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Tradeoff Analysis of Adaptation Strategies for Natural Resources, Water Resources, and Local Institutions in the Philippines[1]

R. D. Lasco, R. V. O. Cruz, J. M. Pulhin, and F. B. Pulhin

1. Introduction

Climate change is one of the primary concerns of humanity today. The Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report (TAR) concludes that there is strong evidence that human activities have affected the world's climate (IPCC, 2001). The rise in global temperatures has been attributed to emission of greenhouse gases, notably CO_2 (Schimmell et al., 1995). 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.

Watersheds are critical to the economic development and environmental protection in the Philippines. More than 70% of the total land area lies within watersheds. It is estimated that no less than 1.5 million hectares of agricultural lands presently derive irrigation water from watersheds. There are between 18 and 20 million people inhabiting the uplands of many watersheds. Despite the tremendous value of the

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watersheds to Philippine economy and its environment, many watersheds are now in varying stages of deterioration. (Cruz et al., 1997).

The Pantabangan-Carranglan Watershed (PCW) is one of the most important watersheds in the Philippines. It supplies water for irrigation and power generation. It is also the home of thousands of people. Construction of the Pantabangan Dam was completed on August 1974. The man-made lake that forms part of the dam reservoir has submerged the old Pantabangan town and seven adjacent villages (Saplaco et al., 2001). All of the residents of the old town were resettled to the upper portion of Pantabangan. The families affected received land grants in place of their submerged lands. The government has poured livelihood projects to help the residents recover from the loss of their properties and to make the place productive (Pantabangan Master Plan 1998–2000). Several reforestation and soil erosion control projects have also been implemented over the years.

Our study assessed climate change impacts on and vulnerability of natural (forest, water) and social systems in the watershed. In addition, we identified potential adaptation options for these systems. This paper presents an approach on how to analyze sectoral adaptation options by looking at the trade-offs between them. The main target of this paper is policy makers at the local and national level in the Philippines. The approach proposed here requires minimal technical training and could be readily used by the target audience.

2. Problem Statement

Our main hypothesis is that specific sectoral adaptation strategies may complement or conflict with adaptation strategies for other sectors. Our study of a Philippine watershed focused on adaptation strategies for three sectors: forest/upland agriculture, water resources, and local communities.

Adaptation strategies for each sector have been identified through multisectoral consultation workshops, expert meetings, and focus group discussions. What is lacking is an analysis of how sectoral strategies reinforce or conflict with those of other sectors. For example, one of the adaptation strategies in the forest resources sector is reforestation or planting of forest trees in denuded areas. Such a strategy could lead to lower water yield and adversely affect water supply for power generation and irrigation. At the same time, tree planting activities may have positive effects on local communities (e.g., greater fuelwood supply).

This paper aims to conduct a cross-sectoral analysis of recommended adaptation strategies to determine potential synergies and conflicts between them. An attempt was made to identify “best bet” and “win-win” adaptation strategies based on the foregoing analysis.

3. Framework and Methods

3.1 Study site

This description of the study site below was partly based on the *Watershed Atlas of Philippine Watersheds* (Bantayan et al., 2000), as well as our own primary data collection activities.

The PCW lies between 15º 44’ to 16º 88’ north latitude and 120º 36’ to 122º 00’ east longitude (Figure 1). It is bounded in the north, northwest and northeast by the Caraballo Mountain Ranges, while the Sierra Madre Ranges bound the south, southeast, and southwest portions. The municipality of Pantabangan is about 176 km away from Manila, about 59 km away from Cabanatuan City, which is the capital of Nueva Ecija, and about 38 km away from the nearby city of San José.

The PCW belongs to Philippine Climatic Type I. This type has two pronounced seasons—dry from December to April and wet during the rest of the year. A small part of the watershed, especially those that are near the boundary of the subprovince of Aurora, falls under Climatic Type II, which is characterized by having no dry season with very pronounced maximum rainfall from November to January. Total annual rainfall from four rainfall stations ranges from 1,777 to 2,271 mm. Air temperature in Pantabangan-Carranglan Watershed from 1961 to 1999 is fairly uniform. The mean monthly temperature ranges from 25.7ºC to 29.5ºC.

Dominant wind direction occurring in the watershed is east to northeast with a speed of 2 meters per second (mps). The area experiences windy days from December to February. The watershed is within the typhoon belt, with most typhoons occurring between September and October.

The PCW has a complex land configuration. Topography ranges from nearly level, undulating and sloping to steep hilly and rugged mountain landscapes. The highest peaks are 1,650 and 1,410 meters above sea level, respectively. The PCW has a mean slope of 40%.

