UNDERSTANDING THE COSTS AND BENEFITS OF DISASTER RISK REDUCTION UNDER CHANGING CLIMATE CONDITIONS

CASE STUDY RESULTS AND UNDERLYING PRINCIPLES

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CONTENTS

LIST OF ACRONYMS

ACCCRN	Asian Cities Climate Change Resilience Network
ADB	Asian Development Bank
ADPC	Asian Disaster Preparedness Center
CADP-N	Climate Adaptation Design Project- Nepal
CBA	Cost-benefit analysis
CEN	Clean Energy Nepal
CFSC	Committee for Flood and Storm Control, Son Tra, Vietnam
COPD	Chronic Obstructive Pulmonary Disease
CtC	Challenge to Change
CV	*Cheval Vapeur* (measurement of horsepower)
DFID	Department for International Development, U.K.
DPNet	Disaster Preparedness Network, Nepal
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DWIDP	Department of Water Induced Disaster Prevention
GCM	Global Circulation Model
GLOF	Glacial Lake Outburst Floods
HCVA	Hazard, Vulnerability and Capacity Assessment
IIED	International Institute of Environment and Development, U.K.
IFRC	International Federation of Red Cross
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return
ISET-I	Institute for Social and Environmental Transition-International
ISET-N	Institute for Social and Environmental Transition-Nepal
JICA	Japan International Cooperation Agency
KVERMP	Kathmandu Valley Earthquake Risk Management Project, Nepal
LAPA	Local Adaptation Plan of Action, Nepal
NAPA	National Adaptation Plan of Action, Nepal
NCVST	Nepal Climate Vulnerability Study Team
NGO	Non-Governmental Organisation
NPR	Nepalese Rupee
NPV	Net Present Value
NSET	National Society for Earthquake Technology
PM10	Particulate Matter of Size Less Than 10 Micrometer
SDR	Social Discount Rate
SLD	Shared Learning Dialogue
TSP	Total Suspended Particles
URBAIR	Urban Air Quality Management Strategy in Asia
USD	United States Dollar
VDC	Village Development Committee
VND	Vietnamese Dong

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The cost-benefit analysis (CBA) of the boat-winch system constructed in Da Nang was proposed, constructed and financed as a pilot project by the Asian Cities Climate Change Resilience Network (ACCCRN), supported by the Rockefeller Foundation. We gratefully acknowledge ACCCRN for funding this prior work. The analysis conducted in this section was made possible thanks to Ms. Nguyen Phuc Hoa of Challenge to Change (CtC) and Ms. Le Dang Thuy Trang of the Da Nang Department of Foreign Affairs (DoFA), who provided research facilitation, interpretation and translation of documents. We thank Laura Seraydarian, Research Associate at ISET, for providing valuable inputs to the preliminary research and writing. We are also grateful for the support and contributions of the Son Tra Committee for Flood and Storm Control and the Tho Quang People's Committee: in particular, Ms. Tran Thi Thanh Tam (Vice Chairman of Son Tra People's Committee), Mr. Mai Van Son (Officer of Tho Quang People's Committee), Mr. Le Van Soan (Chairman of Tho Quang People's Committee) and Mr. Tran Bac Viet (Director of Son Tra Department of Natural Resources and Environment). A specials thanks to Mr. Ngo Van Dang, owner of the original Tho Quang boat winch from 1982 to present.

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EXECUTIVE SUMMARY

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This report documents in detail the results of two case studies on the costs and benefits of investments in reducing climate-related and other disaster risks—one in Vietnam and one in Nepal—and briefly describes the community based qualitative cost-benefit analyses (CBAs) of some other disaster risk management (DRM) strategies.

The costs and benefits of any disaster risk reduction (DRR) intervention depend heavily on the nature of that intervention and on the local context. The first study focuses on a boat winch project initiated to protect the vessels of small-time Vietnamese fishers from damage and loss during extreme storms. The second study focuses on climate-friendly straw-bale building techniques in urban areas of Nepal and their risk reduction benefits in terms of earthquake safety as well as weather and climate. The third section of the report examines qualitative evaluations derived from a low-cost decision-support methodology that can complement or even substitute for an expensive quantitative CBA. These assess a diverse range of potential interventions for building climate resilience in rural areas of Nepal.

The three cases cover three different types of strategies for building climate resilience—medium-term, long-term and small-scale—all of which can play a role in the future of developing countries vulnerable to climate change.

The boat winch case is a low-cost, medium-term strategy which enables the most vulnerable to survive the more frequent and extreme storms likely to be associated with the onset of climate change. This strategy will reduce the negative economic impacts and the risk to lives and livelihood and will help buy enough time for vulnerable populations to diversify their livelihood. This strategy cannot, however, be used as an overarching, long-term one.

The straw-bale case looks at a long-term strategy for urban and peri-urban development that is risk-resilient and sustainable and has mitigation co-benefits. This is a "no-regrets" strategy that may take time to implement but will yield benefits at both the household and the macro level. As a theoretical, forward-looking analysis, it will need strategic pre-positioning to gain the institutional support and social acceptance it needs to be adopted at scale. There may also be technological and design issues to overcome in different climates. Assuming these challenges can be overcome, this strategy can lead toward a development pathway that is more environmentally and climate-friendly than the strategies most countries use today.

The qualitative studies of the third case illustrate the types of issues encountered in many small-scale rural risk management or development programmes. Such programmes often involve a range of activities such as watershed management, changes in agricultural practices, forestry, the development of self-help and early warning groups and livelihood diversification. The investments involved are often too small to justify a full-scale quantitative CBA. In fact, because of data limitations and other factors, merely conducting such an analysis would likely exceed the total amount of funding available for investing in the programme. Qualitative approaches, however, enable local communities to systematically sort out the environmental, social and economic costs and benefits of different activities and are very important for both internal decision-making within the programme and justifying such investments to external donors.

The CBAs of all three cases highlight the fact that investments in DRR, including those related to climate change, can have high returns under a wide range of scenarios. They also demonstrate, however, that the returns depend fundamentally on the specific nature of the intervention and the local context into which it fits. As a result, generalisations about the returns to investment in DRR are misleading. As demonstrated in some of Institute for Social and Environmental Transition's (ISET) earlier projects, poorly selected or poorly designed investments in DRM can have negative returns (Khan and Mustafa 2007). Consequently, the most important role of CBA is as a decision support tool for evaluating the economic viability of specific interventions in specific contexts. While the analyses, such as that conducted by the Risk to Resilience Team (2009), demonstrate that carefully designed and targeted investments in DRM can have rates of return that exceed most other development investments, the nature of the return is most important.

The two detailed case studies and the set of qualitative evaluations also illustrate important differences between the sorts of contexts frequently encountered in risk management programmes.

The Vietnam boat winch case is typical of many contexts where a small, targeted intervention by a non-governmental organisation (NGO), a government or other entity can generate clear returns. The intervention is very replicable (it could be done in many locations along the coast) but not particularly scalable (one or two boat winches are sufficient and there would be little additional return from

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having extra winches in the same location). Furthermore, investments in boat winches benefit a clear and very narrowly defined group of people (small fishers). Winches would not, however, reduce the aggregate level of risk faced by society as a whole from extreme coastal storms. Nevertheless, this small investment paves the way for a very vulnerable population to protect its existing income source in the short-term and to diversify its income sources in the long run.

The straw-bale construction in Nepal is a fundamentally different strategy from that of the boat winch strategy in Vietnam. At least in theory, introducing straw-bale as a primary building material is both a replicable and scalable activity. Urban areas are growing rapidly, so straw-bale techniques could be widely replicated and, if broadly adopted, could affect risk levels of entire urban populations. An external catalytic organisation, such as an NGO, could not, however, achieve such a large-scale change through narrow projects designed only to build straw-bale houses. While each straw-bale building constructed would reduce the risk for its inhabitants, aggregate risk reduction benefits will only be achieved if appropriate forms of straw-bale construction are "internalised" as a standard construction technique. Fostering internalisation requires adopting strategic approaches to build social demand or, when social demand is already high, taking advantage of windows of opportunity. Such strategic approaches require investment, not just in the technology itself, but also in planning, marketing, design, innovation and other activities that are wider in scope and possibly less tangible than those needed to promote a narrowly targeted intervention, represented by the boat winches in Vietnam.

These approaches may also require a phased implementation plan. As discussed in more depth later in this report, the initial introduction of straw-bale techniques in narrowly focused contexts (such as the construction of schools, NGO offices and a few homes) could be used to build skills and social awareness with the expectation that real demand would only grow following a major event, such as an earthquake. The approach would, in effect, involve the pre-positioning of skills, techniques and awareness in high-risk areas with the intent of drawing upon them much more broadly during post-disaster recovery. The approach is analogous to the pre-positioning of relief materials in areas known to be at risk.

The last case illustrates a qualitative method to support cost-effective, local investments in autonomous adaptation. These interventions are taking place even in absence of knowledge of climate, and are highly flexible and responsive. Although implemented without much scientific knowledge, they are based on ground realities and conditions and necessarily vary from place to place. They are very effective in responding to the myriad manifestations of climate change.

THE CORE MESSAGES THAT EMERGE FROM THESE THREE STUDIES INCLUDE THE FOLLOWING:

RETURN ON INVESTMENT

The returns on investments in climate DRM can substantially exceed the returns on most development programmes. Despite wide differences in contexts, returns to appropriately designed investments are high.

COST-EFFECTIVE ADAPTATION STRATEGIES

Cost-effective adaptation strategies can also work hand-in-hand with mitigation and sustainable development. In the case of straw-bale construction, not only does this kind of building save lives and reduce energy use for heating and cooling, but the resulting large-scale replacement of the brick industry can reduce carbon emissions.

TAILORING DISASTER RISK MANAGEMENT APPROACHES

Tailoring DRM approaches to the local context is fundamental. Achieving high returns depends on whether or not the activities undertaken meet needs and are sustainable within a specific context. As a result, the processes that enable strategies to be tailored to local contexts are as important as the individual components of any programme. ISET has used shared learning processes to successfully achieve such tailoring in a variety of situations. The shared learning process identifies and systematically evaluates and prioritises possible interventions with full community participation so that interventions are not only economically cost-effective, but also respond to the local physical, social and political-economic context.

