Environmental Consequences of Lahars, Subsidence, and Human Behavior in Bacolor, Pampanga*

Kelvin S. Rodolfo and Kathleen S. Crittenden

Illustrious, centuries-old Bacolor was the town worst hit by lahars (flowing slurries of volcanic debris and water) following the 1991 Mt. Pinatubo eruption and lasting until 1995. Drawing on a 1996 community survey, official and unofficial censuses of town residents, extended field research in the town proper, and ongoing research on regional subsidence, and human responses to them have transformed Bacolor's physical and social environments, and the implications of these changes for the future of the town.

Most of the outlying *barangays* were totally destroyed and abandoned, and the national government decided to sacrifice the town by enclosing it in a debris basin with dikes in order to protect other communities. Several hundred families in the town proper ignored government orders to leave in 1992, 1994 and 1995, and raised their houses several times between lahar attacks that collectively left deposits more than 6 meters thick. In 1995, declaring the town unsafe, the national government denied it clearance for private reconstruction bank loans and public funds to rehabilitate infrastructure. With little outside help, the families that stayed, municipal government, the parish priest and civic institutions rebuilt the water system, an elementary school and two churches. The decision of the local technical college to remain open greatly helped the town to survive.

Ironically, the elevation of the Bacolor surface has reduced its vulnerability to lahars and increased the threat to the unaffected adjacent communities. Furthermore, Bacolor is now immune to flooding that is increasingly inundating neighboring towns. The worsening floods are caused primarily by over-consumption of groundwater for domestic use, agriculture, and aquaculture. Reduction of potential residential areas by flooding and the growing Pampanga population inevitably target Bacolor as a large residential town. However, pride in Bacolor's past, the desire to return it to pre-eruption conditions, a survival mentality, and lack of vision and resources may hinder realization of the town's maximum potential. Bacolor urgently the national government and philanthropic agencies to give financial and technical support for comprehensive, community-wide planning to reconstruct the town as a disaster-resistant community in harmony with its natural environment.

* An earlier version of this report was presented at the Cities on Volcanoes 3 Conference in Hilo, Hawaii, in July 2003.

INTRODUCTION

Mount Pinatubo is a volcano in Pampanga, Tarlac, and Zambales provinces on the Philippine island of Luzon (Fig. 1A). Its 1991 eruption, the world's most powerful in 89 years, left 5 to 7 cubic kilometers of loose debris on the volcano flanks. Huge amounts were remobilized into flowing slurries called lahars during strong monsoonal and typhoon rains in the following five years. Flowing down rivers to the plains, the lahars escaped from channels and buried towns in volcanic debris as thick as nine meters.

Bacolor, a municipality in Pampanga province, has suffered most from the lahars. Here, we describe how several years of recurrent lahars and human responses to them have transformed its physical and social environments, and the implications of these changes for the future of the town. We draw upon a 1996 community survey of women from Bacolor (Lamug et al. 1999a), official and unofficial censuses of town residents, interviews with town leaders, and other information gathered during extended annual stays in the town proper beginning in 1998 (Crittenden 2001, Crittenden and Rodolfo 2002). Another important source of information is the ongoing research of Siringan and Rodolfo (2003, Rodolfo et al. in press) on regional subsidence and worsening floods in the low-lying plains that border northern Manila Bay.

Physical setting

Bacolor is 65 km north-northwest of Manila and 36 km east-southeast of the Pinatubo summit (Fig. 1A). Volcanic debris and lahar deposits of previous eruptions have left a gently sloping apron east and south of Mt. Pinatubo. Immediately downstream of Bacolor, the apron merges into the swamps at the head of Manila Bay. The volcano is quiescent for centuries between eruptions. The previous eruption occurred sometime between 500 and 800 years ago (Newhall et al. 1996), and so the people around the volcano had little or no knowledge of eruptions.

Bacolor is located along the east bank of the Pasig-Potrero river system, which begins on the Pinatubo flanks 800 meters above sea level, and flows down to the gentle slopes of the volcano apron and into a maze of shallow channels on the low-lying delta complex of the Pampanga and other rivers. Over many centuries, the swampy region has been greatly modified into rice paddies and fishponds, and since pre-Hispanic times has been a major producer of rice and cultured fish. This pre-Hispanic town developed and thrived primarily because its proximity to the river provided domestic and agricultural water, fish, and transport. It also stood slightly higher than the surrounding flats; the name Bacolor derives from *macabaculud*, meaning "high place surrounded by lowlands". The delta experiences severe floods during the rainy season that typically lasts from June through October. Despite Bacolor's small height above the flood-prone neighboring towns, it historically also has been subject to seasonal flooding. In the 1960s, dikes 13 kilometers long were built along the