Soils at PCW are derived mostly from weathered products of metavolcanic activities and diorite. Surface soil textures are silty clay loam, clay loam to clay. Soils in the watershed are classified into four types, namely: the Annam, Bunga, Guimbaloan, and Mahipon. The Annam soil type is primarily a mountain soil derived from weathered igneous rocks. It is moderately deep from 50 to 130 cm. The dominant soil color is brown and clayey. This soil type is recommended for tree and forest crops. Guimbaloan soil occurs on moderately sloping or undulating and generally on hilly to steep hilly and mountainous relief. This type of soil is derived from basalt and metavolcanic materials. It is predominantly clayey with about 50 cm deep and well drained. The surface soil is dark clay to dark grayish brown with manganese concentrations. The Bunga soil type on the other hand occurs on a level to nearly collu-alluvial landscapes. The dominant color is dark gray brown with strong brown and light gray mattles. It has a clayey texture, with a depth of 147 to 155 cm and moderately well drained. Mahipon, which usually occurs on a level to nearly level collu-alluvial landscape, is derived from quartenary (one million) alluvial/tallus deposits and terrace gravels. The soil is clayey in texture but has a restricted internal drainage. It is moderately acidic.

As of 1999, the major land cover types in the PCW are natural forests (secondary), grasslands, reforestation areas, and A and D (alienable and disposable) lands (Figure 2). Of these, the grasslands occupy the largest portion followed by secondary forests). The forest cover in the watershed is predominantly secondary forest. Grazing and reforestation activities are conducted in open and grassland areas covered with cogon (*Imperatra cylindrica*) as predominant vegetation. Rice, vegetables, corn, cassava, onion and other agricultural crops are grown on cultivated lands (A and D, Integrated Social Forestry, and occasionally, grassland areas). Rice, onions, and vegetables are the primary crops raised on the lowland areas of the municipality of Carranglan. Most of the areas devoted for rice production are rain fed. Water pumped from well and run-of-the-river irrigate some areas for rice production. Other crops like banana, cassava, sweet potato, and corn are normally grown on swidden farms.

3.2 Identification of sectoral adaptation options

The Philippines AIACC project focused on three sectors in the PCW: forest resources (including upland agriculture), water, and local communities. Various methods were used to identify climate change impacts, vulnerability, and adaptation options. These include GIS analysis, computer modeling, household survey, focus group discussion, multistakeholder workshop, and key informant interview, which are summarized below (for details see Pulhin et al., 2005 for local communities; Cruz et al., 2005).

Key informant interviews were conducted to determine the services provided by PCW to its different stakeholders, the different climate variability, and extremes experienced in the area, its impacts, as well as the adaptation strategies developed to cope with the adverse effects. A structured interview schedule was developed to obtain the necessary information from the respondents. The informants were composed of government officials from different barangays or communities within the watershed, such as barangay captains, councilors, and secretaries, as well as representatives from different institutions in PCW.

Focus group discussion (FGD) was also done to seek from the participants the natural occurrences of climate variability and extremes that occurred in the PCW in the past 50 years, its impacts, and the adaptation strategies developed by the communities, and their recommendations to the different institutions that manage the watershed. The respondents were composed of representatives from various institutions concerned with PCW. The FGD was conducted through the use of various participatory rural appraisal techniques like historical and cognitive mapping.

A survey was conducted to determine the different strategies developed by the communities to cope with the impacts of climate variability and extremes, to assess the assistance provided by the different institutions present in the area, as well as the satisfaction of the communities, and solicit recommendations from the community people on how to improve the services given by the institutions. A structured interview schedule was used to gather the needed information from the respondents. The survey covered the four municipalities of the three different provinces encompassing the watershed. These are Pantabangan and Carrangalan in Nueva Ecija, Alfonso-Castañeda in Nueva Vizcaya, and Maria Aurora in Aurora. From a complete list of 36 barangays located in the watershed, 25 barangays were selected to constitute the sampling areas. A total of 375 respondents were randomly selected using the barangay records. This sampling technique employed was adopted from Chua (1999) which allows a 0.05 permissible error and 95% confidence interval level.

A major stakeholder's workshop was held in March 2004 at the Pantabangan watershed to validate initial results of the study, conduct consultations on climate change impacts on forests, water, and land use, and to solicit feedback from various stakeholders. Thirty participants coming from different organizations within the Pantabangan-Carranglan Watershed, particularly, the National Power Corporation, National Irrigation Authority, local government units, nongovernment organizations, and people's organizations were able to attend this workshop.