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In addition to tailoring approaches to local contexts, issues of scale and replicability need to be recognised in order to develop clear strategies for designing and targeting programmes in ways that respond to those issues. In some cases, very narrowly targeted programmes can have clear risk reduction benefits for very specific populations (as in the boat winch example in Vietnam). In other cases, gaining the full benefit from an investment may require much more sustained and transformative strategies that may link risk reduction with post-disaster recovery (as in the case of straw-bale construction in Nepal). In yet other cases, replication requires simple processes to guide decisions within small-scale programmes where development and disaster management are intertwined.

Different forms of CBA can play multiple roles within the context of any given programme. Quantitative approaches to CBA are often utilised primarily as a mechanism to evaluate the economic returns on investments and to "make the case" to funding organisations. However, the process of conducting a CBA (whether quantitative or qualitative) generally leads to both strategic and practical intervention-related insights only at the project and programme levels. It takes a qualitative CBA to make the decision-making relevant to local communities and to reveal strategies that are frequently cost-effective, but might not otherwise have been considered. Where large programmes are concerned, qualitative evaluations can build ownership, help identify assumptions and clarify strategic issues. Such insights are often as important to achieving real benefits from a programme as a quantitative economic evaluation.

CHAPTER 1

COST-BENEFIT ANALYSIS OF BOAT WINCH SYSTEM

Da Nang City, Vietnam

FAWAD KHAN AND SARAH ORLEANS REED

INTRODUCTION

This report summarises the results of a cost-benefit analysis (CBA) conducted by ISET of a boat-winch system recently constructed in Da Nang, Vietnam. The winch was proposed, constructed, and financed as a pilot project of the Asian Cities Climate Change Resilience Network (ACCCRN). As described below, the CBA yielded a benefit-cost ratio of approximately 3.5. The quantitative and qualitative results of this study indicate that the winch system is a robust disaster risk reduction (DRR) measure and a medium-term climate adaptation strategy for Da Nang, with high potential for replication in other coastal fishing communities in Vietnam and elsewhere.

The boat-winch system constitutes one aspect of a larger, systematic process of climate change resilience planning in Da Nang through ACCCRN, a programme supported by the Rockefeller Foundation in 10 cities across Vietnam, India, Thailand and Indonesia. ACCCRN is one of the first donor-driven initiatives to address urban climate change in developing countries and employs a number of innovative methods to build local capacity and plan strategically for climate change. The programme began in Vietnam in 2009 by first identifying stakeholders and then fostering engagement, learning and action among them through a shared learning process. Shared learning dialogues (SLDs) which convened diverse stakeholders and external resource persons, provided input on, and review of, vulnerability assessments, pilot projects and in-depth sector studies on topics of interest. In mid 2010, local partners synthesised the knowledge and intervention ideas accumulated throughout this process and prioritised action areas using a variety of methods, including qualitative CBA. The city resilience strategies they developed represent a major milestone in urban resilience planning in ACCCRN cities. The current phase of the ACCCRN project will focus on the implementation as well as the ongoing review and updating of the strategies.

The boat winch case is the product of an intermediate stage of this process in Da Nang. Researchers used participant input from the first SLD to develop vulnerability assessments, including a community-level hazard, capacity and vulnerability assessment (HCVA). Results from the assessment were presented at the second SLD for questions, criticism, and validation. In addition, groups that had participated in the HCVA shared several ideas for experimental pilot projects that they believed would build resilience to climate change. These ideas

Table 1.1
Son Tra District Damage Data 2005–2010

Source: Son Tra CFSC 2010

LIST	2005	2006	2007	2008	2009	2010
DEATHS	0	8	0	0	2	0
INJURIES	15	103	0	0	7	0
SUNKEN SEA VESSELS	11	59	0	11	2	1
DAMAGED SEA VESSELS	172	121	0	5	48	0
AGROUND BOATS	21	174	0	0	13	0
COLLAPSED HOUSES	42	1	0	0	40	0
ROOF BLOWN OFF HOUSE (COMPLETELY)	247	3	0	0	78	0
ROOF BLOWN OFF HOUSE (PARTIALLY)	372	8	0	0	692	0
HOUSEHOLDS EVACUATED	655	3	0	0	2	0
INDIVIDUALS EVACUATED	2,275	16,363	0	0	6,741	0

included a proposal from a group of fishers in Tho Quang and Man Thai wards to construct a new boat winch to haul their boats onto shore before storms, based on a system that has been operating in the area for several decades. Other SLD attendees discussed and evaluated all project proposals, eventually selecting the boat winch project as highest priority for implementation. Project implementation (including local consultations and design, construction and refinement of the winch machine) launched in late 2009. The new winch began operation in August 2011 and will benefit boat owners in Tho Quang and Man Thai wards.

The HCVA results are supported by the data on damage in Son Tra district, given above. Historically, most of the damage has been inflicted upon small boats and houses along the east coast, which is where most fisher families live. As a coastal city, Da Nang is affected by sea storms, and both local officials and fishers have reported significant increases in intensity and frequency of these storms in the last few years. It has also been reported that the storms have occurred outside the usual storm season. One such storm in April of 2006 (Chan Chu) caught the people and authorities by surprise and caused unprecedented damage. Within the Da Nang population, fishers with small boats (less than 90 horsepower (CV)) are the most vulnerable to storms as they fish both near and off-shore. Since their small boats cannot operate in wind levels above 7 on the Beaufort

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scale, they cannot safely reach the harbour if they are far out at sea. The data on the previous page shows that fishers are the population most vulnerable to climate change-related risk in Son Tra district; not only does climate change cause damage to their boats and livelihood, but their homes are also at risk as most live near the South China Sea.

To conduct this CBA, researchers accessed a variety of primary and secondary sources and used both quantitative and qualitative data. They drew upon small meetings and communications with local authorities from Son Tra district and Tho Quang ward, focus group sessions with boat winch operators and local fishers in Tho Quang ward, district-level reports and documentation from the ACCCRN programme.

BACKGROUND

There are approximately 1,600 fishing boats in Son Tra district, with over 700 of these using the harbour in Man Thai and Tho Quang wards (Son Tra CFSC 2010). In Vietnam, boats are classified by CV and are permitted to fish only in the areas which correspond to their category: off-shore for those over 90 CV ("ships"), near-shore for those within 20-90 CV, and in-shore for those under 20 CV. Very few residents of Son Tra district own ships over 90 CV but such large ships do come to fish in Son Tra from other provinces. Most boats owned by Son Tra residents are under 45 CV. For reasons described below, the number of smaller boats has decreased in recent years.

The number of days a boat owner and his crew spend at sea depends on both the season and the size of the boat; during the high season a boat over 30 CV may spend as many as 15 days at sea while one under 20 CV may stay out just two or three days. Between trips, fishers rest and restock supplies for their next journey. Twice each year, boat owners bring their boats ashore for routine maintenance. Generally, boat owners try to minimise the time that boats spend out of the water to prevent damage to the paint on the hull. Boat owners say that they go to sea 7-8 months out of the year, although this duration varies with the weather and the individual fishers.[1]

Tho Quang and Man Thai wards have approximately the following number of boats in each category:

30-45 CV: 150 boats
20-30 CV: 120 boats
16-20 CV: 135 boats

(Son Tra CFSC 2010)

Storms have become more dangerous for fishers in this area in recent years. In the past, storm warnings did not surpass 12 on the Beaufort scale, yet recent storms have measured as high as 15 (Son Tra CFSC 2010). All fishing boat owners consulted through focus group discussions confirmed that storms in the last decade had grown stronger, more frequent and more difficult to manage. Historically, strong storms have occurred in Da Nang from August to November and with particular frequency in September and October. Recently, however, the city has experienced a number of serious and unexpected storms in April and May as well. The time between any two storms is shorter, hindering efforts to recover and prepare. Whereas in the past fishers relied on wind patterns to predict the direction of a storm, wind patterns have become irregular which has made it increasingly difficult to predict a storm's path.

Fishing communities in Da Nang enjoy the support of the local government, which actively pursues measures to reduce risks associated with this livelihood.

In spite of claims that the number and intensity of storms has climbed in recent years, the extent of damage and the number of injuries and fatalities has declined in the past two decades due to increased awareness, caution on the part of fishers, early warning systems and new DRR interventions by both the local government and boat owners themselves.

Since city authorities are concerned about the long-term viability of in-shore fishing, given that fish stocks close to the coast are on the decline, they have prohibited the construction of boats less than 30 CV and are discouraging the construction of any boats under 90 CV. The HCVA notes that overexploitation has reduced the profitability of fishing, which in turn has prevented fishers from investing in large, improved boats that would increase their yields. Compounding these issues is the construction of resorts with private beaches which have forced fishers to fish in smaller locations more densely packed with boats. HCVA researchers found that many fishers are opting for alternative livelihoods, such as factory work (CtC and Hue University 2009).

RESPONDING TO STORMS

When storms hit, two major factors allow fishers to avoid damage and injury: early warning systems, which advise them of the timing and trajectory of the storm, and the accessibility of safe, reliable shelter to protect boats and equipment. A variety of mechanisms for early warnings and options for safe harbour are present in Da Nang, as described here.

When storms hit, two major factors allow fishers to avoid damage and injury: early warning systems, which advise them of the timing and trajectory of the storm, and the accessibility of safe, reliable shelter to protect boats and equipment.

Early Warning System

According to local officials and fishers, fishers in Da Nang receive news of storms in a number of ways, as follows:

Radios

Via radios, near-shore and in-shore fishing boats receive both the local weather forecast and the official early warning for storms. According to the Son Tra Committee for Flood and Storm Control (CFSC), radios are acquired from a variety of sources, including the central CFSC's radio distribution programmes, other city programmes, personal income and families. Boat owners often purchase low-quality radios with the intention of saving to acquire higher-quality radios in the future. All the fishers consulted during this study have radios on their boats and are able to receive news broadcasts as long as the weather is not yet severe enough to disrupt signal.

In theory, the government issues a first warning 48 hours before a storm, a second 24 hours later, and then one every hour after that. Fishers, however, said that the exact timing of the first warning varies from several days to only 24 hours ahead of time.

Walkie-talkies

Off-shore boats are not within radio signal range and therefore rely on what locals call "talkie-talkies" to receive the official storm warnings. The CFSC said that because walkie-talkies are expensive most fishers rely on the government to provide them. The CFSC has issued 50 walkie-talkies to 50 groups, and boats also have shortwave radios so that they are able to communicate the warning to other members of their groups. Many near-shore boats consulted also have walkie-talkies on their boats and use them to communicate with one another.

