

CLIMATE CHANGE R&D AT THE WORLD AGROFORESTRY CENTRE (ICRAF)-PHILIPPINES¹

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1. INTRODUCTION

Climate change is one of the primary concerns of humanity today. It is considerably the greatest environmental challenge in the 21st century based on increasing scientific information in global warming. There are some possible serious implications of climate change, which include variations in the frequency and intensity of storms up to greater occurrence of climate-induced pests and diseases. The most recent Intergovernmental Panel on Climate Change (IPCC) assessment report concludes that there is strong evidence that anthropogenic influences have affected the world's climate (IPCC, 2001). The rise in global temperatures has been attributed to emission of greenhouse gases, notably CO₂ (Schimell, *et al.*, 1996). If current trends on human activities will continue, a 1°C increase in global temperature can cause current sea level to rise about 400 to 500 mm by year 2100 and flood coastal areas and key cities of the world and habitat changes can cause the extinction of some species of plants and animals (Chanton, 2001). Similarly, increases in precipitation have been experienced to cause floods and landslides, while decline may lead to droughts and forest fires. This range of effects and future possible consequences is the reason behind the global consensus and efforts to understanding and addressing the projected adverse impacts of climate change.

Forests play a critical role in climate change. The forest ecosystems can be sources and sinks of carbon (Watson, *et al.*, 2000). Deforestation and burning of forests releases CO₂ to the atmosphere. Indeed, land-use change and forestry is responsible for about 25% of all greenhouse emissions. However, forest ecosystems could also help reduce greenhouse gas concentrations by absorbing carbon from the atmosphere through the process of photosynthesis. Of all the world's forests, tropical forests have the greatest potential to sequester carbon primarily through reforestation, agroforestry and

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conservation of existing forests (Brown, *et al.*, 1996). This is stored in the biomass, soil and their products.

Philippine forest ecosystems have likewise been a source and sink of carbon (Lasco and Pulhin, 2004; Lasco and Pulhin, 2001). Since the 1500s, deforestation of 20.9 million ha of Philippine forests contributed 3.7 billion tons of C to the atmosphere of which 2.6 billion tons were released this century (Lasco and Pulhin, 2000). Of this amount, 70% (2.6 Gt) was released this century alone. However, present land-use cover also absorbs carbon through regenerating forests and planted trees. The vast areas of degraded land in the Philippines, in fact, offer great potential for carbon sequestration through rehabilitation activities such as reforestation and agroforestry.

The World Agroforestry Centre (ICRAF)-Philippines is heavily involved in climate change research and development (R&D). The objective of this paper is to present the current and future R&D activities of ICRAF on climate change mitigation and adaptation in the agriculture, forestry, and natural resources sector.

2. CLIMATE CHANGE MITIGATION PROJECTS

Climate change mitigation projects are those that help reduce the level of greenhouse gases in the atmosphere.

2.1. The Kalahan Forest Reserve

ICRAF with support from the International Fund for Agriculture Development (IFAD) is supporting the Kalahan Educational Foundation (KEF), a community organization in the Philippines, to market the environmental services they provide (Villamor and Lasco, 2006).

The carbon sequestration project will be implemented in a 900 ha grassland portion of the Ikalahan Ancestral Domain located in the provinces of Pangasinan, Nueva Ecija and Nueva Vizcaya, Philippines. The Ikalahan Ancestral Domain covers 58,000 ha of mountainous forest and farmlands from 50 to 1,717 m above sea level. The main strategy of the project will be community-based forest management. The key stakeholders of the project will be as follows: the Ikalahan-Kalanguya indigenous communities, local NGOs, the DENR, project monitoring team, and the funding organization.

All the project activities will be developed with the participation of indigenous communities in the project area. KEF will catalyze the community organizing and development process, manage and implement the project. The project monitoring team will quantify the carbon sequestered and assess the impacts of the project. The funding organization will provide the financial resources for the project.

The project has two major components: agroforestry and reforestation (A/R). The agroforestry component will involve the introduction of fruit trees to

existing upland farms (typically with annual crops such as corn and rice). Aside from its environmental benefits, fruit trees will also be able to provide livelihood for poor upland farmers. On the other hand, reforestation will target degraded areas that have been covered with grasses for many decades.

Only native species and those that have been introduced in the Philippines for the last 10 years will be used, with priority for those species already growing in and around the project area. For reforestation, the following species have initially been identified which are mostly indigenous Dipterocarp species, such as *Bischofia javanica*, and *Alnus nepalensis* observed to be favourable to wildlife. The fast growing species, *Alnus nepalensis* intended to rapidly establish vegetative cover in the area especially in highly degraded areas. Indigenous species will be planted in more favorable areas and underneath fast growing nurse trees.

The existing carbon stocks will be considered as the baseline and shall be assumed to be constant throughout the crediting period. This is in conformity to Dec.14/CP.10: "If project participants can provide relevant information that indicates that, in the absence of the small-scale afforestation or reforestation project activity under the Clean Development Mechanism (CDM), no significant changes in the carbon stocks within the project boundary would have occurred, they shall assess the existing carbon stocks prior to the implementation of the project activity. The existing carbon stocks shall be considered as the baseline and shall be assumed to be constant throughout the crediting period."