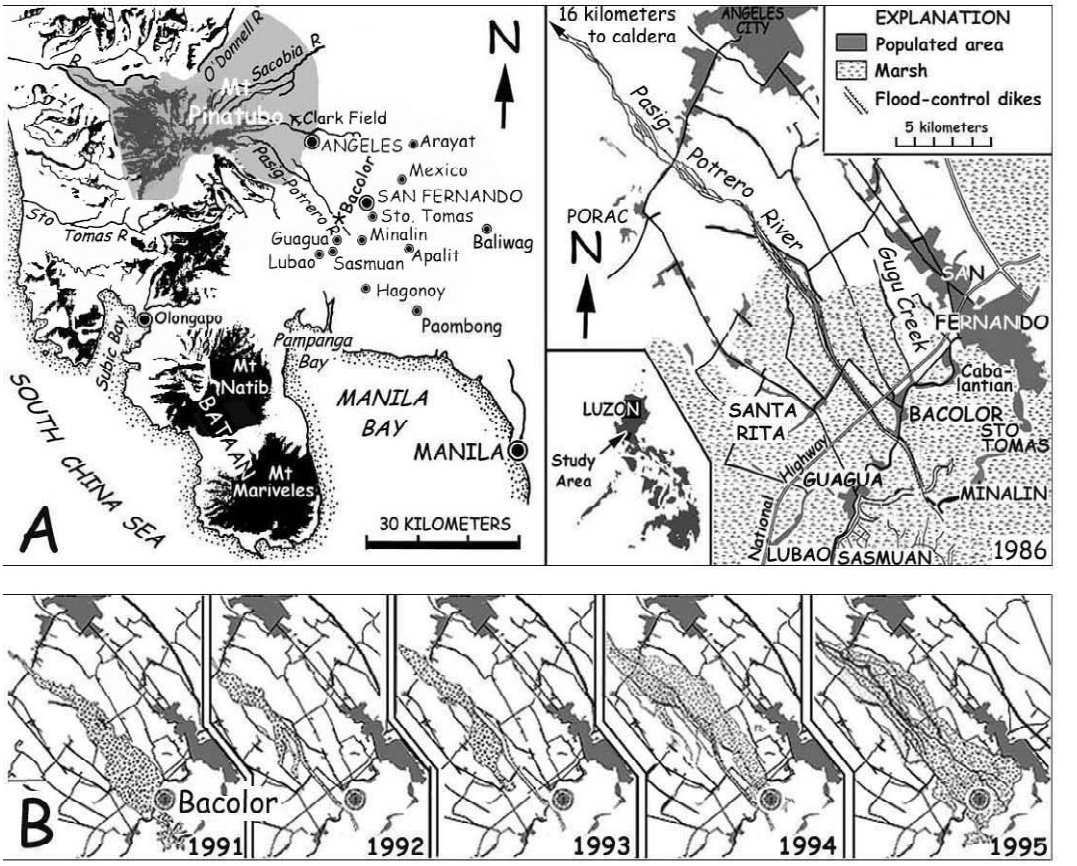

FIGURE 1.

A. Location maps of study area.

B. Lahar deposits (stipples) from 1991 to 1995.

C. Lahars that raised Bacolor have eliminated flooding there, but the adjacent towns of Guagua, Lubao, Sasmuan, Minalin, and large parts of San Fernando increasingly are flood-prone due to subsidence from overuse of groundwater.

The MacArthur Highway is parallel to and one half kilometers southwest of the GSO Highway between Bacolor and San Fernando, and connects Bacolor to Guagua.

Pasig-Potrero River to protect Bacolor and neighboring towns.

Bacolor is bordered to the north by Angeles City; to the east by the provincial capital city of San Fernando; to the south and west, by the municipalities of Minalin and Guagua, respectively (Fig. 1A). Running through the town is the national Gapan-San Fernando-Olongapo (GSO) highway to Subic Bay that serves as a vital link between Manila and points west, including western Pampanga and the provinces of Bataan and Zambales.

Pre-eruption history

Pampanga was the first province inaugurated by the Spanish in Luzon. Its name derives from *pangpang*, "river bank" in the language of its inhabitants, the *Capampangan,* "people of the river banks". Its first settlers are believed to have migrated by boat from the Malay Peninsula or Sumatra. The pre-eruption history of Bacolor is chronicled by Blair and Robertson (1904), Buenviaje (1968), Centro Catolico Officers (1980-81), Galende (1996), Henson (1955), Larkin (1993), and Tantingco (2003).

When Spanish conquistadors arrived in 1571, Bacolor was already a thriving settlement of Muslims engaged in rice farming and commerce. They were defeated by the Spaniards and Christianized by Augustinian missionaries, who corrupted the original name of the settlement to Vacolot or Bacolot, and eventually to Bacolor. In 1576 the Augustinian council designated Bacolor as San Guillermo convent, named after the town patron San Guillermo Ermitańo. Juan de Medina, a seventeenth-century Augustinian, characterized Bacolor as:

> ... the best village not only of Pampanga but of all the islands.... It has the best meadow-land in the islands, and it also produces rice abundantly. .... It has a celebrated church with its crucifix which is entirely built of stone and brick. .... The inhabitants are the richest and best-clothed of all Pampanga... (Blair and Robertson 1904:245).

In 1746, Bacolor became the provincial capital, which it remained for 160 years. From 1762 to 1764, when English invaders drove the Spaniards out of Manila, it served as the temporary capital of the Philippines. In 1765, the Spanish king designated the town as "Villa de Bacolor", one of only three Philippine communities so honored.

By the end of the nineteenth century, Bacolor was a center of *ilustrados* — families whose land wealth, education, and broad social contacts made them preeminent beyond a single region (Larkin 1993). It was often called the "Athens of Pampanga". "At that time, more than any other town, it produced men of letters, congressmen, governors, composers and musicians (Henson 1955: 103)".

In addition to its elaborate, ancient church, Bacolor boasted the oldest vocational school in the country and many elegant nineteenth-century homes. At the beginning of the American colonial period in 1901,

Bacolor became the first capital of Pampanga province, and a townsman was appointed its first governor. In 1904, however, the capital was transferred to the larger town of San Fernando.

At the time of the eruption, Bacolor was a town of 67,000 people. It comprised 21 *barangays* (villages), four of which constituted the town proper (National Statistics Office 1990). Its residents were very attached to the town. A majority of respondents in the 1996 survey had been born in Bacolor and their families had resided in the same barangay for 21 years or more (Lamug et al. 1999a, 1999b).

Lahar of the eruption and its aftermath

Bacolor received only a dusting of ash during the climactic 1991 eruption because winds during the climactic explosions of 15 June were easterly, blanketing downwind areas to the west in decimeters of airfall debris. Shortly before the height of the eruption, a passing typhoon generated lahars that flowed down all major Pinatubo drainages, but those along the Pasig-Potrero River were small and were largely contained by the flood-control dikes. Over the ensuing five rainy seasons, however, Bacolor was to become the town most severely damaged by lahars.

Pinatubo lahars, often called "mudflows", actually are flowing slurries of sand and coarser materials (Rodolfo 1995; 2000). The larger, most sediment-laden lahars can have water contents as low as 10 percent — barely enough to mobilize the debris into "debris flows" called *lahar na malapot* in Pilipino. These most powerful and dangerous lahars can flow as fast as 35 kilometers per hour. Lahars containing less than 70 percent of solid material are called *lahar na malabnaw*. These more dilute lahars can bulk up into debris flows by eroding and incorporating additional material along their paths.