"May Truc Canh"

A number of fishers in Tho Quang ward have received what they call "special machines" from the government—high-frequency radios which receive storm warnings directly from the central Centre for Coastal Safety, which releases storm warnings as early as a week in advance of a storm. Local officials from Tho Quang ward issue such radios to select fishing boats only, but these fishing boats can share the warning with others through walkie-talkies or shortwave radios.

Mobile Phones

When possible, families of fishers send forecast information directly to the fishers by SMS.

In the past, fishers were wary of turning on their radios for fear this would reveal their fishing location to competitors. According to the CFSC, this issue has diminished due to penalties for failure to use radios and advances in forecasting that increase fishers' trust in the warnings. Boat owners confirm that they are more likely to access and heed storm warnings due to the reliability of the warnings and heightened anxiety over changing and worsening storm patterns.

Consultations with fishers show variations in timing at which boats heed a storm warning and begin moving toward the shore. Both the Son Tra CFSC and the boat winch operators claimed that fishing boats attempt to remain at sea for as long as possible after they have received a warning, as the 24-hour period before

the storm can result in large catch sold at high prices. However, all owners of boats over 30 CV and some owners of boats under 30 CV claimed that they do not intentionally remain at sea, as it is simply too dangerous to do so. Owners of 20-30 CV boats and over 30 CV boats claimed that they return to shore immediately after receiving a warning. Only the owners of the smallest boats, 16-20 CV in-shore boats, confirmed that they remain at sea 7-8 hours before a storm in order to reap a high profit for their catch. Some of these owners noted their concern for large, off-shore boats, which are vulnerable to late warnings as they fish far from shore.

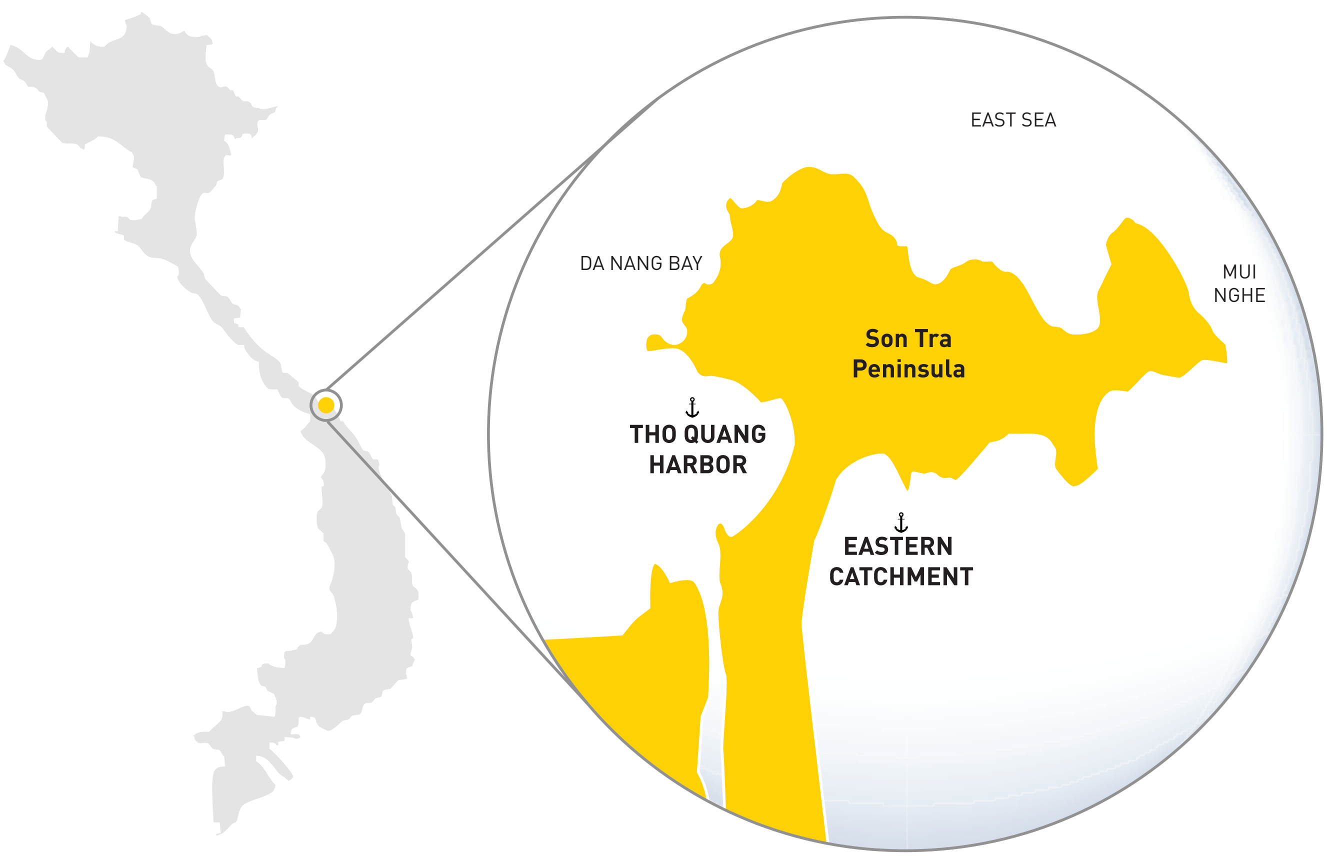
Son Tra boasts a strong record of risk reduction for fishers over the last two decades due to early warning equipment, increase in awareness and compliance from fishers. The improvement is evident in the difference between the hundreds of casualties caused by a medium intensity storm in 1989, and that of a strong intensity storm in 2006 (Xangsane) which caused only 6 casualties (Son Tra CFSC 2010).

SAFE SHELTER FOR BOATS

After receiving a warning that a storm is headed their way, fishers have two main options for seeking shelter. First, boats can choose to circumnavigate Son Tra peninsula (40 km) to shelter in the western harbour of Tho Quang, which is sheltered from storms in the East Sea. However, as a storm approaches, the route can be dangerous, especially around the point Mui Nghe. Boat owners indicated that they only try to pass Mui Nghe if the forecasts indicate a wind speed level of 8 or under on the Beaufort scale. If wind speeds surpass level 9, Mui Nghe is impassable and extremely dangerous. This option is generally more feasible for boats over 30 CV, which can make the journey in 3 hours, in contrast to small boats which can require 4-5 hours. Boats which fish north of Son Tra peninsula are also more likely to use Tho Quang Harbour than those that fish south or east of the peninsula.

Aside from the long and sometimes dangerous journey, boats arriving in Tho Quang Harbour must compete with a number of other boats to find anchorage sites.

Figure 1.1
Son Tra Peninsula



Aside from the long and sometimes dangerous journey, boats arriving in Tho Quang Harbour must compete with a number of other boats to find anchorage sites. Many of these are large off-shore vessels from neighboring provinces, and the crowded space causes boats to scrape against each other, causing vessel damage. Small boats are especially vulnerable. Though the harbour is sheltered from the worst impacts of the storms, occasionally boats sink or suffer damage. In addition, at least one person is required to stay with the boat while it is anchored, a duty which can lead to injury. Despite these risks, however, most of the fishers consulted during this study viewed Tho Quang Harbour as the safest and preferred option for escaping a storm. In principle, boats over 30 CV are expected to use Tho Quang Harbour while the Eastern catchment is reserved for smaller boats.

The decision to move either to Tho Quang Harbour or to the Eastern catchment is affected by the following factors:

1. Boat size; boats over 30 CV are more likely to opt for Tho Quang Harbour.

2. Location of fishing area (north or south); boats in the north are more likely to opt for Tho Quang Harbour.

3. Wind direction and strength; speeds over level 9 cut off access to Tho Quang Harbour.

4. Timing of the warning; small boats require advance notice to ensure sufficient time to reach Tho Quang Harbour.

The alternative to Tho Quang Harbour is to seek shelter on the eastern side of Tho Quang. The Eastern catchment is highly exposed to storms, so owners must drag their ships to the shore rather than anchor in the harbour. In such a case, the boat winch machine provides the safest and most efficient means for coming safely to shore.

THE THO QUANG CATCHMENT BOAT WINCH 1982–2011

Mr. Ngo Van Dang of Tho Quang Province has been operating a boat winch of his own design since 1982, when he first had the idea based on input from local fishers and from other provinces that had similar systems. The winch consists of a machine powered by an internal combustion engine attached to a metal cable that that can be released and pulled outwards, then drawn in again. To bring a boat to shore, an operator affixes it to a large wooden platform which is, in turn, attached to the cable. The winch is turned on, the cable is rolled in, and the boat is dragged to shore.

Mr. Dang operates the winch machine during most storms. The system also requires a number of skilled, strong line operators to affix boats to platforms (a difficult and dangerous job requiring operators to dive under water) to ensure the cable remains taut until the boat reaches the land. The number of boats that the winch can pull in each day before and during a storm depends on the number of wooden platforms and line operators. Prior to a storm, when the water is still placid, the winch system requires fewer line operators and can pull in a greater number of boats in a given period of time than when the sea is choppy and fierce.

Mr. Dang explains that when boats arrive at the shore, he gives priority to pulling in the boats of line operators so that they can assist in pulling in other boats. Fishers, on the other hand, complain that Mr. Dang prioritises family members and makes others wait. Owners of small boats (those under 30 CV) reported that, despite the long waits, their boats were always pulled to safety before a storm. Large boats (those over 30 CV), in contrast, fish further out to sea and are therefore more likely to arrive later, leaving insufficient time to be winched in before a storm. If they are too late, they have two options: they may anchor their boat in the catchment, usually alongside an army station where the fishers themselves can safely wait out the storm. This can result in damage to the boat, sinking or it being swept into the South China Sea. Alternatively, boat owners may drive their boats directly onto the shore, causing certain damage but ensuring the boat will not be sunk or lost completely. Large boats over 30 CV sometimes take the risk of anchoring in the harbour, but small boats rarely do as the risk for them is high. The CFSC and winch operators note that sometimes additional resources, including members of the army and construction cranes, are brought in to assist the remaining boats in the harbour. Using cranes, however,


Video of the old winch: http://www.youtube.com/watch?v=lbOaMSzvArQ

has often damaged boats. In addition, because the Eastern catchment is not well protected from strong winds, even boats which have been pulled on-shore by the boat winch may suffer damage.