The grassland areas to be reforested have been historically covered with grasses at least since 1990 and are expected to remain so, even without the project activity. Thus, the project sites are expected to regenerate as they have for decades, at a level considered insignificant under the CDM. For cropland areas, a similar baseline situation applies. These areas have been under cultivation with annual crops for decades and are expected to be planted with annual crops.

The environmental service (carbon sequestration) to be provided by the project has been estimated in Figure 1 under three rates of growth scenarios. This simulation was done based on limited information on tree growth rates in the area plus other assumptions. The main purpose of the exercise was to assist the Kalahan indigenous people obtain funding for carbon sequestration service they could provide. For this purpose, the estimated carbon sequestration rates will suffice since the objective is to show potential buyers the expected range of benefits.

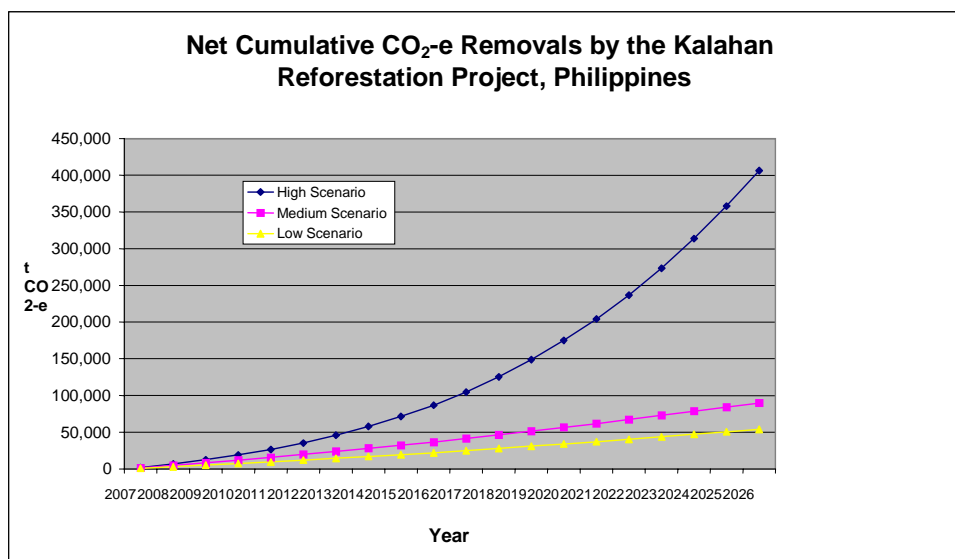


Figure 1. Estimated net cumulative CO₂-e removals by the proposed Kalahan Reforestation Project, Philippines.

2.2. Technical Assistance for Clean Development Mechanism (CDM) Projects

Under the Kyoto Protocol, developing countries (non-Annex 1 parties) can host projects that reduce greenhouse gases from the atmosphere through the Clean Development Mechanism (CDM). ICRAF provides technical assistance in the development of CDM Projects to various organizations in the Philippines such as the Laguna Lake Development Authority (LLDA) and Conservation International (CI).

The main objective of the LLDA project is to reduce greenhouse gases (i.e. CO₂) in the atmosphere while helping rehabilitate the Laguna Lake watershed and providing socio-economic benefits to the local people. It is expected that local communities will be the prime beneficiaries of the project. Farmers could benefit in at least two ways. First, by planting trees, they are expected to gain additional income from harvesting fruit trees. The income from fruit trees could be significant since the area is in close proximity to Manila, the largest market in the country. In addition, it is expected that farmers will benefit from the proceeds of the sale of carbon credits. The exact mechanism for this is still being discussed.

The project is being developed through a grant from the World Bank to LLDA and the local government units (LGUs) in the watershed. There is an existing World Bank watershed project being implemented by the LLDA. The basic idea is to superimpose production of carbon credits to the existing project components. An information campaign was conducted in the various LGUs to increase their awareness on the potential to gain carbon credits through their project activities. Initially, the municipality of Tanay was the first LGU to

develop A/R projects for carbon credits. The project has three components: steambank rehabilitation, ecological enhancement, and agroforestry.

For the Tanay watershed sub-project, the expected Greenhouse Gas (GHG) benefits were calculated using a high and low scenario. For the project period (2004-2014), the project will have total net carbon benefits of 3,204 tC (11,759 tCO₂-e) and 1,424 (5,230 tCO₂-e) under the high and low scenarios, respectively (Figure 2). The anticipated Total Emission Reduction Purchase Agreement (ERPA) value is US\$ 31,380 for the low scenario and US\$ 70,554 for the high scenario.