When a lahar overflows its channel banks, it is rarely more than several meters thick, and so any low hill or tall building can provide safe refuge. As it spreads, frictional resistance increases at its base, slowing it down; thus, it usually is not powerful enough to topple even fragile structures such as thatched huts, and merely flows around and into them.

In 1991, immediately following the eruption, Pasig-Potrero lahars damaged many of Bacolor's outlying barangays (Fig. 1B). On 7 September, a lahar buried much of the town in debris 1 to 3 meters thick (Arboleda and Martinez 1996). In the town proper, flows less than a meter thick buried the outer walls of San Guillermo Church but did not flow into it. By the end of the rainy season, lahar deposits had buried 38 square kilometers of land along the Pasig-Potrero River, including the national highway at Bacolor, to an average depth of 1.3 meters.

In 1992 and 1993, upstream barangays received more lahars, but the town proper was spared. In 1994, however, lahars crossed the national

highway and buried large areas of central Bacolor in deposits several meters thick (Arboleda et al. 1995). Finally, several flows in 1995 again buried nearly the entire town. Worst hit was barangay Cabalantian, south of the highway and between the town proper and San Fernando, which a single six-hour event buried in deposits up to 9 meters thick. By the end of 1995, total deposition in the town proper averaged 6.5 meters (Crittenden 2001, Lamug et al. 1999a). Deposits were thickest in the upstream barangays north of the highway and, of course, in Cabalantian.

Human responses to the lahars

Although the precise timing of the previous eruption remains uncertain (Newhall et al. 1996), the modern residents of Bacolor clearly had neither written history nor an oral tradition of Pinatubo eruptions and lahars.The Philippines has many, much more active volcanoes, but even the national government had no familiarity with eruptions and lahars of such magnitude.

National government

The Philippines is an impoverished developing country with a large and rapidly growing population and more than its share of natural hazards, including typhoons, floods, earthquakes, landslides, and active volcanoes. The multi-year Pinatubo disaster overwhelmed the government's capacity to respond; furthermore, disaster policy decisions were made less on scientific grounds, more on the basis of political considerations, available resources, and greed (Rodolfo 1995).

The National Police was supposed to monitor upstream channels and reports of PAGASA, the national weather bureau, and issue lahar warnings so that people in harm's way might seek high ground or go to temporary evacuation centers. At times, the warning system did not prevent significant loss of life, most notably during the Cabalantian tragedy in October 1995.

In 1992, the initial engineering countermeasures of the government's Department of Public Works and Highways (DPWH) primarily took the form of "sabo" (Japanese for "debris-retention dams") built across upstream lahar channels and dikes along their downstream stretches in 1992. These were quickly overwhelmed and obliterated by lahars. Additionally, from 1992 to 1996 DPWH elevated the national highway about 10 meters in a sometimes futile attempt to protect it from lahar damage. Initially, raising the highway also helped to protect central Bacolor.

In 1992 the national government decided to sacrifice Bacolor by enclosing it in a debris basin with dikes, in order to protect the yet-unaffected adjacent communities. DPWH instituted an annual program to build dikes out of low-density, porous lahar sand and gravel deposits. These structures, either lacking concrete armour or only thinly encased, were inadequate to contain lahars or even normal floodwaters and were breached every lahar season and

even enlarged the lahars that absorbed them. They also enhanced the danger by promoting a false sense of security. In 1995, Cabalantian residents were unprepared for lahars because they believed they were protected by the eastern portion of a dike complex along Gugu Creek, even though its western components had already been breached several times before the catastrophe.

It has been recognized for centuries that engineering measures to save one town from volcanic disaster often increase the risk to others. San Fernando, the provincial capital and a more populous commercial center, lobbied successfully for dikes, joined in this effort by Angeles City, Guagua, and Lubao. The ostensible intent was to restrict the lahar deposition to Bacolor land, but in fact the dikes were built atop deposits of the previous seasons (Rodolfo 1996, Rodolfo et al. 1996).

The dikes were inadequate to stand up to lahars or even floods. Each year when they failed, they were replaced with larger and more expensive, but still inadequate, structures, in no small part due to the notorious corruption of DPWH. The FVR Megadike, constructed in 1996 after the Cabalantian tragedy at a cost of P1.4 billion, has the undeserved reputation for effectively containing the lahars, thereby limiting the damage to Bacolor. Two weeks after it was dedicated, accumulated flood waters from two small typhoons were enough to breach its "transverse dike" component – actually a dam – simply by seeping underneath the structure and undermining it. In fact, the only lahar event of any significance after the Megadike was built occurred in 1997; its flows were too dilute to wreak much damage. With or without the series of dikes built since 2002, the lahars would have been limited to Bacolor and small adjacent areas of Sta. Rita, Guagua, and San Fernando. Meanwhile, the unaffected areas surrounding Bacolor were becoming increasingly more flood-prone (Siringan and Rodolfo 2003).

In 1992 and again during the 1994 and 1995 lahar seasons, the national government ordered Bacolor's inhabitants to evacuate and resettle elsewhere. However, no government agency ever took responsibility for funding or enforcing the evacuation orders. By 1994 there already was a huge backlog of families awaiting resettlement, and the increasing cost of the dikes led each year to diversion of funds allocated for resettlement.

Communities were supposed to be resettled away from the lahar areas by a three-step process. First, victims or threatened residents were moved to schools and other evacuation centers that were supposed to be temporary; in practice, the evacuees stayed in them as long as six months. The second step was for residents to move to staging centers for a rehabilitation period, where they lived in bunkhouses of 10 or 12 small, single-family rooms. This step lasted from 18 months to two years. Finally, residents were supposed to move into "permanent" resettlement communities offering small houses and modest livelihood, such as making cement building

blocks. These resettlement villages improved the pre-eruption standard of living for the most economically marginal town residents. However, only families who could document ownership of their lots and their destroyed homes were eligible for the housing. For many eligible Bacolor homeowners, government resettlement represented reduced circumstances: overcrowding and limited access to education, commerce, services, and viable livelihood.