Most of the adaptation options identified are in response to climatic variability observed in the study site. This is from necessity, as the stakeholders were more familiar with these phenomena. There is thus an implicit assumption that adaptation options to climate variability could be applicable to the impacts of climate change. In addition, since the adaptation options were derived from local stakeholders, their applicability to other areas will have to be determined.

3.3 Tradeoff analysis of adaptation options

The concept of trade-offs is a basic principle in economics and arises from the idea that resources are scarce. As a general principle, trade-off analysis shows that for a given set of resources and technology, to obtain more of a desirable outcome of a system, less of another desirable outcome is obtained (Stoorvogel et al., 2004*a*). Although there can be win–win outcomes in two dimensions, even such a win–win must come at the expense of some other desired attribute.

Tradeoff analysis has been used in exploring the effects of change in land use, policies and scenarios in agricultural production systems in Ecuador and Peru (Antle et al. 2003; Stoorvogel et al., 2004*b*). In these studies, the researchers developed a simulation model called TOA (for trade-off analysis), which is a tool for an integrated analysis of trade-offs between economic and environmental indicators. The analysis to quantify these relationships was based on a multidisciplinary approach and used biophysical, as well as econometric process simulation models. It was also based on spatially explicit econometric simulation models linked to spatially referenced biophysical simulation models to simulate land use and input use decisions.

Another form of trade-off analysis was used in marine protected area management in West Indies (Brown et al., 2000). The approach developed in this study highlighted the objective of enabling decision makers to consider trade-offs between different criteria to evaluate alternative management options.

In this paper, we propose a less technically demanding approach in analyzing the trade-offs between adaptation options in various sectors, which policy makers and stakeholders can use as a first-order estimate. Specific adaptation options were initially analyzed individually by sectors (i.e., forest/agriculture, water resources, local communities/institutions), the results of which we reported earlier (Cruz et al., 2005; Pulhin et al., 2005). The adaptation measures were elicited from local stakeholders through consultation workshops, focus group discussions, and surveys, as described above. We analyzed trade-offs using matrices to show the positive and negative interactions between sectoral adaptation options. The positive and negative ratings were based on the researcher's judgment. Mitigation measures were identified to minimize or eliminate adverse impacts. Adaptation strategies common to all sectors were also identified.

4. Results and Discussion

4.1 Sectoral adaptation options

4.1.1 Forest resources and agriculture

Table 1 shows the recommended adaptation options to climate arising out of a multistakeholder workshop conducted by the research team in the watershed. These adaptation options focus on: use of appropriate species/crops, scheduling, technical innovations (e.g., water conservation), capacity building, and law enforcement. The range of adaptation options identified by participants suggests that there is a high degree of awareness on how to adjust to climate variability and extremes. These could provide solid building blocks for future climate change adaptation.

In general, the adaptation options identified are consistent with those recommended in the Philippines Initial National Communication (1999) and the IPCC TAR (2001).

4.1.2 Water resources

A wide range of adaptation options to climate variability and extremes has also been identified by workshop participants for water resources (Table 2). These include water conservation practices, choice of crops/species, technical innovations, alternative, and livelihood options.

4.1.3 Social and institutional

The institutional adaptation strategies to current climate variability and extremes are as varied, if not more so, than the forest/agriculture and water resources (Table 3). Interestingly, local government units (LGUs) seem to have been more responsive to climate variations, as is reflected in the long list of adaptations they have.

4.2 Tradeoff analysis of adaptation options

4.2.1 Effects of adaptation strategies for forests and agriculture

The effects of adaptation strategies for forests/agriculture on water resources are generally positive (Table 4). This suggests a very synergistic relationship between adaptation for forest/agriculture and water. In contrast, adaptation strategies for forests/agriculture have mixed effect on the various institutions in the PCW. Most of the adaptation strategies recommended require additional investments. Under tight budget constraints of many Philippine agencies, this could pose a significant hurdle to the implementation of the recommended strategies. Likewise, the effects on local communities are mixed. In some cases, there are positive effects and quite the opposite in others. For example, it is possible for farmers to obtain higher yield and income as a result of adaptation options such as the use of appropriate crop varieties. However, some adaptation activities such as supplemental watering could require more labor.

Adaptation strategies for the forest/agriculture sector could be prioritized on the basis of their effects on other sectors (in addition to their effectiveness in forestry/agriculture). In general, those that have positive effects on other sectors should receive higher priority, while those that have negative effects could be mitigated if possible.