Each of the options available to fishers during a storm has an associated risk of damage. The costs of repair, replacing a ship and days of lost work vary depending on the type of boat and the nature of damage. Other factors are also considered by Mr. Dang and boat owners when deciding to pull a boat to shore, described below.

Capacity of Winch

The original winch built by Mr. Dang in 1982 was fixed to one location and had an 18-CV engine; it was capable of pulling in boats of up to 30 CV at the rate of 10 boats per day before a storm, or 20 boats in total if the warning was received two days in advance. In 1996, Mr. Dang upgraded the system, putting it on a tractor so that it could be moved to various parts of the shore as needed, and installing a 30-CV engine. This new system was able to pull in boats of up to 45 CV and as many as 15-20 boats in one day before a storm. Once a storm hits, the winch can pull in about three boats per day. The winches ability, however, is limited by available labour for affixing boats to platforms and is done with assistance from the army personnel stationed nearby.

In addition to rescuing boats before and during storms, the winch is used to pull boats to shore for routine maintenance. Mr. Dang estimates that he receives roughly three times as much income providing this regular service than from his evacuation and rescue services.

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According to Mr. Dang, the effectiveness of both the stationary and the mobile winch systems before and during a storm depends on 1) the number of available line operators, 2) the skill of the machine operator and line operators

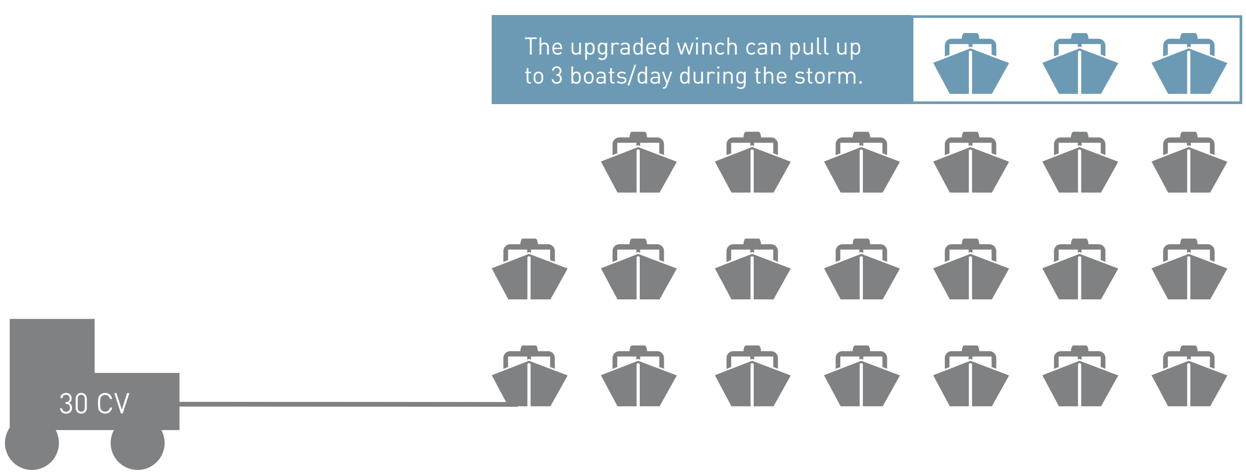
FIGURE 1.2
Capacity of the 1982 and the 1996 boat winch

CAPACITY OF THE 1982 WINCH

The original boat winch system was fixed to one location and had an engine of 18 CV; it was capable of pulling in boats of up to 30 CV at the rate of approximately 10 boats per day. It was not capable of operating during a storm.

CAPACITY OF THE 1996 WINCH

The upgraded boat winch is now mobile. With a stronger engine of 30 CV, the winch can pull boats of up to 45 CV and as many as 15–20 boats in one day before the storm. Once the storm hits, the system can pull roughly 3 boats per day with assistance from operators.



and 3) when fishers heed the warning. Mr. Dang claims that most fishers do not choose to come in more than two days before the storm, even though the warning is often received well in advance of this. Mr. Dang avers that if boats arrived sooner than they currently do after receiving a storm warning, the winch could pull more boats into shore before the storm.

Several boat owners claimed that increasing the number of platforms would increase the number of boats that the winch could pull to shore in a given period of time and that currently there are not enough platforms. One group commented that a strong storm, such as Xangsane in 2006 (a Category 4 storm with winds 210-249 km/h and seas 4.0-5.5 m), can overwhelm the winch.

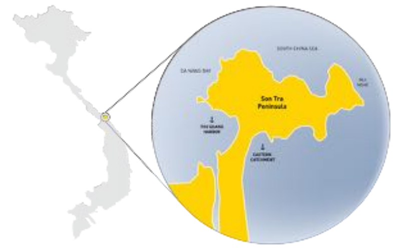
Fees

Depending on the size of the boat, Mr. Dang explained that he charges 500,000-600,000 VND (24-29 USD) to pull boats both onto the shore and back out to sea. These rates are consistent with the costs quoted by boat winch users. Some owners noted that there was an additional cost for boats to remain on platforms while they are on-shore, an option that reduces the time and effort needed to pull boats back to sea. Boats under 30 CV benefit from a subsidised fee paid directly to Mr. Dang by the local government in emergency cases. According to an officer of the Tho Quang People's Committee, the subsidy reduces their costs to 200,000 VND (about 10 USD). It was not clear whether owners were aware of the subsidy or whether they assumed the lower rate was the normal fixed price for boats under 30 CV. Boats over 30 CV do not benefit from this policy as, they technically should use Tho Quang Harbour.

Costs of Production and Operation

Mr. Dang was not able to estimate the cost of duplicating his winch system, although he estimates that the engine alone would cost about 10,000 USD. The old system has lasted a remarkably long time (since 1982, with regular maintenance and intermittent upgrades of machinery), a longevity which Mr. Dang attributes to private rather than public management. Boat winch operators receive 150,000 VND (about 7 USD at the time of writing) per day of work.

Figure 1.3
Flow Chart of Shelter Options and Risks for Fishing Boats



Decision to go to Tho Quang Harbor
(more likely for > 30 CV boats)

Boat Arrives Safely at Harbor
(Sufficient time to find a secure place to drop anchor)

- **Frame Scratched**
(Due to crowds)

Boat Arrives Safely at Harbor
(Insufficient time to find a secure place to drop anchor)

- **Frame Scratched**
(Due to crowds)
- **Boat Damaged in Storm**
(Frame and propeller damaged)
- **Boat Sinks in Harbor**
(All equipment lost, and engine damaged)

Boat Caught in Storm

- **Boat is Damaged in Storm**
(Frame and/or equipment lost)
- **Boat Sinks at Sea**
(Boat and all equipment lost)

Decision to go to Catchment
(more likely for < 30 CV boats)

Pulled by Winch System

- **Boat Overturned by Wind, Resulting in Damage to Frame**

Unable to Be Pulled by Winch System

- **Drive to Shore**
(Propeller and Frame damaged)
- **Anchor Near Military Base**
  - **Boat Sunk in Harbor**
(All equipment lost, engine damaged)
  - **Boat Carried Away by Strong Current**
(Boat and equipment lost)
- **Boat Sunk in Harbor**
(All equipment lost, engine damaged)

Insufficient Warning to Travel to Shore
(Boats seek shelter at Sea)

- Damage to Frame and/or Equipment Lost
- Boat Sinks at Sea
(boat and all equipment lost)

TABLE 1.2

ADVANTAGES/DISADVANTAGES OF WINCH SYSTEM VS. THO QUANG HARBOUR

ADVANTAGES	
WINCH SYSTEM	**THO QUANG HARBOUR**
MONEY Savings on cost of fuel	**MONEY** Cost of fuel to arrive in Tho Quang Harbour is lower than the fee for using the winch system
SAFETY No one is required to stay on ship	**TIME** Easier and less time consuming to go back to sea after storm
TIME Faster arrival to shore	

DISADVANTAGES	
WINCH SYSTEM	**THO QUANG HARBOUR**
CAPACITY Strong storms can overwhelm the winch system, which occurred during Xangsane in 2006	**CAPACITY** If the larger fishing boats arrive late, they may not find a place to anchor in the harbour
DAMAGE While on-shore, boats can suffer damage or be overturned from strong winds, which occurred during Xangsane in 2006	**DAMAGE** The harbour is poorly organised and crowded, and smaller boats can be scratched against larger ships
MONEY After remaining on-shore, boat owners must repaint the frame of the ship due to scratches	**SAFETY** Route between fishing area and the harbour is dangerous during storms, especially around Mui Nghe
MONEY Cost of using the winch system is higher than the cost of fuel to arrive in Tho Quang Harbour	**SAFETY** One fisher must remain on the boat in the harbour during the storm, which can result in injuries
TIME Fishing boats must wait until platforms are available. Larger boats that arrive later may not reach the Eastern catchment with sufficient time to access the winch system	
TIME After a storm boat owners may be required to wait up to 10 days to have their boat moved back to sea because of a long queue	

Boat Winch Clients

The users of the existing private winch system include both near-shore and in-shore boat owners. Mr. Dang estimates that about 60% of his clients are owners of boats 16-20 CV and 40% are owners of boats 30-45 CV. Consultations with owners of boats over 30 CV suggested that the winch system is used mostly for smaller boats and only in emergency cases for large boats (when they cannot reach Tho Quang Harbour before a storm). Most of the focus groups contained several people who identified themselves as boat winch users, meaning that they had used the winch on a number of emergency occasions and may have a verbal agreement with Mr. Dang that gives them priority for pulling. Even those who have no such agreement with Mr. Dang can use the system, however. Some participants in the focus group discussions had never or had rarely used the winch system in the past.

In addition to the list of advantages and disadvantages in Table 1.2, discussions with Mr. Dang and the workers at the winch indicated that there are two other major advantages of the winch system. Thus far, these have not been confirmed by fishing boat owners:

Less Damage

Using the winch results in less damage to the boats than if boats were pulled ashore manually. According to the winch operators, pulling a boat ashore by hand usually damages it and requires that it be repaired before being put back in the water. When fishers were asked about their options for coming on-shore, however, they did not identify pulling boats up manually as an option except in the case of small bamboo boats. Unlike large boats, small bamboo boats can be pulled ashore using a simple vehicle which is easier to use and less costly than the winch system.