Pinatubo resettlement policy applied one lesson documented in the disaster research literature (e.g., Erickson 1976): As much as possible, whole neighborhoods of evacuees were resettled together so as not to needlessly exacerbate the social dislocation caused by the natural disaster. Resettlement communities were organized to cluster residents according to preexisting barangay structures, in order to maintain social bonds among neighbors. In many cases, relatives lived along the same street or in the same block. There were "Little Bacolor" communities in staging centers and resettlement communities across Pampanga.

After the catastrophic 1995 lahar season, the national government declared Bacolor an unsafe place; no government funds could be used for reconstruction of schools or other public facilities. The Philippine Institute of Volcanology and Seismology (PHIVOLCS) denied clearance for construction bank loans, and the national water-utilities administration abandoned the local water district. To make matters worse, the interim census of 1995 (National Statistics Office 1995) was conducted in July, while 11 lahars flowing through the town hindered access and many citizens were in temporary evacuation centers. The severe undercount was to have drastic revenue consequences for the town at the time of its greatest need.

Given the diaspora and the fierce attachment of its members to Bacolor, in 1998 the Philippine Commission on Elections waived the legal residence requirements for voting and holding office in Bacolor. The scattered former residents returned in force to vote for mayor, vice-mayor, and eight municipal councilmen. Of those elected, only the mayor actually resided in Bacolor at that time. This electoral policy further encouraged the loyalty of the scattered populace to the town. At the same time, it multiplied the demands on the impoverished municipal government for services, and deprived the legitimate town residents of political representation.

Families and local government

In order to save the town, the municipal government, families who were determined to stay, the parish priest, and a few local institutions toiled energetically to restore essential services. They rebuilt one elementary school and two churches, all without help from the national government, although the school reconstruction was aided greatly by imposing an informal tax on lahar sand and gravel being quarried from the town in increasing amounts for construction in the region and Metro Manila. After

lahars destroyed the water system in 1995 and the national government refused to help, the local members of the Water District voluntarily reconstructed the system with the help of the mayor. The electric cooperative that serves Bacolor quickly restored power in inhabited parts of the town, and service has been interrupted only briefly by typhoons, lahars, and scheduled "brown-outs".

The Don Honorio Ventura College of Arts and Trades (DHVCAT), founded in 1861 by local philanthropists, runs the public high school for the town proper and also offers vocational and college curricula at very low tuition to students from all over the province. It was badly damaged by lahars in 1994 and 1995, when classes were suspended indefinitely. Many students transferred to other schools. The college president, faculty and staff decided not to give up on the college and the town. Classes resumed in December with little instructional equipment. Physical conditions were deplorable for years. Classes occasionally had to be suspended during the rainy seasons, when floods isolated the school. The low-lying campus was inundated for much of the year, necessitating footbridges between buildings. Beyond its academic services, DHVCAT brought many more people into the town daily than lived there. It was the primary employer in the town proper and indirectly provided additional livelihood through small cafeterias, transportation, and rented housing for students. Bacolor could not have survived without DHVCAT.

By 1995, the half-buried, 350-year-old Spanish baroque San Guillermo parish church had become a famous visual symbol of the devastation wrought by Pinatubo lahars. Restoring the church was a high priority, not only to serve religious needs, but also to symbolize the continuing life of the town. The choir-loft window above the buried main doorway became the new entry. With lahar deposits exposing only the top few centimeters of the arched side windows, and huge chandeliers nearly reaching the ground, the church interior resembled a dark cave. In November of that year the parish expanded the annual religious festival of the *poblacion* to include the entire scattered populace of Bacolor. In 1997, with contributions from scattered townspeople and tourists, the parish began to remodel and restore the church. The massive masonry structure was much too heavy to lift, so the ceiling was removed to increase the height of the interior. The roof was fitted with large dormer windows to admit light, and lined with silvery, reflective insulation to block solar heat. In 1998, a room adjacent to the sanctuary was converted into a museum that attracted donations from increasing numbers of tourists. Restoration and remodeling continue as resources become available.

The smaller archdiocesan shrine had been buried under 5 meters of lahar deposits by 1995. A massive concrete structure, completely shortly

before the eruption, had to remain buried, but the older chapel was rehabilitated in two stages. First, a new main entrance was added above the original, and the interior redecorated, so that masses could resume early in 1996, contributing a sense of normalcy to the town. Then in 1997 the roof and cupola were lifted by 5 meters to accommodate a remodeled sanctuary constructed about 2 meters above the surrounding land.

In all barangays but two outlying ones, virtually all of the houses were destroyed by the end of 1995. No families remained in most barangays, but no single event had destroyed every house in the town proper. Many families were determined to stay and others, discouraged by resettlement conditions, had returned. The interim government census in 1995 listed only 229 people in the town proper. Unofficial but more accurate censuses counted 1488 sturdy souls in 1996 and 1755 in 1997 (Lacsamana 1996, Lacsamana and Crittenden 1997, as cited in Crittenden 2001), struggling to maintain their freehold and rebuild their town. The 1997 count in the town proper was only 11 percent of the pre-eruption population (National Statistics Office 1990).

Stilted houses are a traditional and very functional form of domicile in the Philippines. To recover and protect their homes from the repeated lahars, Bacolor families reverted to this form, developing their own unique building methods (Crittenden and Rodolfo 2002, Crittenden 2001). For several years, the practice was limited to small houses of lightweight materials such as new or recycled wood or woven bamboo (*sawali*). To raise the salvageable part of a buried house, family members dug with shovels to a level just below the floor of the highest story, which they sawed off so they could lift it up from the portion that would remain buried. In late 1995, we observed a family raising their house with a single automobile jack, raising each corner in turn a few centimeters at a time until the house was high enough to install on concrete stilts. Once stilted, a house could always be raised again if necessary.

Almost half of the 353 families living in the town proper in 1997 had raised their house on stilts, and about 8 per cent had added rooms or new stories on top of stone or concrete houses too heavy to lift. Some families had raised or completely rebuilt their houses as many as four times during the period.