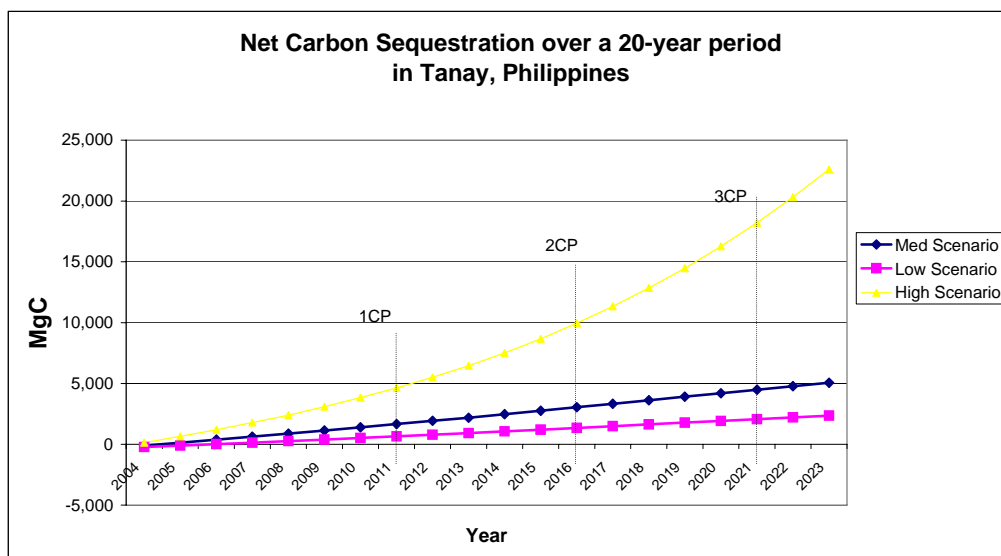


Figure 2. Net carbon sequestration under various scenarios of the LLDA project in Tanay, Rizal (Santos-Borja, *et al.*, 2005).

The proposed CI carbon sequestration project is part of its concerted efforts to build alliances with local communities, private sector, government agencies and Non-Government Organizations (NGOs) to facilitate the management of the Sierra Madre Biodiversity Corridor and strengthen enforcement of environmental laws. It uses a multifaceted approach to alleviate threats and to restore and protect 12,500 ha of land within the Corridor. The ultimate objective of the project is to demonstrate that a properly designed and implemented carbon offset project not only offers an economically attractive, risk-managed portfolio option, but also generates multiple benefits such as biodiversity protection, watershed restoration, soil conservation, and local income generation. It will also demonstrate that tradeoffs such as soil erosion, water table decrease, and loss of livelihoods can be avoided.

3. CLIMATE CHANGE ADAPTATION PROJECTS

As the climate changes, increasing attention is given to how societies can adapt to a new climate regime. Adaptation refers to adjustments in natural or human systems in response to observed or expected changes in climate stimuli, or their effects in order to alleviate adverse impacts or take advantage of opportunities (Adger, *et al.*, 2005; IPCC, 2001; McCarthy, *et al.*, 2001). It includes adaptation to present climatic condition.

ICRAF is involved in three climate change adaptation projects in the Philippines and Southeast Asia.

3.1. Tropical Forest and Climate Change Adaptation (TroFCCA)

TroFCCA is a four-year project of the Center for International Forestry Research (CIFOR) and the Tropical Agriculture Center for Research and Higher Education (CATIE). The main objective is to contribute to national processes of adaptation to climate change, in particular, and create efforts to mainstream adaptation into development policies.

The specific objectives of the project are as follows:

- Identify regional development issues related to climate change impacts over forest that can increase the vulnerability of the society;
- Develop specific methodologies to assess vulnerability;
- Contribute to current national and regional adaptation processes;
- Develop criteria and indicators for adaptive forest management;
- Develop policy-oriented adaptation strategies; and
- Facilitate a science-policy dialogue on adaptation.

The project operates in three regions: Central America, Southeast Asia and West Africa. All regions share the same project's general framework but each will develop their own methods on the basis of their respective regional contexts and prioritized needs. In the Philippines, water resources and landslides are the chosen priority topics. The first year of project implementation started this year.

The general approach of TroFCCA is shown in the following figure:

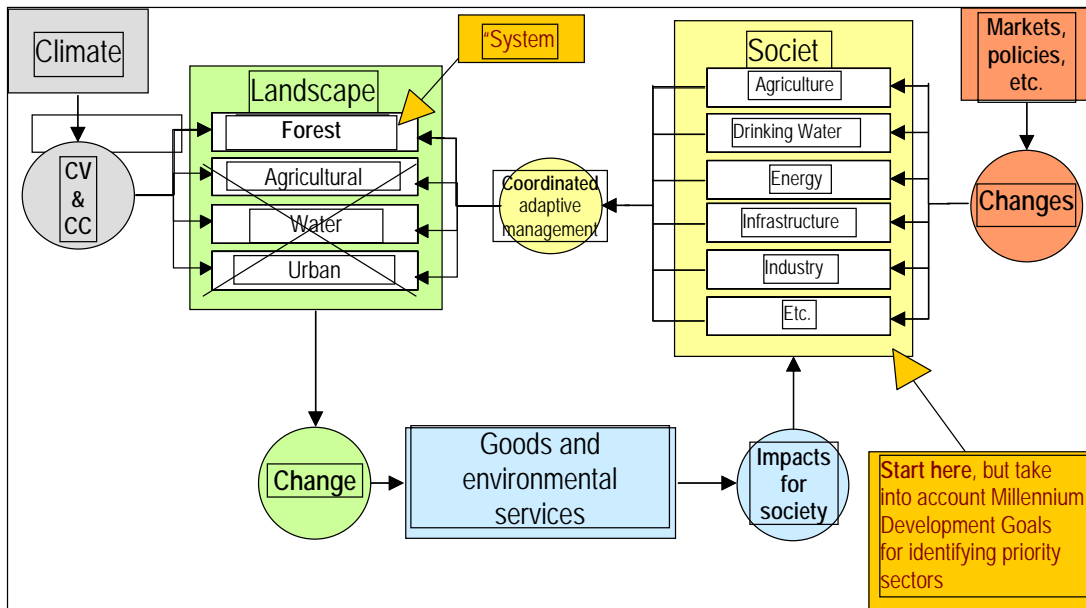


Figure 3. General approach of TroFCCA..

The methodology describes the actions to be undertaken and the tools to be used in order to assess vulnerability to climate change deriving from impacts over forests. After its application, the project team will be able to identify priorities for the development of policy-oriented adaptation strategies. The methodology has been designed to link vulnerability-related variables across different levels (policy, landscape, ecosystem and species levels), so that a streamlined assessment of vulnerability can take place. In other words, the methodology can be seen as a chain of elements, which starts from the policy development and returns to it with the idea of incorporating adaptation as a component of development. This is illustrated in the figure below:

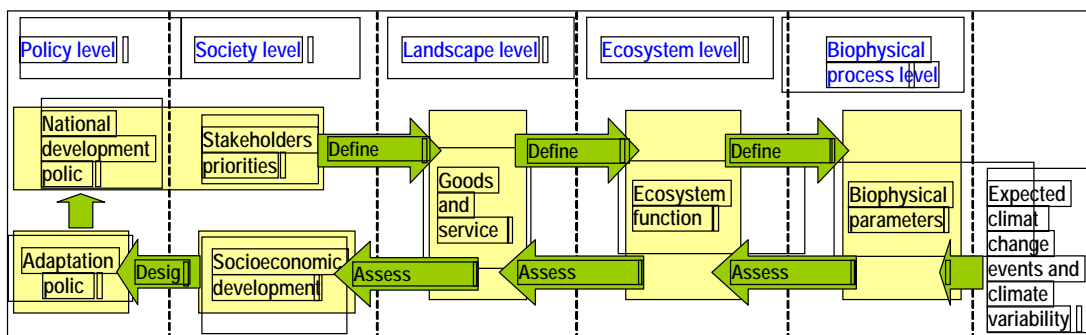


Figure 4. TroFCCA's Methodology.

Why TroFCCA?

- To explore the potential for innovative mechanisms to finance adaptation activities and compensate eventual trade-offs as a means for sustainability of adaptation strategies; and
- Promoting and encouraging involvement of government, and stakeholders through policy dialogues, as part of national processes of development and adaptation to climate change.

As of 2006, some simulation studies have been developed using Global Circulation Models (GCMs) for Southeast Asia and the Holdridge Lifezones. The results observed a shift of lifezone classifications into drier types of forests. However, there is a need to validate the results on what can really happen on-site.

Two approaches were used in assessing how far climate change has been integrated into major development plans and programs of the government. Relevant documents were initially reviewed, such as the Philippine Medium Term Plan and the Philippine Agenda 21, to determine whether and in what way climate change has been considered. In addition, sectoral plans and programs in the agricultural and forestry sector were also examined.

Key informant interviews were also conducted among people who are most active in the climate change discussion in the Philippines. This was used as a basis for making the list of attendees in the various national climate change meetings, conferences and workshops, including the project team. Figure 5 shows the profile of the respondents:

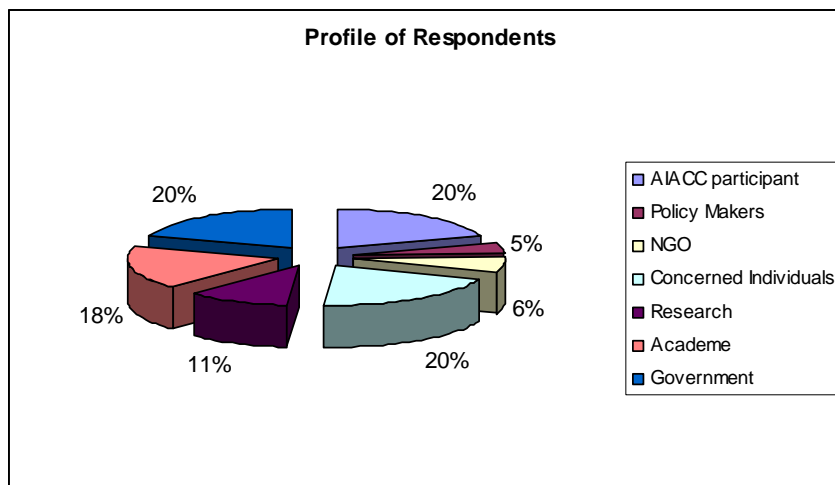


Figure 5. Profile of the respondents to key informant interviews.