Lack of Disruption to Livelihoods

Mr. Dang and the winch operators claimed that using the winch saves time, allowing fishers to return to sea following a storm much faster than if they pulled their boats back to sea manually. They estimated that pulling a boat manually requires about 15 days (including the time to repair it), whereas the winch system takes 30 minutes and eliminates the need for repairs. Boat owners, however, said that after a storm they usually wait as long as 10 days to go back to sea in case another storm comes that would require them to invest additional time and money in coming to shore again. Boat owners that anchor in Tho Quang Harbour, however, can resume fishing immediately though most said they wait for a few days for the weather to clear and use the hiatus to repair and maintain their boats.

Manually pulling ashore a boat requires about 15 days (including the time to repair it), whereas the winch system takes 30 minutes and eliminates the need for repairs. Boat owners, however, said that after a storm they usually wait as long as 10 days to go back to sea in case another storm comes that would require them to invest additional time and money in coming to shore again.

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IMPACTS ON HOUSEHOLDS

Boat-owning families that were consulted during this study claimed that their profession is growing increasingly more difficult. Moreover, money earned from fishing is increasingly covering only the basic necessities of life. Inflation has driven up the prices of basic products, but this does not necessarily mean that their catch can be sold at higher prices. In particular, focus group participants shared their concern over the rising cost of fuel, which is controlled by the Vietnamese government and was recently raised.

Focus group sessions also indicated that storm damage causes serious stress for boat-owning families. Repairs are costly, especially when normal livelihoods are disrupted. Fishers usually sell their catch to a wholesaler, and often, the wives of the fishers additionally buy and sell fish from other sources at the local market. Earnings are around 50,000-70,000 VND (2.40-3.40 USD) if all catch is sold. After a storm, families can lose both incomes.

If boats are damaged, families often incur large debts in order to repair or replace them. Boat owners borrow from family or from local lenders, with interest rates at around 6-7% monthly, resulting in the accumulation of large debts. One woman said that her family had lost their boat twice in recent years, compelling them to take out a loan of 70,000,000 VND (3,398 USD) at a monthly interest rate of 7% on two separate occasions, in addition to borrowing money from relatives. The family has repaid the loans but still owes money to the extended family. Women interviewed during focus group discussions stated that they experience constant anxiety due to the fear of bankruptcy and losing their boats or homes.

THE NEW WINCH SYSTEM

As described earlier in this chapter, the boat winch project in Tho Quang Harbour was identified as an ACCCRN pilot project following consultations by researchers from Challenge to Change (CtC) and Hue University with community members in Tho Quang and Man Thai wards. Community members presented the idea to stakeholders at SLD 2 of the ACCCRN programme, where it was selected as a priority project. After receiving approval from the Da Nang ACCCRN Project Steering Committee and co-financing from Rockefeller Foundation, the CFSC worked closely with fishers and Mr. Dang, the owner of the existing winch, to design a new, higher-capacity winch. The VINASHIN ship-building company led the design (in consultation with fisherman) and produced the winch. Initially, the design incorporated a Chinese-made engine that engineers assessed as weak. The redesign, which used a stronger, Japanese-made engine instead, was double the cost. The increase was absorbed by the Da Nang People's Committee.

The winch has been tested with the new engine, but due to design delays, it is not yet operational. Fortunately, there were no major storms in 2010, so the winch was not needed. Most of the fishers consulted during this study were not aware that there was a new winch.

REGULATIONS AND OVERSIGHT

Unlike the existing privately owned and operated winch, the new winch will be publicly managed. The district and ward-level people's committees have not yet established regulations for the oversight or operation of the new winch. Because they intend to involve community members in coming up with a set of procedures, details at this point are quite vague.

According to the CFSC, 18 "young and strong" fishers will serve as line operators for the system. Officials indicate that the new government winch will most likely operate only in response to storm warnings and during storms, and not, as Mr. Dang does, to pull boats ashore for maintenance. The decision of whether to assign a fee for the service, as well as the cost of that fee, was unclear at the time of writing. Early discussions during the design phase suggested that the new winch system would serve fishing boats under 30 CV only; however, more recently, the

Video of the new winch: http://www.youtube.com/watch?v=UtjaXP4GGZs

Tho Quang People's Committee shared that boats over 30 CV will also have access to the winch, despite regulations specifying that they should anchor at Tho Quang Harbour. Mr. Mai Van Son, the officer from Tho Quang People's Committee, expects that the system will operate on a "first-come, first-serve" basis and that the Da Nang People's Committee may impose an appropriate price for the use of the winch based on community consultations. The CFSC has a budget for maintenance and fuel but has not yet estimated these costs. Mr. Son expects that the fees charged will need to cover the cost of labour for line operators, but again, this supposition has not been confirmed or wages fixed.

Both Mr. Son and Mr. Dang said that they do not expect problems will arise due to competition if the government winch charges a fee lower than that for use of the private winch. At the same time, the Son Tra CFSC indicated that the new winch would eventually replace Mr. Dang's winch, which is made of low quality materials and lacks safety features for the operator (such as a protection shield should the cable break and lash backwards, and a light for nighttime operation).

Capacity

Although the Son Tra CFSC does not know the exact capacity of the new winch, it is expected that all boats will be accommodated by the two winches in future storms in the time following the first storm warning (issued 48 hours before a storm strikes). Mr. Dang predicts that, operating at full capacity, the new winch system will be able to pull ashore 25-30 boats per day (or 50-60 in the 48 hours before a storm strikes). Mr. Dang and the operators note that, as with the old winch, the new winch will be able to pull ashore more boats prior to a storm than during the storm. Local officials expect that the winch will be able to operate until a storm reaches level 7 on the Beaufort scale.

Production and Maintenance Costs

As described above, VINISHIN produced the winch in close consultation with the fishers and the community. Initial cost estimates for the winch system were approximately 25,000 USD issued as a grant from the Rockefeller Foundation and a local contribution of 1,500 USD. The redesign midway through the project, which called for a Japanese-made engine rather than initial Chinese one, doubled the original estimate to 45,135 USD or 929,781,000 VND.[2] Son Tra People's Committee contributed the additional funding.

STORM DAMAGE DATA

The local CFSC provided a limited amount of data on historical storm damage in Tho Quang and Man Thai wards in the form of annual damage reports for the years 2005, 2006, 2008, 2009 and 2010. In 2005, a major flood wiped out the committee's computer and paper files, so no prior data is available. There is no report from 2007 as the district did not suffer any major storms that year.

Description of Data Collection

According to Son Tra CFSC, each ward, including Tho Quang and Man Thai wards, is responsible for collecting damage data and issuing an immediate report within 2-3 hours after the storm. The 25 members of the Son Tra CFSC and approximately 15 additional People's Committee staff members are responsible for specific wards. They work with the section-level staff of the ward-level CFSC and with volunteers to collect data. The CFSC's are aware of the most vulnerable areas, and distribute their task force accordingly. After 24 hours, each ward issues a full ward report to the district. The district compiles all ward reports and sends these to the Da Nang People's Committee and the Da Nang Committee for Flood and Storm Control, which assembles all the storm damage reports for use in informing the central government and the media. At the national level, authorities use the data to allocate relief and to request assistance from NGOs and international NGOs (INGOs). The INGOs, in turn, conduct rapid field assessments to verify the reports. The Son Tra CFSC states that the primary function of the reports is to inform the media and solicit relief.

2 Phases of Relief
Emergency relief which is heavily financed by the local budget.

Reconstruction for which external government support is required.

Relief and Compensation

Relief comes in two phases: emergency relief, which is heavily financed by the local budget; and reconstruction, for which external government support is required. The central government does not offer direct compensation for damage or loss. However, Da Nang has a budget to provide support to households suffering loss from damage to fishing boats or homes, on a case-by-case basis. The amount provided depends on the severity of the damage. For instance, owners of large boats receive more support than those with smaller boats, and owners of severely damaged houses receive greater support than lesser damaged houses. The CFSC explained that the amount allocated usually increases each year, which it sees as an indication of the state's commitment to post-disaster recovery. The amount granted by the city also depends on the amount of insurance money a victim receives, with greater support for those whose insurance companies do not provide adequate relief. The CFSC also offers training for new jobs and credit (1-2 year loans) following a storm.

The types of damage recorded in the reports include (but are not limited to) the following:

- Loss of life
- Injuries
- Sunken fishing boats and ships[3]
- Lost or damaged fishing boats and ships
- Fishing boats run aground
- Collapsed houses
- Houses with roofs partially blown off
- Houses with roofs completely blown off
- Evacuated households
- People evacuated

The data on damages does not include damages to fishing boats that may have drifted in from other districts, as damages are reported in their respective districts. The CFSC notes that boats that have drifted in from outside the area are usually very large boats (over 90 CV), and thus suffer little damage anyway. Mr. Dang's old winch and the government's new winch were designed for local boats, which are mainly small or medium-sized ones (less than 45 CV). Son Tra has a fairly large population of temporary residents pursuing education or working in the district, but most of them are registered migrants, so they are included in the damage data. Few of these migrants are boat owners (Son Tra CFSC 2010).

The reports are not uniform in the type of information they provide or the method in which information is aggregated. In some cases, the reports provide monetary estimates of loss and the amounts of relief provided.

Insurance Coverage

Regulations compel fishers to purchase both "hull" and "crew" insurance (state, private or foreign), but small boat owners often ignore these regulations. Data on recent insurance claims is unavailable at this point in time.

COST-BENEFIT ANALYSIS

This CBA is based on an estimation of losses from extreme events and is derived from cost comparisons of the project, with the cost of the avoided losses. Since the existing winch is sometimes unable to pull all the boats to shore and cannot pull in boats larger than 30 CV, the benefits are calculated by estimating the number of additional boats that can be pulled in with the new winch. There may also be benefits in having a winch that are unrelated to reducing storm risks. For example, the winch could be used for hauling boats to the shore for repair or for safe berth during the off-season.

RESULTS

The investment in the additional boat winch, even at the revised cost, still yields positive returns to the investment.

The CBA of the new boat winch system yields a benefit-cost ratio of approximately 3.5 at the social discount rate of 12%. The analysis assumes that the winch will last 30 years. The high internal rate of return means that the results are also valid for much higher discount rates. The net present value is calculated at 4.7 billion VND (228,157 USD) for an initial investment of about 1 billion VND (48,544 USD). In this case, the new boat winch is to be used in tandem with the existing winch. Had it been the sole boat winch in the area, the ratio would have been much higher. The investment in the additional boat winch, even at the revised cost, still yields positive returns to the investment.