House-raising was not limited to families who stayed in the town. According to survey respondents from the town proper in 1996, many of the 'resettled' families also had valiantly resisted by raising their Bacolor homes, only to be defeated by the continuing dangers and exhaustion of their resources. Other families had moved more willingly, but elevated their houses for their eventual return or to protect their investment. A majority of those residing in permanent resettlement communities and half of those in temporary staging centers had raised their houses in Bacolor one or more times. Only among families who had resettled on their own to other

towns was it unusual (only 7 percent) to have raised their Bacolor houses.

In early 1996, six large hydraulic jacks donated by Capampangans living in the United States allowed the town to exhume and raise larger houses with a *Taas Bahay* program. For structurally-suitable houses, the municipal government designated a local contractor and contributed cement, forms for molding stilts and concrete beams, and the use of the jacks. Homeowners paid only the labor costs. Sixty houses were lifted in 1996 and 1997, drastically altering the landscape that was visible from the national highway. Additional families borrowed the jacks and forms, and over 250 houses eventually were raised in this manner.

Standing on concrete stilts at least 4 meters tall, a typical house in 1996 was constructed primarily of wood, with the bottoms of the walls cut irregularly and stained where they had been buried. The raised part of the house, entered by a wooden ladder or staircase, normally had running water and a functioning bathroom with a commode connected by a long plastic pipe to a buried septic tank. The lower level was left unfinished and open.

In 1997 and 1998, many large families made their stilted houses more comfortable. Some families enclosed the lower level with concrete blocks made of the omnipresent lahar sand; others raised the floor a meter or more with truckloads of lahar deposits, so as to provide a dry, sheltered area.

Beginning in 1999, returning families were building new, unstilted homes. Typically these were multistory, concrete-block houses constructed atop the original buried ones, with a foundation raised 2 to 3 meters, on a lot already raised with lahar deposits at least a meter. New home construction has been accelerating, but almost always with a substantial foundation and a lot raised 1 to 2 meters higher than the lahar deposits.

Living in Bacolor was difficult. Lahars choked all existing drainages and were deposited unevenly, leaving an irregular surface with no integrated drainage. After each lahar episode, water channels began to be reestablished, only to be destroyed by the next onslaught. The GSO highway posed a special problem; it ponded water from the north and sent it through one or two culverts into the town proper, where it spread out and drained sluggishly through any lows in the terrain. Given the absence of an organized drainage system, the unpaved streets in the town proper were flooded and eroded whenever it rained, becoming difficult or impossible to traverse. No funds were available to repave the streets or build sewers. Ironically, the only organized drainage was created inadvertently, when the municipal government tried to smooth the streets by scraping them down. The next heavy downpour made the old MacArthur Highway, a major thoroughfare through the town proper, into a new tributary of the Pasig-Potrero River. This situation persisted for several years, eliminating vehicular traffic and requiring improvised foot bridges for crossing the “street”. Stagnant water also posed serious

health hazards, including dengue and other insect-borne diseases and aquatic parasites. Athlete's foot was pandemic.

THE TURNING POINT

Late in 1998, DPWH proposed yet another hazard-containment structure to sacrifice Bacolor, this time a system of tail dikes enclosing the south end of the town to protect downstream communities from flooding and lahars. DPWH announced a public "focus group and community consultation meeting", one day before it was held on a weekday in virtually unpopulated Cabalantian. Word spread very quickly among the concerned citizenry. Consultants from the University of the Philippines at Los Bańos charged with conducting an environmental impact assessment were faced with about 60 irate Bacoloreńos and had to plead for "civility" during their presentation. The meeting was nevertheless very productive. The townspeople convinced the consultants that the goals of the project would be achieved equally well by raising the MacArthur highway in Bacolor, a project desperately needed to reestablish traffic through the town proper. Even if the raised highway trapped sediment on its north side, affected landowners would have accepted it because, given the local architecture that had evolved, they had no objection to having their land raised even more above the floods. DPWH agreed to this counter-proposal, but had to justify it officially not in terms of its benefits for the condemned town, but instead as an "evacuation route" through it, should the main highway be damaged or blocked. Thus, despite the prohibition against public monies for Bacolor, national funding was expended on a project that greatly enhanced the rehabilitation of the town.

The final design elevated and paved the MacArthur highway and rebuilt the bridge across Gugu Creek between the town proper and Cabalantian, thus restoring the routes to San Fernando on the east and Guagua on the west. It also raised and paved the streets around the perimeter of the *poblacion* to connect the MacArthur with the national GSO highway. Drainage ditches alongside the raised, paved roads went a long way toward solving Bacolor's flooding problem.

It often is said that disaster can provide an opportunity to build for the future. DPWH plans for building the "evacuation route" included modest widening of the highway and streets. However, the project was stalled for some time by over 100 landowners reluctant to cede right-of-way. The deep distrust of the national government engendered in the beleaguered residents of the town proper had extended to the local officials. Despite the obvious benefits to the town and the seemingly equally obvious economic advantages to themselves, many owners of frontage property were quite reluctant to sell even a narrow strip of their land to widen the roads.

Eventually a compromise was reached. Construction began in 2000

and was completed in 2004. As soon as the MacArthur highway was opened, residents flooded back to rebuild in their beloved town. The municipal government encouraged the return through its *Balik Barangay* (return to the *barangay*) program that forgave land taxes for the land on which property owners resided. Opening the highway also brought back much-needed commercial establishments, the first a hardware store to service the construction boom. The municipal government used donations from candidates for provincial office to begin paving local streets and connecting them with the newly raised and paved "evacuation route". However, funds were short, and the local paved streets are narrow and substandard.

The Department of Environment and Natural Resources was required to return to municipalities the proceeds of quarrying of lahar deposits. In 2000, the "Lahar Shares" program returned to Bacolor a sum substantial enough to fund construction of a new municipal building. Together with the newly raised and paved streets, this new *municipio* was a striking sign that, despite the national prohibition, Bacolor could rebuild.