Among technical adaptation strategies, the use of early maturing crops and drought-resistant crops have the most positive effects on other sectors. The establishment of fire lines has also a generally positive effect but requires more labor time to establish. Similarly, social adaptation strategies (e.g., community organizing) have positive effects on the other sectors.

For most of the adaptation strategies there are clearly trade-offs in that there are both positive and negative effects on other sectors. In many cases, the negative effect is the additional cost required to be able to implement adaptation strategies. This hurdle may prove daunting, considering the lack of resources of many Philippine government and nongovernment agencies.

4.2.2 Effects of adaptation strategies for water resources

Adaptation strategies for water resources have overwhelmingly positive effects on forest and agricultural crop production (Table 5). This is understandable considering that proper water management is essential to crop growth and development. Consequently, farmers are expected to have greater income if adaptation strategies for water are implemented. On the other hand, the effect on institutions is mainly negative in the sense that they will incur more expenditures, as many of the adaptation strategies require some reengineering, retooling, increase provision of training, technical assistance, and other related services. This implies that in the face of limited financial resources, adaptation strategies for water may not be implemented fully. One possible approach is to determine the costs of recommended adaptation options to know which are affordable given current budget constraints of those who will implement them.

4.2.3 Effects of adaptation strategies for institutions

Adaptation strategies identified by various institutions have generally positive effects on the other sectors (Table 6). This shows that the identified strategies are holistic in nature. Of course, the underlying assumption is that financial resources are available to implement these strategies, which is the major constraint identified above. There are a couple of exceptions to this. First, stricter enforcement of forest protection rules could adversely affect farmers with no clear land tenure instruments. Many farmers in the PCW are informal settlers, and forest protection officers could compel them to leave their farms. Second, the release of water in the Pantabangan Dam to prevent overflow could lead to flooding in downstream communities.

Overall, most of the adaptation strategies identified for all sectors have mixed effects (both positive and negative). This suggests that in most cases, adaptation strategies are not neutral; that is, they could affect other sectors both positively and negatively. Thus, a cross-sectoral analysis should be done at the watershed scale to ensure that negative effects are anticipated and mitigated before the implementation of adaptation strategies.

4.2.4 Common adaptation strategies among all sectors

Three adaptation strategies are common to all the sectors: tree planting/reforestation, selection of appropriate species/crops, and better implementation of laws (Table 7). The results reflect the high degree of consciousness of stakeholders on the importance of forests in the watersheds. A number of adaptation strategies were also identified by two sectors. For example, the use of soil and water conservation strategies was explicitly identified in the forest and water sectors and was also implied in the institutional sector. These suggest that individual adaptation strategies could address more than one sector, allowing for greater synergy and cost-efficiency.

4.2.5 Quantification of trade-offs

The approach used in this study is qualitative. Succeeding studies may wish to quantify trade-offs in adaptation strategies between sectors. Some indications of the financial trade-offs are discussed below.

Although reforestation has been identified as a desirable adaptation strategy by all sectors, the trade-off to institutions that will finance it may be quite high. In the Philippines, the official cost estimates of the Department of Environment and Natural Resources (DENR) for reforestation is about U.S.$900 per ha for three years (DENR, 1999). Such level of investment may prove limiting for those organizations that would bear the cost of reforestation such as the National Irrigation Administration (NIA), National Power Corporation (NPC), and the DENR. One possible mitigating measure is to explore more community participation to lower the labor cost, as it is the biggest fraction (about 70%) of the total cost of reforestation.

Another adaptation strategy identified by stakeholders as part of forest/grassland fire prevention in the watershed is fire line construction. This strategy entails less cost than reforestation (about U.S.$20/ha). Although it is typically part of reforestation work, it can be constructed separately.

Other adaptation options have even less cost. For example, proper scheduling of planting to coincide with the late or early onset of the rainy season involves practically no financial cost to farmers and institutions. And yet the effect of farm yield and income could be very high.

4.2.6 Presenting the results to policy makers and local stakeholders

One way of visually presenting the results of the study in a nutshell to policy makers is shown in Figure 3. The chart summarizes the impacts of adaptation strategies in one sector to other sectors. In this way, the potential synergies and conflicts are immediately captured. For example, adaptation measures in water resources have mostly positive effects on forests and agriculture. These include tree planting and provision of irrigation water, which directly benefits forestry and agriculture. However, adaptation in water resources will have a largely negative effect on institutions. This can be attributed to the high cost of many of the adaptation measures identified, such as construction of shallow tube wells and impounding structures (Table 2). On the other hand, the effect of adaptation measures in forest resources and agriculture to local communities is mixed; that is, some are positive whereas some are negative. For example, use of more resistant varieties could lead to higher incomes but establishment of fires lines mean higher labor cost.