A total of 64 respondents were interviewed either by telephone, fax, or actual face-to-face interview. Twenty percent of the respondents were government employees, 5% policy makers, 6% from non-government organizations, 20% AIACCC (An Integrated Assessment of Climate Change Impacts, Adaptation

and Vulnerability of Watershed and Communities in Southeast Asia) participants, 18% from the academe, 11% from research organizations and the remaining 20% were concerned individuals. There was a fairly even distribution of respondents from all sectors.

Baseline data on mainstreaming climate change into forest policies were also initially collected showing that people in the national sector recognized the importance of mainstreaming climate change in the country. The goal of the interview was to check for baseline information on some perceptions of the different organizations on whether climate change mainstreaming is important or not. 95.31% of the respondents said “yes” while the remaining said they had “no comment/lacks sufficient information”.

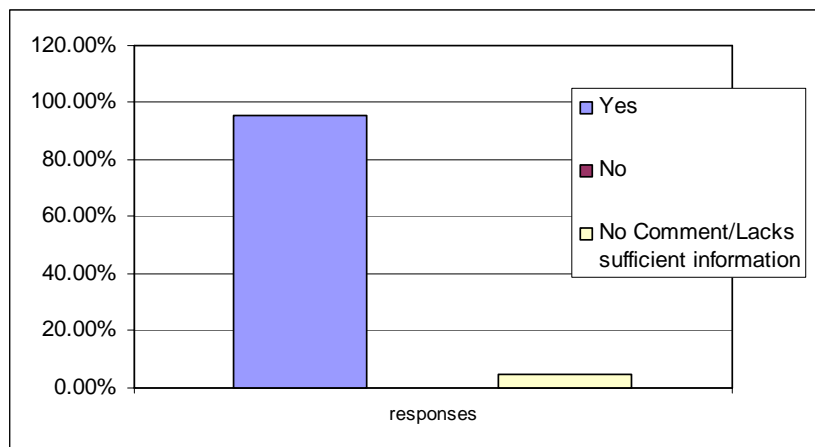


Figure 6. Perceptions on whether or not the respondents think mainstreaming climate change is important or not.

The next question was on whether or not they think climate change has been mainstreamed into Philippine policies or not. Fifty percent of the respondents said “no”, 28.13% said “no comment/lacks sufficient information” while the remaining 21.88% said “yes”.

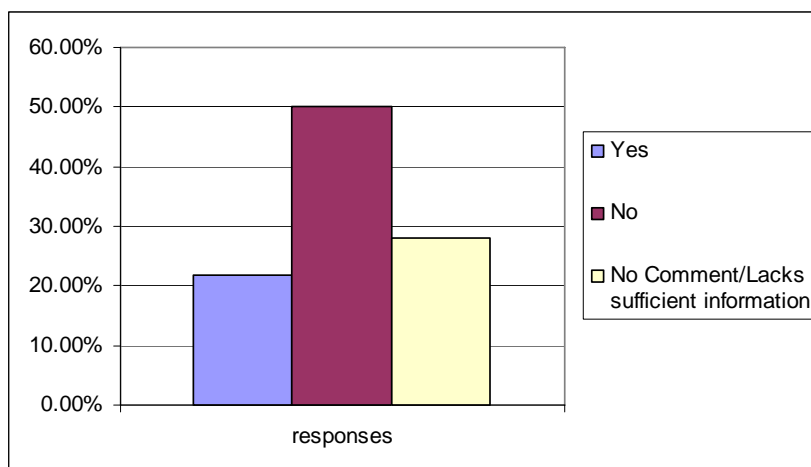


Figure 7. Perceptions on whether or not the respondents think climate change has been mainstreamed into Philippine policies or not.

It is interesting to note that when asked for reasons why they said “yes”, 1-advocacy of NGOs ranked the highest, 2-awareness, 3-availability of funds and 4-political will. There do exist policies (e.g. water act, clean air act, etc.) that include climate change into the picture “indirectly”, but there is a strong need to repackage this to focus more on the climate change issue.

More methodologies are currently being developed for the succeeding years of the project.

3.2. Climate Change and Sustainable Development Project

This project is supported by the Asia Pacific Network (APN), an intergovernmental body based in Japan. The general objective of the project is to clarify the links between climate change adaptation and sustainable development. Specifically, the project aims to:

- Synthesize research on adaptation strategies for climate change and climate variability in Southeast Asian countries;
- Analyze the links of adaptation strategies to the sustainable development goals of the respective countries;
- Hold a science-policy workshop to disseminate results and solicit recommendations; and
- Publish the results of the study in a format that is useful to policy makers and other stakeholders.