Finally, in 2004, PHIVOLCS lifted the designation of Bacolor as an unsafe place, thereby removing the prohibition against public funding. This action also made bank loans for construction possible.

As of this writing, the municipality is planning to reconstruct its long-buried public *palengke*, or market, with funds promised by national politicians. When the *palengke* reopens, it will stimulate even more commercial and residential development, restoring a sense of normalcy as well as a tax base to support the needs of town residents. Bacolor will have come a long way toward reaching the end of its long ordeal.

REGIONAL FLOODING PROBLEMS

In coastal and deltaic Pampanga and adjacent areas, storm floods and tidal incursions have worsened since the 1991 Pinatubo eruption. This is especially the case in southwestern Pampanga, where stream channels have been choked by great amounts of eruption debris brought down by floods and lahars. Long before 1991, however, the region was already notoriously flood-prone, and floods were already increasing in frequency, magnitude and duration. Furthermore, coastal Bataan, Bulacan and Manila suburbs that received virtually no Pinatubo sediment are also suffering from aggravated flooding by storms and high tides. Clearly, factors independent of Pinatubo are important. The more widely recognized causes stem from urbanization: decreased infiltration and increased runoff due to expanding pavement; encroachment of channels by fishponds and informal settlers; and choking of streams by improper garbage disposal. Upland deforestation also contributes in a major way by increasing runoff, slope erosion, and channel filling (Siringan and Rodolfo 2001, 2003).

Studying why floods are worsening in low-lying Pampanga, Siringan and Rodolfo (2001) discovered that by far the most important cause is land subsidence, at rates of centimeters to more than a decimeter per year. The subsidence results primarily from overuse of groundwater for agriculture, aquaculture, and domestic use. Any deltaic area in the world where water is being pumped too quickly out of the ground subsides and suffers from exacerbated flooding (Rodolfo et al., in press).

In trying to understand the enhanced flooding and tidal incursion in the coastal region around northern Manila Bay, the Philippine public and its decision makers have only recently begun to recognize that global warming is causing a worldwide rise in sea level of about 2 millimeters per year (cf. Mimura and Harasawa 2000). They have yet to accept that the regional sea level rise from human-induced subsidence is more than ten times faster. As long as the government underestimates the effects of subsidence, its multi-billion-peso dredging and diking flood-mitigation projects probably are futile.

Serious, prolonged monsoonal flooding in Pampanga drew wide attention in 2002. From July 8 to 30, Guagua, Minalin, Sasmuan, Santo Tomas and large areas of the City of San Fernando (Fig. 1C) were seriously inundated, up to 2 meters deep in places. Ironically, the only community spared was Bacolor, because the lahar deposition has raised its surface several meters above its surroundings. Owing to imperfect drainage, Bacolor did experience flooding during the heavy rains, but the waters left after only one or two days. By 2004, its drainage system had been greatly improved, and so flooding was essentially eliminated.

For as long as groundwater is the principal source of water for domestic use, agriculture and aquaculture, land subsidence and the consequent flooding from rains and tidal incursions will continue to worsen. The population of Pampanga continues to grow, requiring additional housing that would be impractical to build in the flood-prone communities. Indeed, many people of these towns will need to relocate. Bacolor is an obvious place for them to resettle, and for the burgeoning provincial population to live.

LOOKING TO THE FUTURE

Lahars

Are the lahars over? Since 1996, weather patterns have been dominated by El Niño episodes of the climatic southern oscillation, during which fewer typhoons approach the Philippines and monsoon rains are reduced. As a result, there have been no serious Pinatubo lahars, and many people believe that the risk of lahars is entirely over. But this is a temporary condition. Much of the debris on the volcano flanks has been exhausted, but great volumes of debris that the lahars have deposited on the volcano apron can be remobilized into new lahars. It is important to remember

that the lahars that buried Cabalantian in 1995 did not come directly from the volcano. They were remobilized from deposits of lahars that from 1991 to 1994 had buried the eastern barangays of Porac municipality, 18 kilometers up the apron from Bacolor. The period that followed the Cabalantian tragedy had relatively low rainfall, and only dilute lahars were generated that were deposited upstream of Bacolor. Future storms may remobilize this accumulation into large lahars. The lahar threat may last for years or decades before it becomes minimal and remains so for centuries until the next eruption.

It is important to note that the lateral dikes of the FVR Megadike complex have not yet been seriously tested by lahars. In 2002, however, relatively mild storms generated lahars that stripped the cement armor off a 100-meter-long portion of the eastern lateral Megadike. Had the rains lasted a day or so longer, the dike could well have been ruptured and sent lahars into San Fernando. The damaged portion was repaired much more strongly than it had originally been built, but the next lahars cannot be expected to attack only at that point along a 22.5 kilometer-long structure.

However, future lahars are not expected to affect Bacolor directly. The town proper has been elevated at least 6 meters by the lahars. Bacolor is now truly *macabaculud,* standing even higher above its surroundings than ever before, and any future lahars will probably skirt this high ground. The town also is protected by the raising of the GSO highway, and, to a lesser extent, by the dikes intended to sacrifice it. The towns most at risk are Santa Rita to the northwest, Guagua to the southwest, and the City of San Fernando to the east.

Furthermore, residents of Bacolor's town proper have elevated almost all of their buildings well above the current ground level. Thus, Bacolor now is much less vulnerable to lahars than any of the towns around it. And unlike that of the national government, its approach to mitigation does not pass the threat to the future or onto other towns. Indeed, people of the low-lying communities around it could well benefit from the house-raising technology developed in Bacolor. Even if lahars do not reach them, they are suffering from ever deeper and longer-lasting floods from storms and high tides.

Flooding: *"Napakasuwerte naman ang mga taga-Bacolor!"*

"The people of Bacolor are so lucky!" we heard a citizen of the neighboring town of Minalin exclaim during a recent Pampanga flood. Not only has the elevation of Bacolor solved its lahar problem, but it no longer suffers from the flooding that is becoming increasingly severe in the lowlands of the province.

