in theory live on 90 percent less land if they obtained their energy exclusively from plants rather than cows and pigs.

The other reason eating less meat is good for the planet is that cows and pigs produce methane, which is a much more powerful greenhouse gas than CO_2. A recent study (Eshel and Martin 2005) showed that the difference in the greenhouse gases emitted by an American eating a typical animal protein-rich meal and a vegetarian with the same calorie intake amounts to the same difference between the emissions of a small car and an SUV.

Perhaps this measure will mean less to the average Filipino, who survives on smaller meals and cereal-heavy diets. But domestic livestock production emitted more than 10 million tons of CO_2 in 1994, as much as our total industrial emissions. It was also 10 percent of our overall GHG contribution, even without accounting for the loss of forests that were converted to pastureland on which to raise livestock. Eating less meat is healthy for humans, and for the planet.

The need to understand the environmental consequences of food choices may well be just another one of many forgotten lessons scientists have suggested to protect the environment. But unlike planting trees, which will not have significant impact on global emissions except on an unrealistic scale, eating less meat can actually have significant impact. Scientists will need to draw upon the same sense of ethical responsibility that drives

people to plant trees and preserve nature if these and any measure requiring ordinary citizens to participate are to generate maximum results.

Strategic Roles

Many disasters in the Philippines have been difficult to forecast, but the aftermath has historically been predictable: outpourings of anguish, then charity, followed by blame. Occasionally a resolution towards stronger preparation will be forged, but very rarely will it translate to true readiness. Luckily, disasters rarely strike the same community twice in succession, but this rarity has only led to more complacency.

Communities that have adapted to different disasters have in common a recognition of the risks after being exposed to them for hundreds of years. The problem with climate change is that it threatens us with disasters with intensities and increased frequencies not over centuries, but over a few decades. Perhaps a quick succession of deadly disasters can reinforce the lesson of preparation, but there is certainly no need to see more suffering before preparations for climate change should begin.

The national government must play a lead role in such preparations to ensure that all levels of local governments get the message. This has been

assigned to the Presidential Task Force on Climate Change (PTFCC). In its Climate Change Response Action Plan, the Philippines commits to participate in global efforts to address global warming, but the country does so mainly for its own benefit. The success of its efforts will depend solely on how local stakeholders perform in their own roles.

For the moment, the country's minimal emissions do not bind industries to reduce their greenhouse gas emissions. In return, they should commit funds needed in implementing many components of the response to climate change. From funding research to study climate change and its effects, to assisting communities in developing warning systems, the private sector's involvement will be critical in filling in gaps in the capacity of the government and international funding agencies to support all the necessary actions.

Many non-government organizations are already deep into empowering various stakeholders to adapt to climate change. Like the media, they should continue to serve as the conduit between scientists and the communities they work with.

Lawmakers, from the national down to the barangay level, have the urgent task of developing laws and ordinances that will effectively turn the principle of reducing vulnerability and enhancing preparedness into enforceable procedures. To this end, they must

be united by a common concern for the public and the understanding of the science of disaster management. They must also review why, despite the abundance of laws to protect natural resources, human activity continues to be a bigger threat.

Provincial, municipal, and barangay leaders have the difficult task of putting into effect the new and existing laws. But beyond this usual role, they must expand the sharing of knowledge and experiences. Localities that receive a helping hand from their neighbors after suffering from a calamity have, in the past, given little back but their deep gratitude. That will no longer suffice in the coming age of disasters. Local governments must realize that the best way to thank those who help them in emergencies is to resolve to be more capable in the future, to learn from the event, and to teach others its lessons.

Higher level academic institutions should provide practical knowledge to the community around them by including climate change in their own research agenda. Schools in general are uniquely placed to teach new and coming generations of the urgency of preparing for the changes the Earth is undergoing.

Just as Philippine climate is changing, so must our missions, roles and relationships.