Although the results are based on a short-scale of time, they are fairly robust. The short-term data has the advantage of capturing both the increased climate-related risks and also the benefits of improved weather forecasting and communication of storm warnings. Large variations in the primary data collected and the sometimes contradicting data from different sources, makes this analysis susceptible to errors. Sensitivity analysis, however, shows that even large variations result in the same conclusion. More specifically, the cost-benefit ratio remains well above 1 for different social discount rates. Some data—like fishing income, the cost of repairs and operational cost—may change the exact value of the final ratio, but the results do not vary substantially.

DATA AND LIMITATIONS

The CBA is highly dependent on the quality of data available. For climate-related data, it is important to have reliable data for long periods of time (at least 25 years). However, in developing countries it is rare that such a long history of data is available, and researchers must derive their results from limited sources. In this case, just six years of data was available. In addition, there were discrepancies in the nature of the primary data.

DAMAGE DATA

The damage data collected from Son Tra CFSC is provided below and spans only six years between 2005 and 2010 (in 2007 there were no major storms).

Since the nature of damage has changed significantly over time, the limited range of data actually provides a more accurate CBA. Interviews with fishing communities and local officials confirm that both the accuracy and quality of early warnings, as well as the means of communicating the warnings, have improved greatly. In particular, weather forecasting at the national level has been upgraded and modern technologies such as cell phones, walkie-talkies, FM radio and, more recently, high-frequency radios, have drastically changed how storm warnings are disseminated. During the 2004 storm season, there were no warnings and damages were high. Now, there is warning at least 24 hours in advance and, in some cases, it is compulsory for boats to come to shore. Boats that do not comply with warnings are not eligible for compensation from the government for any damage they may suffer.

The damage categories that the boat winch can eliminate are the number of boats which either sink or are run aground. The largest category of boat damage is to anchored and beached boats.

The damage categories that the boat winch can eliminate are the number of boats which either sink or are run aground. The largest category of boat damage is to anchored and beached boats.

TABLE 1.3
Damage to boats and ships: 2005–2010

LIST	2005	2006	2007	2008	2009	2010
Sunken boats and ships	9	15	0	11	1	1
Damaged boats and ships	4	26	0	5	6	0
Aground boats	12	74	0	0	11	0

Data provided by Son Tra CFSC 2010.

HAZARD DATA

Hazard data, in terms of wind speeds, was not available over the long-term for Son Tra district or for Da Nang. The wind levels for various storms over the period studied (2005-2010) were not specific to the eastern harbour or to the catchment area of the study. Hence, there was little correlation between the actual damage quoted previously and the wind levels on the Beaufort scale. Instead, damage was determined by the intensity and direction of the wind in the study area.

Because of these deficiencies in data, the reported analysis was used as an estimation of future damages for the lifespan of the project. The implicit assumption is that the weather pattern of the last six years is representative of what is to be expected in the next 30 years. The implication of this assumption is that if there is significant worsening of extreme weather events, the damage averted will be greater than what has been estimated, making the analysis a conservative one. This conservative bias will hold true until the point at which storms are so strong that beached boats are no longer safe. On the other hand, any further improvement in the prediction of extreme weather events and warning systems may reduce future damage, which would make the analysis over-estimate the benefits.

COSTS

Most of the data on costs was taken from an accounting report of the Son Tra People's Committee. There is also some data on the cost of livelihood lost because of false alarms, data which was collected from interviews with boat-owners.

BENEFITS

The benefits in terms of DRR are the losses averted because of the introduction of the government boat winch. In this case, most of the benefits were calculated on the basis of data collected through interviews with owners of boats of various sizes and triangulated with the following sources:

- Interviews with boat workers;
- Son Tra CFSC and officials from Tho Quang ward;
- Interviews with the wives of boat owners/fishers; and,
- Operator of the current winch system.

For various reasons, including translation, vested interests and the way the data was collected or interpreted, there was often inconsistency in the primary data. Triangulating various sources and repeating interviews resolved some of the issues, but in other cases, estimates were made. In such cases, estimates were conservative. Thus, the results quoted can be said to be those for the worst-case scenario.

Additionally, in terms of the damage averted, this analysis assumed that the winch would save only 5% of the boats that were run aground. Looking at the decision tree matrix for boats to seek shelter, however, that proportion could easily be over 25%. Similarly, only 25% of the boats lost at sea were considered to be in a position to be saved by the new winch, though this figure could realistically reach up to 50% given the danger of going round the Mui Nghe and the fishers' knowledge that the Eastern catchments had additional capacity for pulling boats ashore.

One of the main benefits from the new winch that was identified by most stakeholders could not be quantified. The boat owners and the Son Tra district authorities said that the biggest value of the new winch is the "peace of mind" that fishers would get from knowing that their boats can be hauled ashore in time and that they would not have to wait for hours to see whether they could be rescued. Some fishers also said that if their boats were hauled in early they would be able to go home and take precautionary measures to reduce damages to their houses and, if necessary, organise a timely evacuation.

The boat owners and the Son Tra district authorities said that the biggest value of the new winch is the "peace of mind" that fishers would get from knowing that their boats can be hauled ashore in time and that they would not have to wait for hours to see whether they could be rescued.

CONCLUSIONS

INSIGHTS

Although the boat winch project was planned as a humanitarian project for which the capital cost did not have to be reclaimed, analysis shows that the additional boat winch is indeed a cost-effective investment. The damage averted will save enough money in terms of damage compensation to pay for purchasing and maintaining the equipment. If there had been no boat winch in the area, then the savings from damages averted would have been substantially higher. Moreover, the revenues from hauling boats ashore for repair, maintenance and safe storage in the off-season would also bring in substantial revenue. Mr. Dang, the current winch owner, said that he made three-quarters of his revenue from the non-emergency activities throughout the year. Moreover, by engaging in such non-emergency operations, the winch would be kept in working condition and would be operational when an emergency arises.

Analysis shows that the additional boat winch is indeed a cost-effective investment. The damage averted will save enough money in terms of damage compensation to pay for purchasing and maintaining the equipment.

Vietnam has a very long coastline along the South China Sea and the increase in frequency and intensity of storms as well as the occurrence of more off-season storms has increased fishers' exposure to risk. For this reason, the winch system has potential along global coastlines where communities of fishers live. Because of their modular nature, mobility and small ecological footprint, these systems are much more suitable than large, permanent infrastructure. The larger infrastructure would be much more expensive, have a profound environmental impact and fail beyond designed threshold causing massive damages on people living in false perception of complete safety. The low cost and the business model behind the Vietnamese boat winch system makes it very sustainable, and it is still operational and earning a profit 15 years after it was last renovated.

LIMITATIONS

The main limitation of the boat winch is that it caters to small boats. Because of the higher risk associated with fishing and the decline in fishing stocks close to the shore, both climate change and the increasing population are adversely impacting livelihoods dependent on these boats. The coastline in the catchment area is being developed for tourism and multiple resorts and restaurants are being built. Very soon there will be very little area left for small boats to fish. In fact,

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in the future, the government plans to allow only large deep-sea boats of 90 CV to be manufactured. These can be anchored safely in Tho Quang Harbour. Since no new small boats are being manufactured, this form of livelihood will not last much longer, and soon there will be no use for the winch.

When communities were asked why they continued to work in the small fishing sector, despite the sector's future, they answered that fishing was the only skill that they had. Fishers' wives said that none of their children were learning the fishing trade. The younger generation were either going to work in factories or, if they could, were going to university to study other professions.

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THE WAY FORWARD

Boat winches seem to be a cost-effective and suitable solution for the most vulnerable communities of Da Nang. Since this form of livelihood is slowly becoming non-viable, this low-cost option is much preferred to a large structural intervention. It will provide the necessary buffer for the next couple of decades before the next generation of fishers diversify their livelihoods. Livelihood diversification is the ultimate long-term option for small boat owners. With the rise in tourism, some can use their boats to provide entertainment to tourists. A small group of boat owners voluntarily guard and protect coral reefs along the coast. A rise in conservation may provide opportunities for eco-tourism services like scuba diving. For those who decide to abandon their boats, the tourism industry, if it is successfully developed, may provide alternative jobs.

ENDNOTES

1 During a focus group session wives of fishers claimed that changing weather patterns had reduced the number of fishing months per year to 3-4. The reason for this discrepancy is not clear.

2 Reed, S. and Nguyen P.H. (November 2010), Meeting with Son Tra Committee for Flood and Storm Control, Son Tra district, Da Nang.
The exchange rate used in this report is 20,600 VND = 1 USD.

3 "Ships" in the damage reports refers to large vessels over 90 CV.

PERSONAL COMMUNICATIONS

MEETINGS AND COMMUNICATIONS

Reed, S. (September 2010), Skype communication with Nguyen Tri Dzung.

Tyler, S. (October 2010), Site visit, Tho Quang ward, Da Nang.

Reed, S. and Nguyen P.H. (November 2010), Meeting with Son Tra Committee for Flood and Storm Control, Son Tra district, Da Nang.

Reed, S. (January 2011), Email communication with Tran Thi Thanh Tam, as translated by Le Dang Thuy Trang.

Nguyen P. H., S. Reed and Le D.T.T. (March 2011), Interview with Mr. Dang, Tho Quang People's Committee Office, Da Nang.

Nguyen P. H., S. Reed and Le D.T.T. (May 2011), Meeting with Mr. Mai Van Son, Tho Quang People's Committee Office, Da Nang.

Khan, F., S. Reed and Nguyen P.H. (June 2011), Meeting with Son Tra district and Tho Quang ward officials, Tho Quang People's Committee Office, Da Nang.

Khan, F., S. Reed and Nguyen P.H. (June 2011), Meeting with Mr. Dang and representatives of VINISHIN Co., Tho Quang People's Committee Office, Da Nang.

FOCUS GROUP SESSIONS WITH THO QUANG RESIDENTS

6 operators of private boat winch system, Tho Quang ward, Da Nang, March 2011.

8 owners of boats over 30 CV, Tho Quang People's Committee Office, Da Nang, May 2011.

7 owners of boats over 30 CV, Tho Quang People's Committee Office, Da Nang, May 2011.