It will involve synthesis of climate change adaptation and related research in the Southeast Asian region. Recently, research studies have been completed on climate change adaptation in the natural resources and agriculture sectors in Southeast Asia (e.g., Global Change System for Analysis, Research and Training (START), AIACC project). In addition, studies have been conducted

on adaptation to climate variability and extremes (e.g., tropical storms). These results will be synthesized for each country to be able to identify the most promising adaptation strategies in the natural resources and agricultural sectors. In-depth review on issues of socio-economic development, policies on environmental protection and climate change adaptation will be conducted with focus on use of natural resources and agricultural practices. Vulnerable areas will be identified alongside with their existing challenges caused by climatic and institutional changes. Common problems in coping with climate impacts of the region will also be addressed and examined. The project team members will take charge of writing the synthesis papers for the Philippines, Indonesia, Vietnam, and Lao PDR.

For each participating country, the link of the most promising adaptation strategies identified above to sustainable development will be analyzed. For instance, the consistency of climate change adaptation strategies to national policies and development plans (e.g., Millennium Development Goals, Philippine Agenda 21; Medium Term Plan) will be analyzed. Scientists and policy makers of the countries involved will be interviewed and consulted on various issues related to climate change adaptation, environmental protection and socio-economic development to identify the appropriate links between climate issues and national development plans. Scientists from international organizations and institutions, whose works focused on the Southeast Asian region, will also be consulted.

At the end of the project, a science-policy workshop will bring together the policy community and the science community in the participating countries to discuss the appropriate climate change adaptation strategies and how they can be linked to the sustainable agenda of the countries involved. A key output will be policy recommendations to facilitate the mainstreaming of climate change adaptation to sustainable development planning.

3.3. Assessment of Impacts and Adaptation to Climate Change (AIACC)

In collaboration with the University of the Philippines Los Baños (UPLB), this study was designed to address the lack of scientific research on climate change impacts, adaptation and vulnerability of watershed resources and local communities in the Philippines, Indonesia and Indo-China. The main objectives of the study were to:

- Assess the impacts of climate change to water resources, forest ecosystems, and social systems of the watersheds;
- Conduct integrated vulnerability assessment of natural and social systems in the watershed areas;
- Develop adaptation strategies for natural water resources, forests ecosystems and social systems;
- Promote stakeholder participation in the research process;
- Contribute to peer reviewed literature; and
- Help build capacity of local scientists to conduct integrated assessment studies.

In the Philippines, the study was conducted in Pantabangan-Carranglan Watershed (PCW) in Nueva Ecija Province while in Indonesia, the study was conducted in Citarum Watershed in West Java.

The study also characterized the recent and future trends in rainfall and temperature along with land use and land cover including the associated patterns of streamflow. Description of recent trends was made using primarily available records of observed climatology and hydrology. To characterize future trends in climate, downscaling of regional GCM results was undertaken. CLUE-S model was used to project the likely land use scenarios while SEA-BASIN model was used to predict the future changes in streamflow resulting from changes in climate and land use and land cover. Furthermore, the study was also conducted through desk study (simulation modeling), survey and interview with a number of stakeholders (local government, electricity companies, water drinking state company and local community).

The study revealed that in Pantabangan-Carranglan Watershed in 2080, rainfall is projected to increase by as much as 12.7% and temperature to increase by more than 5% of the average observed daily values between 1960 and 1990 (Cruz, *et al.*, 2006). This change in climate could translate to about 17% increase in wet season streamflow and a decrease of around 35% in dry season streamflow of PCW. The increase in streamflow could lead to higher likelihood of floods in the service areas of Upper Pampanga River Integrated Irrigation System (UPRIIS) than it is at the present. Likewise, the projected decrease in streamflow of PCW during the dry season will likely increase the incidence of water shortage which could be aggravated by the increasing water demand due to increasing temperature. The projected changes in climate and the associated changes in streamflow patterns of PCW will likely have more serious impacts on the lowland farmers in view of the absence of deliberate program to reduce the vulnerability of the lowland farmers to floods and water shortages.

Furthermore, assessment of vulnerability of the watershed by land use with the aid of Geographical Information System (GIS) revealed that more than 65% of the entire PCW is moderately vulnerable to climate extremes and change while more than 25% is highly vulnerable. Most of the areas that are highly vulnerable are forests, grasslands and brushlands by virtue mainly of their location in steep and highly elevated areas and proximity to roads. Areas that are moderately vulnerable are largely grasslands, brushlands and forests.

Among the vulnerable places in PCW identified by the local communities themselves during Focus Group Discussions (FGD), include low-lying flood-prone settlement areas, agricultural areas prone to floods and droughts, dying streams/rivers, farmlands at the tail-end of irrigation canal, highly erodible areas (in steep slopes) along riverbanks, unstable areas with steep slope that support infrastructure, and grasslands and forested areas/plantations near roads and settlements susceptible to fire (Pulhin, *et al.*, 2006).