Through this figure, policy makers and stakeholders will be able to flag which adaptation measures need special attention and further study. Those with negative interactions could also be prioritized for quantitative analysis of trade-offs.

4.3 Management and policy implications

The foregoing discussion has several management and policy implications in the design and implementation of climate change adaptation strategies in Philippine watersheds.

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 ongoing in the watershed, irrespective of climate change considerations.

5. Conclusions and Recommendations

Adaptation strategies in one sector could have positive and/or negative impacts on other sectors. Negative impacts should be mitigated and positive impacts enhanced. We have shown that cross-sectoral analysis of adaptation strategies should be employed at the watershed scale to maximize synergy and minimize conflicts.

Our study qualitatively assessed the trade-offs and cross-sectoral impacts of climate change adaptation strategies in watersheds in the Philippines. Future research could focus on quantifying the trade-offs between sectoral adaptation strategies. Moreover, the results of the study could be validated in a stakeholder forum similar to the ones that resulted to the sectoral adaptation strategies we presented here.

As mentioned earlier, the study elicited adaptation options to observed climatic variability from various stakeholders. The assumption is that these adaptation options will also apply to the impacts of climate change. For example, general circulation models project that the Philippines will have higher rainfall as a result of climate change. The adaptation options identified here for La Niña events would likely be useful under an increased rainfall scenario. In spite of this limitation, the paper's usefulness is not diminished because its primary objective was to demonstrate an approach in helping policy makers think through the trade-offs involved in implementing adaptation options to climate change.

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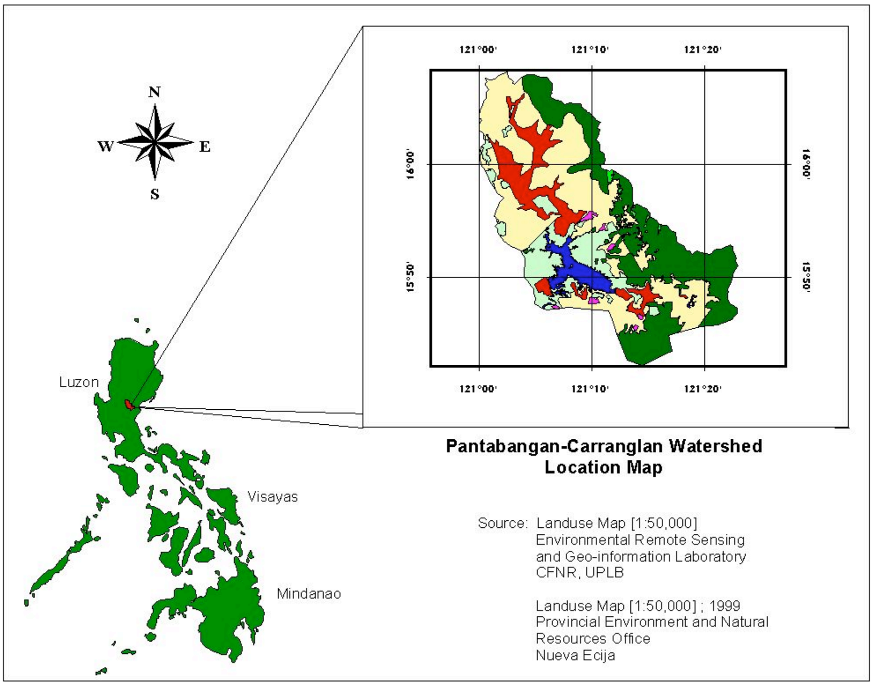