8 owners of boats over 30 CV, Tho Quang People's Committee Office, Da Nang, May 2011.

8 owners of boats 16-20 CV, Tho Quang People's Committee Office, Da Nang, May 2011.

10 owners of boats 20-30 CV, Tho Quang People's Committee Office, Da Nang, May 2011.

6 women from boat-owning households of over 30 CV, Tho Quang People's Committee Office, Da Nang, May 2011.

4 owners of boats over 30 CV, Tho Quang People's Committee Office, Da Nang, June 2011.

4 owners of boats 20-30 CV, Tho Quang People's Committee Office, Da Nang, June 2011.

4 owners of boats under 20 CV, Tho Quang People's Committee Office, Da Nang, June 2011.

6 women from boat-owning households of various CVs, Tho Quang People's Committee Office, Da Nang, June 2011.

CHAPTER 2

MULTI-HAZARD RISK REDUCTION COST-BENEFIT ANALYSIS OF STRAW-BALE HOUSING

KATHMANDU, NEPAL

FAWAD KHAN, AJAYA DIXIT, SANTOSH SHRESTHA AND KANCHAN DIXIT

INTRODUCTION

Nepali people are constantly exposed to two or more types of disasters at any given place and time (MoHA and DPNet 2009). The most common disasters in Nepal are earthquakes, floods, landslides, drought, fires, avalanches, glacial lake outburst floods, hailstorms, thunderbolts, cold waves, heat waves and epidemics. Of these, earthquakes have the greatest potential to cause mass casualties and property destruction in any given event. To address the risks associated with earthquakes in Nepal, there is a great need for appropriate, affordable, energy-efficient, environmental-friendly and earthquake-resistant building methods and materials.

The objective of this study is to perform an *ex ante* cost-benefit analysis of straw-bales as a construction material in Kathmandu Valley. Straw-bale structures are resistant to earthquakes and also offer good insulation. The largest benefit of straw-bale construction would be saving of lives in an earthquake. It is, however, difficult if not inappropriate, to place an economic value on human lives. Therefore, this study does not take into account the lives and injuries saved. Moreover, the current construction practices (with regard to earthquake proofing) show that the majority of people who have not witnessed a major earthquake in their lifetime tend to underplay life risk in their decision-making. They are much more likely to make decisions on construction material/standards based on financial and other practical considerations such as availability of materials, technology and other aesthetic concerns. Without attempting to estimate the economic benefits from lives saved, making a house from straw-bale instead of bricks yields a cost-benefit ratio of 2.0 using a 12% social discount rate (SDR) and a project period of 30 years.

Since straw-bale construction costs 16% less than brick construction, most of the financial benefits accrue in the first year after construction. Discounting future benefits in terms of reduction in heating and cooling costs further increases the cost-benefit ratio. Therefore, straw-bale construction will remain cheaper than brick construction even if discount rates are increased. Most of the micro level financial benefits of this technology come from the fact that straw-bales cost less than bricks and save over the long run in expenditures on heating and cooling, expenditures which are likely to increase with the impact of projected climate change scenarios. Sensitivity analysis on the price of rice straw shows that

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straw-bale construction will remain more economical even when the straw prices increase over three fold due to high demand for construction. Nepal produces enough straw that, in theory, it can replace brick production with straw-bales.

The financial benefits aside, it is important to recognise that straw-bale construction technologies can save lives. Based on published death rate projections, 40,000 human lives are at risk (NSET and GHI 1999). Because the cost of straw-bale construction is lower than conventional methods, this represents a unique opportunity where instead of costing money to save lives, one can save money while saving lives.

At the macro level, the large-scale adoption of straw-bale technology can have additional benefits through the reduction of greenhouse gas emissions. Straw-bale construction reduces emissions that would otherwise have occurred from the production of bricks and cement and from the heating and cooling of buildings. There are also environmental benefits, such as less ground and surface water will be used, and air quality will improve with the phasing out of pollution caused by the brick and cement industries. Less brick production will, in turn, result in a reduction in the disease burden associated with respiratory problems since the brick industry is a known source of irritants of the respiratory track (Joshi and Dudani 2008). Among social co-benefits, there is a potential transfer of economic activity from the brick industry, which is notorious for using bonded and child labour, to the straw-bale industry, which can employ individual labourers and provide an additional source of income for agriculture, without the need for much training or equipment.

The above discussion demonstrates that straw-bale construction, as a strategy for earthquake risk reduction, is also a financially viable strategy for adaptation to climate change at the micro level, and that it has positive mitigation co-benefits at the macro level. Further work needs to be undertaken to design houses using the material that respond to consumer demands and to test the social acceptability of this construction material. Scaling up would require technical inputs on design for building structures, manufacturing manual baling machines and training labourers to produce bales.

BACKGROUND

According to the World Disaster Report of 2009, Nepal ranks 23rd in the world in terms of the total number of natural hazard-related deaths in the two decades from 1988 to 2007. It ranks seventh in terms of deaths resulting as a consequence of floods, landslides and avalanches; and eighth in terms of flood-related deaths alone (MoHA and DPNet 2009). Data on the loss of lives due to various types of disasters in Nepal between 1971 and 2009 is presented in the diagram below.

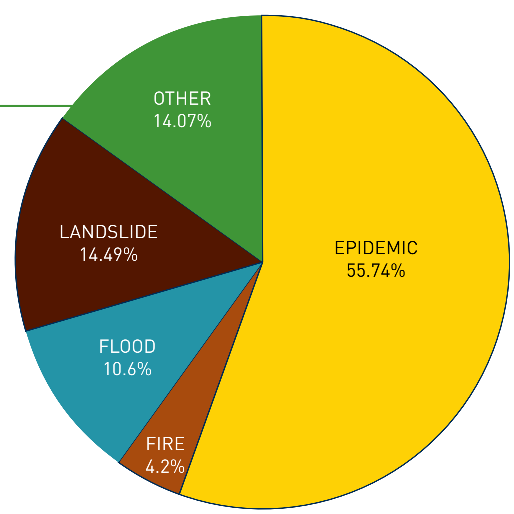
The data below, however, does not accurately reflect the huge potential risks associated with earthquakes. The period between 1971 and 2009 for which data has been collected, did not include any major earthquake events. Major earthquakes have caused very large-scale devastation in Nepal and occur at a return rate of roughly 70 years; the last occurred in 1934 and was measured 8.4 on the Richter scale (MoHA and DPNet 2009; DWIDP 2006). The reported death toll from this earthquake in Nepal was approximately 10,500 – but this is almost certainly an underestimate due to the fact that many deaths probably occurred in inaccessible rural areas (Billham 2003).

FIGURE 2.1

Death Due to Disasters in Nepal (1971–2009)

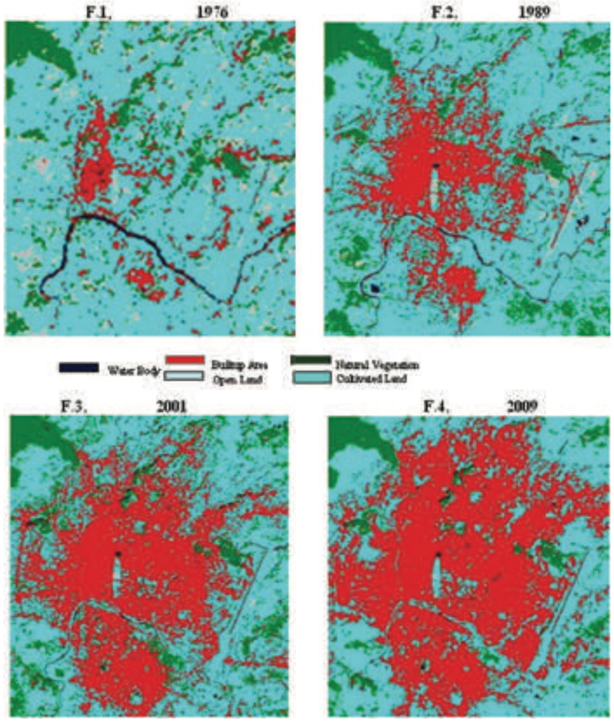
OTHER 14.07%

0.89	Boat Capsize	0.20	Forest Fire
1.29	Cold Wave	0.22	Hailstorm
1.30	Structure Collapse	0.30	Rains
3.10	Thunderstorm	0.30	Panic
2.10	Accident	0.55	Strong Winds
2.97	Earthquake	0.74	Avalanche
0.11	Explosion		



Source: Nepal DisInvestar data base, NSET 2009

FIGURE 2.2
Urbanisation of Kathmandu

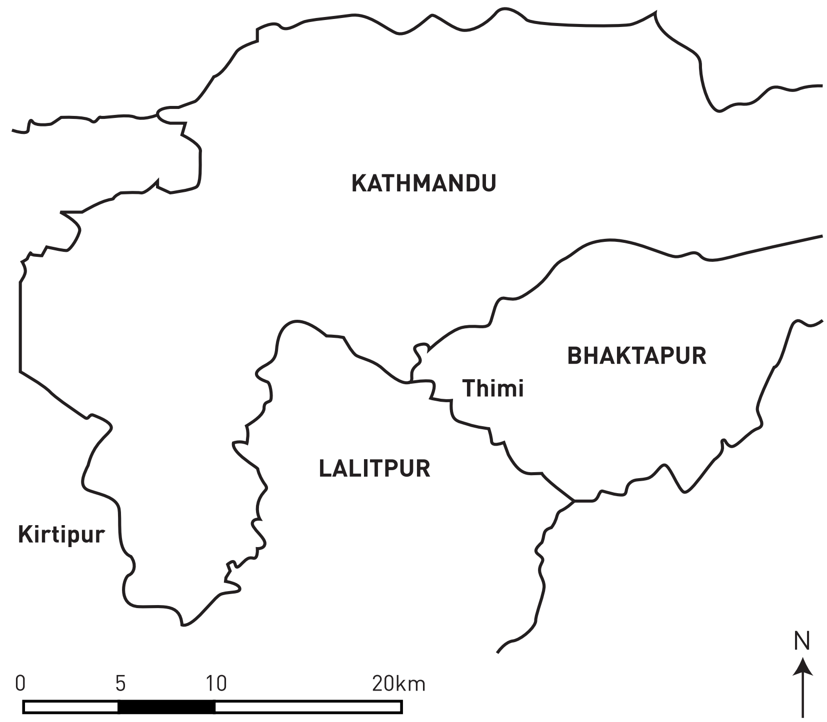


URBANISATION

Greater Kathmandu is comprised of three major cities—Bhaktapur, Lalitpur and Kathmandu—as well as the smaller cities of Thimi and Kirtipur. With its fertile soil and rich culture, Kathmandu Valley has attracted people since antiquity. When the country was unified in 1768, Kathmandu became the country's centre, and people started moving there from other parts of the country. This shift led to an increase in the cultural diversity of the Valley as well as a surge in its population and rate of urbanisation.