The project also studied the tradeoffs between climate change adaptation strategies in the water sector, forest resources, and local communities (Lasco, *et al.*, 2006). Several observations emerged as follows:

1. Adaptation strategies in one sector could have positive and/or negative impact in other sectors, i.e., trade-offs do exist. This implies that while sectoral analyses have their merits, they are not sufficient. A cross-sectoral analysis at the watershed scale should be done to reveal potential synergies and conflicts between sectors.
2. Cross-sectoral analysis of adaptation strategies will enable managers to anticipate potential conflicts early on. As we have shown, certain adaptation strategies could negatively affect other sectors. For example, reforestation may require more labor from farmers or increased expenditures by government agencies. If these effects are not considered, adaptation strategies may not be implemented at all for lack of cooperation by affected sectors. By considering these at the beginning, there will be greater opportunities of finding solutions.
3. It is possible to identify climate change adaptation strategies that could address more than one sector, thus enhancing synergy. A good example of this is tree planting/reforestation, which was identified as an adaptation strategy by all three sectors. By focusing on such strategies, conflicts are avoided. There is also a greater chance of stakeholder acceptance when all are convinced of the desirability of implementing common adaptation strategies.
4. Cost is the major limiting factor of adaptation strategies. The most common trade-off identified for all sectors is the additional cost that will be incurred in the implementation of adaptation strategies such as in the construction of a water-impounding structure or in tree planting. In developing countries such as the Philippines, priority for climate change adaptation is low. Adaptation strategies that meet other (“more important”) goals may have better chances of implementation. For example, reforestation and tree planting are on-going in the watershed, irrespective of climate change considerations.

Table 1 shows an example of a tradeoff matrix for cross-sectoral impacts.

Table 1. Analytical Matrix of Cross-Sectoral Impacts (Forest/Agriculture to Water, Institutions, and Local Communities).

Adaptation Strategy for Forests and Agriculture	Effect on Water Resources	Effect on Institutions	Effect on Local Communities
Use of early maturing crops	+ Lower water demand	0	+ Higher income
Use of drought-resistant crops	+ Lower water demand	0	+ Higher income
Supplemental watering	– Higher demand for water	– Increase cost of developing alternative sources of water	– Greater labor demand + Higher income
Proper scheduling of planting	0	– Increase cost for training, technical assistance, R&D	0
Soil and water conservation measures	+ Conservation of water	– Increase cost for training, technical assistance, R&D	– Cash expenses
Establishment of fire lines	+ More vegetative cover promotes good hydrology	+ Less expense for fire fighting	– More labor demand + Less damage to crops from fire; more income
Construction of drainage structures	+ Better water quality (less sediment load)	– Increase cost of implementation	+ Less soil erosion in the farm; greater yield
Controlled burning	+ Less damage to watershed cover	0	0
Tree planting	+ Better hydrology	– Increase cost of implementation	+ Steady supply of fuelwood – Less area for farm
Enhance community-based organizations	+	+ Better participation in the political process	+ Better participation
Total logging ban	+ More forest cover	– Increase cost of enforcement and protection	– Less income – Fewer sources of income
Use of appropriate silvicultural practices	+/- Could promote or impair hydrology depending on the practice.	– Increase cost of implementation	– Increase cost of implementation
Better coordination between LGUs	+ Promotes better watershed management	+ Greater collaboration among LGUs	+ Better delivery of services to farmers
Information campaign	+	+ Increase awareness and competence	+ Increase awareness and competence
Better implementation of forest laws	+ Promotes better watershed management	– Increase cost of implementation	+/- Could adversely affect current livelihood of farmers that are deemed “illegal”

Legend: (+) positive impact; (–) negative impact; (0) no effect; na not applicable. R&D, research and development.

4. SUPPORT PARTNERSHIPS AND FUTURE INITIATIVES

ICRAF is actively supporting partners in climate change R&D including policy formulation and capacity building. More recently, ICRAF was involved in training the Department of Environment and Natural Resources (DENR) staff in the technical evaluation of CDM forestry projects. It is also assisting NGOs in developing CDM projects.

The first author of this paper is also involved in the writing teams of the forthcoming IPCC Fourth Assessment Report and the IPCC 2006 Greenhouse Inventory Guidelines.

ICRAF also maintains future R&D initiatives in collaboration with the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD), Ecosystems Research and Development Bureau (ERDB), academe and state universities. There is a need to address the research gaps on climate change impacts and adaptation strategies in the country. The program proposal on “Climate Change Impacts and Adaptation Strategies on Natural Resources, Agriculture and Rural Communities in the Philippines” is currently in pipeline under the Department of Science and Technology (DOST) Environmental Agenda. This has been envisioned as a national research undertaking in climate change research in the agriculture, forestry and natural resources sector. The expected output will help provide the basis in formulating strategies and mitigating measures to address the impacts of climate change both at the national and community level.

The main objectives of the program are to:

- Assess the impacts of climate change to natural resources, agricultural production systems, and rural communities;
- Conduct integrated vulnerability assessment of natural systems, agroecosystems, and rural communities;
- Develop adaptation strategies for natural resources, agriculture, and social systems;
- Promote stakeholder participation in the research process; and
- Help build capacity of local scientists to conduct integrated assessment studies.