Figure 1. Location map of the Pantabangan-Carrranglan Watershed

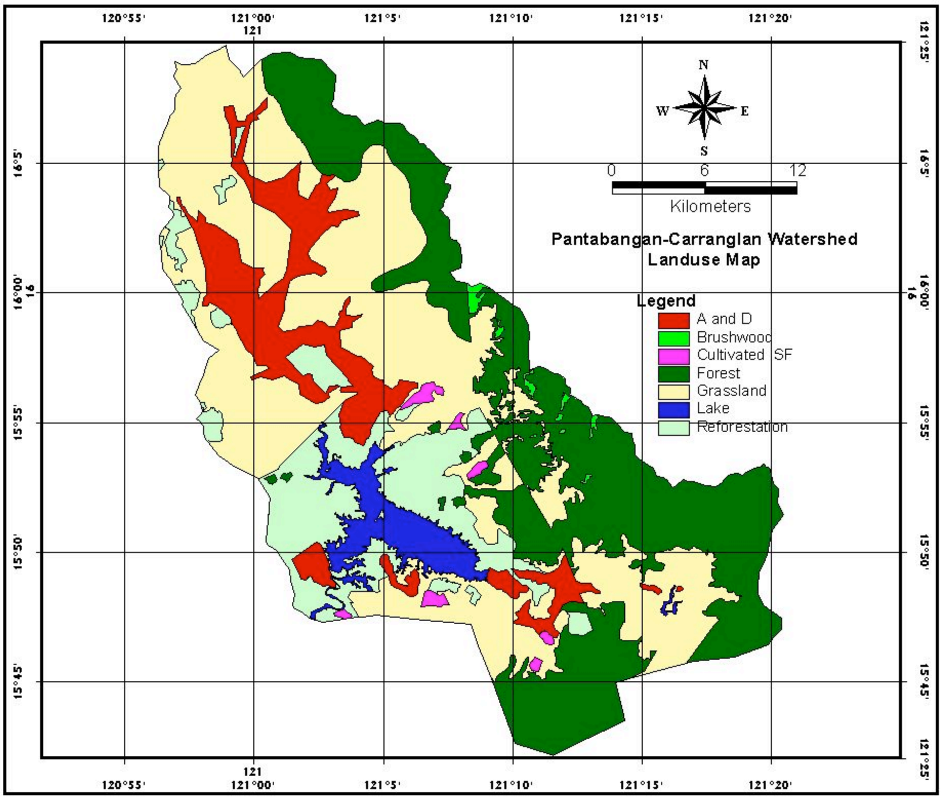

Figure 2. Land use map of the Pantabangan-Carranglan Watershed, Philippines

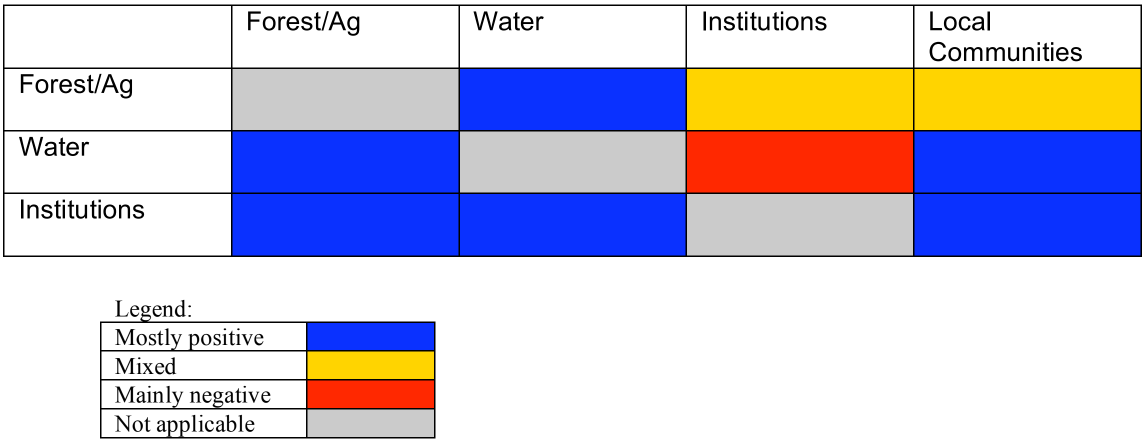

Figure 3. Summary of effects of adaptation strategies in one sector to other sectors.

Table 1. *Adaptation Options to Climate Variability and Extremes for Agriculture and Forest in the PCW, Philippines*

Land Use	Adaptation Options
Lowland farms	Late rains: • use of short-term varieties (early varieties) • shift to drought-resistant crops • use of adaptable species • supplemental watering Early rains • installation of SWIP
Upland farms	Use of appropriate variety of planting materials Shift to more tolerant crops Use of drought-resistant crops Use of prescribed fungicides/pesticides Installation of fire lines Strict implementation of forest laws Adoption of modern method of farming suited for upland (e.g., SALT) Visibility of enforcement agencies to the area Delay of planting
Tree plantation	Adjust silvicultural treatment schedules Plant species that can adjust to variable climate situations Proper timing of tree-planting projects or activities Implement proper silvicultural practices Construction of fire lines Control burning Supplemental watering
Grasslands	Supplemental feeding of dependents Reforestation-adaptation of SALT method of farming in combination to organic farming Promote ISF or CBFM Increase funds for forest protection and regeneration from national government Increase linkage building of LGU-GO-NGO Introduction of drainage measures Control burning Introduction of drought-resistant species Intensive information dissemination campaign among stakeholders
Natural forest	Safety net measures for farmers by local and national government Coordination between local government units Cancellation of TLA

Source: Multistakeholder workshop, 2004. SWIP: Small Water Impounding Project, definition; SALT: Sloping Agricultural Land Technology, definition; ISF: Integrated Social Forestry, definition; CBFM: Community-Based Forest Management, definition; LGU-GO-NGO: Local Government Unit-Government Organization-Non-Government Organization, definition; TLA: Timber License Agreement, total logging ban.