The lahar threat can only decline in the long term, but the problem of chronic flooding in Pampanga's coastal and estuarine areas continues to grow and reduce the quality of life. Population statistics may already be reflecting the environmental deterioration of this area, which grew

12.7 percent from 1995 to 2000, compared with 15.0 percent for the entire province (National Statistics Office 2002). Growth was much lower in the most flood-prone communities, for example, -1.5 percent in Minalin, 0.9 percent in Sasmuan, and 2.4 percent in Guagua. If land subsidence and flooding continue to worsen, we can expect more and more people to be displaced. High-and-dry Bacolor is an obvious place for them to resettle.

Building the Bacolor of the future

Residents have saved their town, but their building for the future has been severely handicapped by lack of coordination, resources, and support. Residential reconstruction has been *kanya-kanyahan* (each family for itself), with little attention paid to the overall layout and appearance of the town. The daunting task of rebuilding understandably dominates the attention and resources of Bacoloreños, leaving little time, thought, and funding for long-term planning.

A town with more *civic capital* — the social resources a community has for making decisions and getting things done — can respond more successfully to major changes in its environment (Orum 1998, Orum and Gramlich 1998). In order of frequency of presence, the types of resources are *alliances* among the leading economic, political and social sectors; a *commitment* to the place on the part of the citizenry; a *consensual vision* for the direction and future of the town; and *bridges* that connect the leading sectors to the citizenry.

How does Bacolor's civic capital measure up to the monumental task of rebuilding?

Disasters often elicit a spirit of cooperation across community sectors. In the aftermath of the devastating 1994 and 1995 lahars, the leading sectors of the town formed an alliance to solve critical town problems, without the assistance or even the cooperation of the national government. This alliance was essential for the town to survive at all but, born of an emergency, it was transitory. Furthermore, having fled, the commercial sector did not participate.

Vision and long-term perspective are seriously limited in Bacolor by severe lack of resources and the habits developed in the fight for survival. Although disasters can occasion community development and planning for the future, in this case, the initial rebuilding activities were *ad hoc* for several years before initiation of comprehensive planning. Bacoloreños are justifiably proud of their town's illustrious past, and their planning and effort have focused primarily on restoring the routine amenities of a sleepy bedroom community and predominantly agricultural economy. Seemingly paralyzed by short-term thinking, they spend little effort in visualizing what Bacolor might be in the future. Thus, the current municipal plans include restoring farm-to-market roads without the wide frontage that could evolve into the

thoroughfares needed by the urban center of the future. The local government is considering placing its garbage disposal sites in more elevated areas north of the town proper. This would depreciate elevated areas well suited for housing, and contaminate the groundwater upon which the community relies so heavily.

Unplanned development is not unusual in the Philippines. However, the longer that Bacolor continues to rebuild in an uncoordinated, family-based manner, the more difficult and expensive it will be to achieve a comprehensive plan for the town infrastructure. What the town most urgently needs now is support from the national government and private philanthropy to launch a comprehensive, community-wide, participatory planning effort to reconstruct their town as an attractive, disaster-resistant community (Crittenden 2001).

Ironically, restoring Barangay Cabalantian from its total obliteration by the catastrophic lahars of 1995 seems to be a far easier task. In the post-disaster years, during which reconstruction was proscribed by the national government, the barangay and its leadership had ample time for coordinated planning. A new network of wide, well-drained roads with street lights was built so that the new houses could be erected as integrated neighborhoods.

Bridges between the leading sectors and the citizens are lacking in many municipalities. Residents of the town proper tend not to be joiners (Lamug et al. 1999a). However, communication across all town sectors has been facilitated by their long acquaintance, and the adversity they have shared and transcended. The captain and council of some *barangays* are well connected to the residents, but such connections in other *barangays* are hindered by the dispersal of residents and elected officials alike.

CONCLUSION

The Pinatubo lahars of 1991 to 1995 devastated Bacolor. Struggling to recover life in their town without outside assistance, and learning from repeated lahar invasions, Bacoloreños learned to elevate their houses, rebuilding their environment to protect both houses and people from future lahars.

Disaster historically has presented an opportunity to build for the future, and Bacolor is a prime example. Ironically, the catastrophic flows raised the ground surface of Bacolor by several meters, thus exempting it not only from future lahars but also from the floods that are plaguing nearby towns that have been spared from lahars. Unlike the diminishing lahar threat, rain floods and tidal incursions promise to deepen, occur more frequently, and last longer. The primary cause is the excessive withdrawal of groundwater. As the number of people increases, so must groundwater usage, the subsidence it causes, and the resulting floods. The deteriorating quality of life in the flood-prone communities may be forcing

people to relocate. In addition, while the floods continue to diminish the areas in Pampanga that are suitable for housing, the population of the province is expected to double by 2025 (National Statistics Office 2002). Bacolor is an obvious place to develop into a large residential area. It needs to build with the future in mind, to realize its maximum potential as a pleasant community not only for itself, but for the entire region. Bacolor urgently needs the national government and any other pertinent agencies to provide financial and technical support for comprehensive, community-wide, participatory planning in order to reconstruct the town into a sustainable community in harmony with the natural forces of its environment.

ACKNOWLEDGEMENT

Our research was supported by the Center for Integrative and Development Studies and the National Institute of Geological Sciences of the University of the Philippines, the Philippine office of Oxfam Great Britain, the Bureau of Agricultural Research of the Philippine Department of Agriculture, and the College of Liberal Arts and Sciences of the University of Illinois at Chicago. Our colleagues in this research are Corazon Lamug, Gloria Nelson, Cristina Remotigue, Ramoncito Rivera, and Fernando Siringan. We dedicate this report to the people of Bacolor, in admiration for their courage and love for their town, and we are especially grateful to the late Rustico Lacsamana who suggested the research, and Nilo Caballa, Ananias Canlas, Jr., Romeo Dungca, Ernesto Nicdao, and Father Nestor Tayag for their invaluable assistance.

REFERENCES

Arboleda, R.A., S.G. Catane, P.J. Delos Reyes, M.L. Martinez, H.T. Mirabueno, T.M. Regalado, B.S. Tubianosa, J.V. Umbal, R.S. Punongbayan, C.G. Newhall, and R.A. Alonso

1995 "Chronology of the 1994 Lahars at Pinatubo Volcano and Consequent Hazards and Risks." Unpublished report of the Philippine Institute of Volcanology and Seismology.