The program will involve the assessment of climate change impacts, vulnerability and adaptation strategies in all the three sectors: natural resources, agriculture and rural communities.

The first step will be assessment of climate change impacts on natural resources, agricultural production systems, and rural communities. Climate scenarios will be developed based on GCMs and with the aid of computer simulation programs such as MAGIC-SCENGEN. This will be followed by an assessment of the vulnerability of these sectors to climate change. Finally, on the basis of the potential impacts, adaptation strategies will be developed with the participation of the various stakeholders.

LITERATURE CITED

- Adger, W. N., N. W. Arnell, and E. L. Tompkins. 2005. Successful adaptation to climate change across scales. *Global Environmental Change* (in press).
- Brown, S., Sathaye, J., Cannel, M., and Kauppi, P.: 1996, 'Management of forests for mitigation of greenhouse gas emissions', Chapter 24 in R.T. Watson, M.C. Zinyowera, and R.H. Moss (eds), *Climate Change 1995: Impacts, Adaptations, and Mitigation of Climate Change: Scientific-Technical Analyses*, Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge and New York, Cambridge University Press, pp. 775-797.
- Chanton, Jeff. 2001. Sea Level Rise. Heart of the Earth Newsletter. Volume 1 Issue No. 3. 2001. at: <http://www.heartoftheearth.org/index.html>.
- Cruz, RVO., RD Lasco, JM Pulhin, FB Pulhin, KB Garcia. 2006. Assessment of Climate Change Impacts, Vulnerability and Adaptation: Water Resources of Pantabangan-Carranglan Watershed. AIACC Final Report. Environmental Forestry Programme, CFNR, UPLB, College, Laguna.
- IPCC. 2001. Third Assessment Report. Intergovernmental Panel on Climate Change (IPCC), Geneva, Switzerland.
- Lasco, RD, RVO Cruz, JM Pulhin, F.B. Pulhin. 2006. Tradeoff analysis of adaptation strategies for natural resources, water resources, and local institutions in the Philippines. Paper to be published in the AIACC adaptation synthesis book (*in press*).
- Lasco, R.D. and F.B. Pulhin. 2003. Philippine forest ecosystems and climate change: Carbon stocks, rate of sequestration and the Kyoto Protocol. *Annals of Tropical Research*.
- Lasco, R.D. and F.B. Pulhin. 2000. Forest land-use change in the Philippines and climate change mitigation. *Mitigation and Adaptation Strategies to Global Change Journal* 5: 81-97.
- Lasco, R.D., R.V.O. Cruz and F.B. Pulhin. 2001. The Kyoto Protocol: opportunities and threats to Philippine forestry. *J of Environmental Science and Management* 3: 53-63.
- McCarthy, J. J., O. F. Canziani, N. A. Leary, D. J. Dokken, and S. W. Kasey (Eds.). 2001. *Climate Change 2001: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the IPCC Third

Assessment Report. Cambridge, UK: Cambridge University Press, 1032 pp.

- Mouro-Costa, P.: 1996, 'Tropical forestry practices for carbon sequestration', in, A. Zchulte and D. Schone (eds), *Dipterocarp Forest Ecosystems: Towards Sustainable Management*, Singapore, World Scientific. pp. 308-334.
- Pulhin, JM, RJ Peras, RVO Cruz, RD Lasco, FB, Pulhin, and MA Tapia. 2006. Vulnerability of watershed communities to climate variability and extremes in the Philippines. Paper to be published in the AIACC vulnerability synthesis book (in press).
- Santos-Borja, A.C., R.D. Lasco and J. Morton 2005. Microwatershed enhancement through community participation: a pilot approach to carbon finance. Paper presented at the Workshop on Carbon Sequestration and Sustainable Livelihoods, held in Bogor on 16-17 February 2005. viii, 215p.
- Schimmel, D., Enting, I.G., Heimann, M., Wigley, T.M.L., Rayneud, D., Alves, D. and Seigenthler, U. 1995. 'CO₂ and the carbon cycle', in J.T. Houghton, L.G. Meira Filho, J. Bruce, H. Lee, B.A. Callander, E. Haites, N. Harris, and K. Maskell (eds), *Climate Change 1994: Radiative Forcing of Climate Change and an Evaluation of the IPCC IS92 Emission Scenarios*, Published for the IPCC, Cambridge University Press, Cambridge, pp. 35-71.
- Villamor, G. B. and Lasco, R. D. 2006. The Ikalahan Ancestral Domain, the Philippines. In: *Community Forest Management as a Carbon Mitigation Option*. Eds. D. Murdiyarso & Skutsch, M., Center for International Forestry Research, Bogor, Indonesia, pp. 43-50.
- Watson, R.T., I.R. Noble, B. Bolin, N.H. Ravindranath, D.J. Verardo and D.J. Dokken (eds): 2000, *Land Use, Land-use Change, and Forestry*, Published for the Intergovernmental Panel for Climate Change, Cambridge University Press, 377pp.