Table 2. *Adaptation Options to Climate Variability and Extremes for Water Resources in the PCW, Philippines*

Climate Variability	Adaptation Options
General	Adaptation of SALT method of upland farming Implementation, intensification of reforestation program Strict implementation of forest laws

	Programs and research ground water for the household More funds from national and local government Potable water is needed (more deep wells in each village) Construction of small water impounding project (SWIP) Cloud seeding Introduction of water conservation measures (SWIP, SWIS, STW) Stabilization of watershed
Water shortage	Use of shallow tube wells Planting of new varieties of rice (i.e., Gloria rice) and other crops with less water requirements Rotation method of irrigation Use of shallow tube wells Scheduling (rotation method) of irrigation is being implemented Planting early maturing varieties of crops and vegetables Use the direct seeding method, which requires less water Use of other water sources (i.e., from the Atate River and Penaranda River, which are connected directly to the irrigation main canal)
Floods	None (wait for the next cropping season to cope) Repair the damages Close the main canal if possible Switch to other crops that can sustain floods and heavy rainfall Explore other livelihoods (swine production, squash, and saluyot farming, canton (noodle) making and fruit juice making) through Farmers' Business Resource Cooperative Construct fish ponds in the flooded area Switching to early maturing varieties of crops (i.e., from palay to corn). Attend seminars and trainings conducted by stakeholders about crop production

Source: Multistakeholder workshop, 2004. SWIS: Small Water Impounding System, definition; STW: Shallow Tube Well, definition.

Table 3. *Adaptation Strategies of Different User-Institutions to Minimize the Negative Impacts of Climate Variability and Extremes*

Institutions	**Adaptation Strategies**
National Irrigation Administration	Reforestation Forest protection (campaign) Physical rehabilitation Letting go freely of excess water from the reservoir/dam especially in rainy season when the dam is overflowing to avoid flooding
Department of Environment and Natural Resources	Reforestation Forest protection (fire brigade) Adjustment in schedule of program implementation/prioritization Monitoring Shading of seedling in reforestation sites Deploying of forest guards to patrol the forest Planting of fire breaks Information, education, and communication Hiring of additional manpower, especially of casual laborers Adjustment in program prioritization Integrated Social Forestry Program
National Power Corporation	Reforestation Information, education and communication Proper choice of species Adjustment in schedule and implementation
Local Government Unit	Tree planting and reforestation Provision of relief goods Information, education, and communication, information dissemination and conduct of seminar on proper farming, and house visits, especially during typhoon season Creation of task force El Niño/La Niña, formation of disaster brigade Planned action to be taken to avert current and destructive effects of El Niño and La Niña Diversion of program to other urgent problems and adjustment in program schedules Bridge development, hanging bridge construction Repair, development, construction, and maintenance of roads (including the DPWH), development, and road construction Provision of solar dryer, multipurpose pavement for drying palay Free medicines Hiring of extension worker especially *barangay* health worker Request for free seedlings from Department of Agriculture Helping people in evacuation centers Repairs of deep well and canals Rehabilitation of destroyed infrastructure and reporting it to the DPWH Relay information about the status of the barangay after a calamity to the municipal government Visits by Barangay Tanod to the community to help with their problems Small organizations that buy palay (rice) at higher prices and sell rice at lower prices Training of PO Digging possible water sources for irrigation, spring or deep diverting the flow of water from the river into the direction of the people farm fields Diverting the flow of water from the river into the direction of the people farm fields through the help of Barangay Tanod Spring development, formulation and implementation of SWIP, provision of additional water tank, pump and hose, finding other sources water sources, deep-well construction and dissemination of water distribution schedules.

Source: Pulhin et al., 2005. DPWH, Department of Public Works and Highway; PO, People's Organization.

Table 4. *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 conservation of water	+ Better participation in the political process	+ Better participation
Total logging ban	+ More forest cover	– Increase cost of enforcement and protection	– Less income from timber – 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 Local Government Units	+ Better delivery of services to farmers
Information campaign	+ Better conservation of water	+ 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.