Arboleda, R.A., and M.M.L. Martinez

1996 "1992 Lahars in the Pasig-Potrero River System." In C.G. Newhall and R.S. Punongbayan (eds.) *Fire and Mud: Eruption and Lahars of Mount Pinatubo, Philippines.* Seattle, U.S.A.: University of Washington Press, 1045-1054.

Blair, Emma Helen and James Alexander Robertson (eds.)

1904 *The Philippine Islands: 1493 -1898*. Volume XXIII. Cleveland, U.S.A.: Arthur H. Clark, 1629-1630.

Buenviaje, Conrado B.

1968 "Villa de Bacolor Non-plus Ultra: History of Bacolor and its Barrios." Unpublished manuscript.

Centro Catolico Officers

1981 Centro Catolico Souvenir Program (1980-81), Villa de Bacolor.

Crittenden, Kathleen S.

2001 "Can this Town Survive? Case Study of a Buried Philippine Town." *Natural Hazards Review* 2:72-79.

Crittenden, K.S., and K. S. Rodolfo

2002 "Bacolor Town and Pinatubo Volcano, Philippines: Coping with Recurrent Lahar Disaster." In R. Torrence and J. Grattan (eds.) *Natural Disasters and Cultural Change*. London: Routledge, 43-65.

Erickson, Kai

1976 *Everything In Its Path:Destruction of Community in the Buffalo Creek Flood.* New York, U.S.A.: Simon and Schuster.

Galende, Pedro G.

1996 *Angels in Stone: Augustinian Churches in the Philippines*. Manila: San Agustin Museum.

Henson, Mariano A.

1955 *The Province of Pampanga and Its Towns (A.D. 1300-1955).* 2nd ed. Manila: Villanueva Book Store.

Lacsamana, R.

1996 Certified Updated Masterlist of Current Residents of Barangays Cabambangan **[**the poblacion**]**, San. Vicente, Sta. Ines and Cabetican, Bacolor, Pampanga.

Lacsamana, R., and Kathleen S. Crittenden

1997 Unofficial census of current residents of the Barangays Cabambangan, San Vicente, Santa Ines and Cabetican, Bacolor, Pampanga, July, 1997. Town of Bacolor, Pampanga, Philippines.

Lamug, Corazon B., Kathleen S. Crittenden, and Gloria L. M Nelson

1999a *Processes through which Families in Bacolor (Pampanga) Respond to Natural Disaster with Emphasis on Relocation.* Manila: Center for Integrative and Development Studies, University of the Philippines.

1999b "Place Identity of Women of Bacolor." *Philippine Sociological Review* 47:21-30.

Larkin, John A.

1993 *The Pampangans: Colonial Society in a Philippine Province*. (University of California, 1972). Quezon City: New Day Publishers.

Mimura, N. and H. Harasawa (eds.)

2000 *Data Book of Sea-Level Rise 2000*. Japan: Center for Global Environmental Research, National Institute for Environmental Studies, Environmental Agency of Japan.

National Statistics Office

1990 *Pampanga Census of Population and Housing.* Philippine Government, Manila, Philippines.

1995 *Central Luzon Census of Population 1995*. Philippine Government, Manila, Philippines.

2002 "Pampanga: Population to Double in 23 Years." http://www.census.gov.ph/data/pressrelease/2002/pr02121tx.html.

Newhall, C., A. Daag, F.D. Delfin Jr., R. Hoblitt, J. McGeehin, J. Pallister, M. Regalado, M. Rubin, B. Tubianosa Jr., J.V. Umbal

1996 "Eruptive History of Mount Pinatubo." In C. G. Newhall, R.S. Punongbayan (eds.) *Fire and Mud: Eruptions and Lahars of Mount Pinatubo*. University of Washington Press, Seattle, pp. 165-196.

Orum, A. M.

1998 The Urban Imagination of Sociologists: The Centrality of Place." *The Sociological Quarterly* 39 (1), 1-10.

Orum, A. M., and J. Gramlich

1998 "Civic Capital and the Construction (and Reconstruction) of Cities." Presented at the annual meeting of the American Sociological Association, San Francisco, CA.

Rodolfo, Kelvin S.

1995 *Pinatubo and the Politics of Lahar: Eruption and Aftermath, 1991*: Quezon City, Philippines: University of the Philippines Press.

1996 "Mount Pinatubo Lahars: Scientific "Givens", and some Political and Socioeconomic Consequences." Proceedings of the International Symposium On Disasters and Health, Manila, pp. 325-332.

2000 The Hazard from Lahars and Jökulhlaups. *Encyclopedia of Volcanoes*. Philadelphia, U.S.A.: Academic Press, 973-995.

Rodolfo, K.S., R.A. Tamayo, C.T. Remotigue, and J.A. Cagas

1996 "Geological Reasons for Breaching of the "Transverse Dike," Pasig-Potrero "Megadike" System, Pampanga." *Proceedings of the 1996 Convention of the Geological Society of the Philippines*.

Rodolfo, K.S., F. P. Siringan, C. T. Remotigue, and C. B. Lamug

In press "Worsening Floods around Northern Manila Bay, Philippines: Research-based Analysis from Physical and Social Science Perspectives." *Philippine Sociological Review*.

Siringan, F. P. and Kelvin S. Rodolfo

2001 "Net Sea Level Changes in the Pampanga Delta Region: Causes and Consequences." Final report submitted to the Center for Integrative and Developmental Studies, University of the Philippines, pp. 1-5.

2003 "Relative Seas Level Changes and Worsening Floods in the Western Pampanga Delta: Causes and Some Possible Mitigation Measures." *Science Diliman* 15:1-12.

Tantingco, Robby (ed.)

2003 "Bacolor: One Brief Shining Moment." *Singsing* 2 (2). Angeles City, Philippines: The Juan D. Nepomuceno Center for Kapampangan Studies, Holy Angeles University.