Table 5. *Analytical Matrix of Cross-Sectoral Impacts (Water to Forest/Agriculture, Institutions and Local Communities)*

Adaptation Strategy for Water Resources	Effect on Forest Resources/ Agriculture	Effect on Institutions	Effect on Local Communities
Reforestation/AF farming	+ Greater tree cover	– Higher investment cost	+ More income
Soil and water conservation measures	+ Increased yield	– Higher investment cost	+ More income
Water impoundment	+ Increased yield	– Greater expenses	+ More income – Greater expenses
Well construction	+ Increased yield	– Greater expenses	+ More income – Greater expenses
Cloud seeding	+ Increased yield	– Greater expenses	+ More income
Use of appropriate crops/varieties	+ Increased yield	– Greater expenses for R&D, TA, IEC	+ More income
Irrigation management	+ Increased yield	– Greater expenses for implementation	+ Increased income
Tap other water sources (e.g., rivers)	+ Increased yield	– Greater expenses	+ Increased income
Fishponds in flooded areas	+Decreased pressure on forests and agricultural resources	– Additional expenses for TA	+ Increased income – Greater expenses
Repair of damaged infrastructure	0	– Greater expenses	0
Shift in livelihood	+ Less use of land	– Additional expenses for TA, training	+ Increased income
Strict implementation of forest laws	– Could affect crop production in areas deemed for forest	+ Strengthen role of regulatory agencies	+/– Promote peace but possibly lower income
Research on ground water	0	– Greater expenses for R&D, TA, IEC	0
Capacity building activities	+ Build up of mass of competent players	– Greater expenses for R&D, TA, IEC	+ Build up of mass of competent players

Legend: (+) positive impact; (–) negative impact; (0) no effect; na not applicable. IEC, information, education and communication; TA: Technical Assistance, .definition.

Table 6. *Analytical Matrix of Cross-Sectoral Impacts (Institutional to Forest/Agriculture, Water, and Local Communities)*

Adaptation Strategy for Institutions	**Effect on Forest Resources/ Agriculture**	**Effect on Water Resources**	**Effect on Local Communities**
Reforestation	+ Increased tree cover	+ Better watershed cover	+ Source of fuelwood/ tree products
Forest protection	+ Reduce forest destruction	+ Better watershed cover	+/– Could affect source of forest products
Physical rehabilitation	0	0	+ Better facilities
Release of water from the dam	0	0	– Flooding in low-lying areas
Adjustment of schedule	0	0	0
Fire break establishment	+ Reduced fire loss	+ Better watershed cover	+ Reduced fire loss
Community-based management	+ Better forest land management	+ Better watershed cover	+ Empowerment of local people
Development of water sources	+ Increased crop yield	+ Stable water supply	+ Increased crop yield
Hiring additional personnel	+ Better forest protection	+ Improved water quality and regimen	+ Additional sources of income
Proper choice of species	+ Increased yield	0	+ Increased income
Provision of relief goods	+ Reduction of pressure on forest and agricultural resources	+ Reduction of pressure on water	+ Relief goods supplied
Creation of task forces	+ Better coordination	+ Better coordination	+ Better coordination
Infrastructure repair and construction	+ Increased farm yield	+ Stable and more efficient water supply	+ Increased income
Information, education, and communication	+	+	+
Training of People's Organization	+ Better forest/farm management	+ Better water management	+ Skills developed

Legend: (+) positive impact; (–) negative impact; (0) no effect; na not applicable.

Table 7. *Degree of Similarities in Adaptation Strategies Among All Sectors*

Adaptation Strategy	**Forest/Agriculture**	**Water**	**Institutions**
Tree planting/ reforestation	X	X	X
Selection of appropriate crops/varieties	X	X	X
Better implementation of forest laws	X	X	X
Soil and water conservation measures	X	X	
Establishment of fire lines	X		X
Construction of drainage	X		
Controlled burning	X		
Enhance community-based organizations	X		X
Total logging ban	X		
Appropriate silvicultural practices	X	X	
Better coordination between LGUs	X	X	
Information campaign	X	X	X
Water impoundment		X	
Well construction		X	
Irrigation management		X	
Cloud seeding		X	
Develop other water sources		X	X
Research		X	
Capacity building		X	X
Release of water from the dam			X
Adjustment of schedule			X
Additional personnel			X
Provision of relief goods			X
Creation of task forces			X
Infrastructure repair and construction			X