The increasing urbanisation of Kathmandu Valley through the dual forces of internal population growth and rural-urban migration is increasing the pressure to expand housing and commercial space, changes which have accelerated vulnerability. Land-use changes in Kathmandu and Lalitpur metropolitan cities between 1976 and 2009 are shown in Figure 2.2. Housing complexes and industrial parks are being rapidly constructed on unused land (including former swamps or wetlands) in and around the city. Such land is unstable and buildings constructed on them are highly prone to damage during disasters such as floods and earthquakes. Rapid land-use change followed by hasty housing construction has led to large proportions of the population living in unstable structures with inadequate access to the services and resources necessary for livelihood sustainability, including energy and water.

FIGURE 2.3
Study Area: Kathmandu Valley



STUDY AREA: KATHMANDU VALLEY

Rapid land-use change followed by hasty housing construction has led to large proportions of the population living in unstable structures with inadequate access to the services and resources necessary for livelihood sustainability, including energy and water.

We chose the Kathmandu Valley conurbation, which comprises the cities Kathmanadu, Lalitpur, Bhaktapur, Kirtipur and Thimi as the study area for this report. This area is urbanising at a fast pace — over 5% annually (Thapa and Murayama 2009) — and is the economic hub of much of Nepal's growing economy, especially the service sector. With livelihood opportunities in rural economies likely to decline as a result of climate change and other pressures on natural resources, the pace of urbanisation may increase further as people migrate to find alternate livelihoods. Other advantages of studying Kathmandu Valley is the availability of data in the various sectors investigated in this report and because the Valley is large enough to give a sense of the macro impacts of intervention.

Kathmandu Valley is in the central region of Nepal and encompasses an area of approximately 30-35 km (see Figure 2.3). The generally flat floor of Kathmandu Valley is at an average elevation of 1,300 m; its sides slope steeply to elevations of more than 2,000 m.

EARTHQUAKE

Tectonic activity is a critical concern in Nepal and especially in Kathmandu Valley. According to the seismic record, which dates back to 1255 A.D., major earthquakes occur approximately every 75 to 100 years (NSET and GHI 1999). More broadly across Nepal the frequency of earthquakes exceeding magnitude 6 (a level where significant damage to unreinforced structures commonly occurs) is every 5 years (See table below).

Table 2.1
Earthquake of Magnitudes in Richter Scale

	5–6	6–7	7–7.5	7.5–8	8+
No. of events	41	17	10	2	1
Approximate Recurrence Interval, yr.	2	5	8	40	81

Source: Nepal DisInvestar data base, NSET

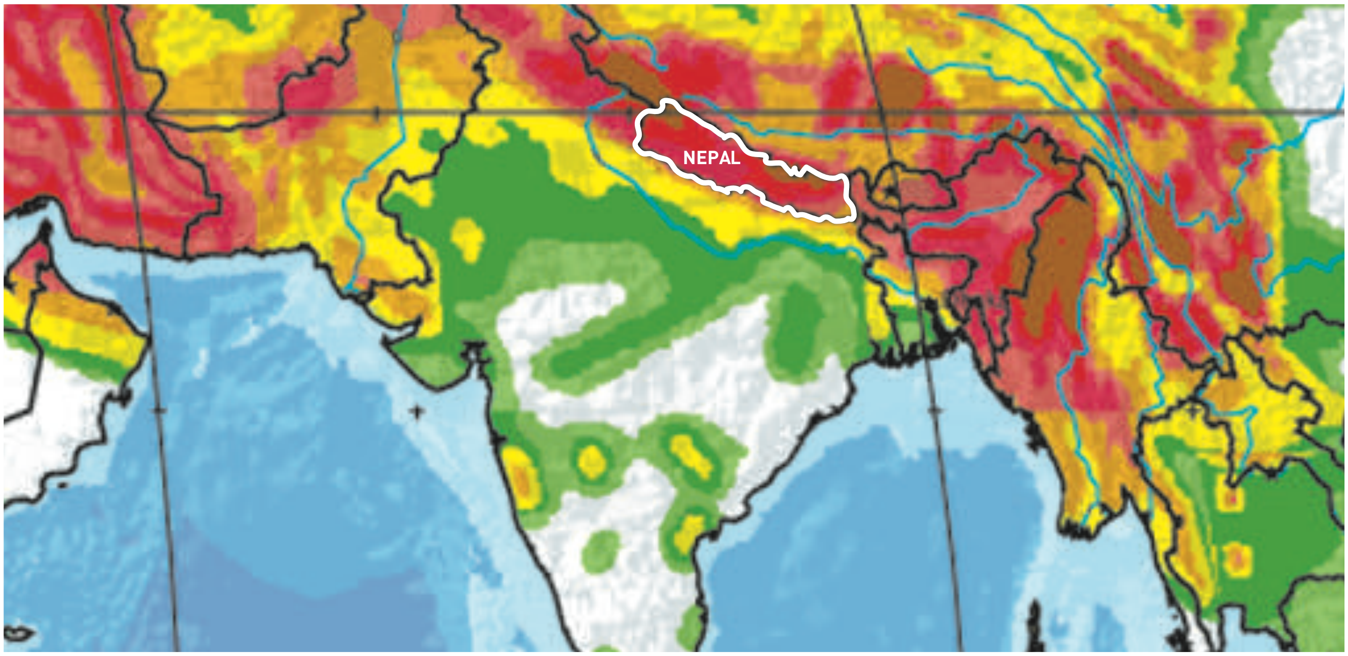
This high level of earthquake activity is due to the tectonic plate configuration in the region; the Indian plate is slowly, but constantly moving towards the Eurasian plate due to magmatic convection cells beneath the earth's surface. When the plates collide, the differential densities between them cause the less dense Indian plate to subduct beneath the more dense Eurasian plate, creating the uplift which is responsible for the Himalayas and the Tibetan Plateau.

EARTHQUAKE DISASTER MITIGATION STUDY

A loss estimation study for a major earthquake in Kathmandu Valley was carried out as part of the Kathmandu Valley Earthquake Risk Management Project (KVERMP) in 1998. The study examined the likely consequences of an earthquake equivalent in magnitude to the last major earthquake in 1934 (8.4), which killed more than 10,000 people, if it were to occur today. NSET and GHI (1998) reported that:

> Simply applying the percentage of the population killed or injured in the 1934 earthquake to the population of the Valley today results in an estimate of 22,000 deaths and 25,000 injuries requiring hospitalisation. Applying more recent earthquake casualty figures from cities comparable to Kathmandu Valley results in an estimate of 40,000 deaths and 95,000 injuries in Kathmandu Valley's next major earthquake. An additional 600,000 to 900,000 residents of Kathmandu Valley are expected to be left homeless by the earthquake due to damaged buildings or fear of being in their homes. (p. 10)

FIGURE 2.4
Seismic Zoning of Surrounding Region



Source: Global Seismic Hazard Assessment Program (GSHAP), http://www.seismo.ethz.ch/GSHAP/

Peak Ground Acceleration (m/s2) 10% Probability of Exceedance in 50 years, 475-year period
LOW MODERATE HIGH VERY HIGH
0 0.2 0.4 0.8 1.6 2.4 3.2 4.0 4.8

Peak Ground Acceleration (m/s2) 10% Probability of Exceedance in 50 years, 475-year period
LOW MODERATE HIGH VERY HIGH
0 0.2 0.4 0.8 1.6 2.4 3.2 4.0 4.8

In 2002, Japan International Cooperation Agency (JICA) published an earthquake scenario analysis as a part of its study titled, "The Study on Earthquake Disaster Mitigation in Kathmandu Valley, Kingdom of Nepal." Simulating the effects of the 1934 earthquake if it were to occur in the present day, the study estimated the likely damage to buildings and infrastructures in Kathmandu Valley. An earthquake centered on the existing seismic gap in middle Nepal would result in most buildings being damaged and an extremely high death toll. According to the study, the anticipated losses from a mid-Nepal earthquake are as follows:

% of Heavily Damaged Buildings

21%

% of Total Population Seriously Injured

3.8%

% of the Population in Kathmandu Valley Killed

1.3%

The two reports suggest that Kathmandu Valley has a very high seismic risk. Historically, a major earthquake has occurred in the Valley every 75-100 years. Furthermore, there has been a long seismic hiatus in the middle of Nepal; there has been no energy release through a minor quake for a long time. These facts suggest that a major earthquake in Kathmandu Valley is inevitable and even at conservative estimates, the death toll will be in the thousands. If, as some estimates suggest, the population of Kathmandu Valley is now approaching 5 million, a fatality rate of 1.3% implies a death toll of 65,000 along with an additional 190,000 (3.8% of the population) seriously injured.

In addition to deaths and injuries, the JICA earthquake report suggests that approximately 95% of Kathmandu Valley's water pipes and 50% of other water system components, like pumping stations and treatment plants, may be seriously damaged in a major earthquake. Almost all telephone exchange buildings and 60% of telephone lines are likely to be damaged, as are approximately 40% of electric lines and all electric substations (NSET and GHI 1998). This would translate into a massive failure of the very systems that support resilience to shocks, and would make the task of relief and recovery extremely difficult.

The above data implies that the development and adoption of earthquake resilient housing systems in the Kathmandu Valley is of critical importance. While it is unlikely that the building practices commonly used across the Valley can be changed dramatically over the short-term, even a small number of earthquake resilient houses could serve as a base to meet immediate shelter and other response and recovery requirements in the immediate aftermath of an earthquake. If these homes are also equipped with resilient water supply, communication and power systems, they could provide a key base for initial recovery activities.

CURRENT CONSTRUCTION PRACTICES

Houses in Kathmandu can be roughly divided into four categories: traditional houses built with mud-mortar and timber; non-engineered constructions with low-quality bricks and minimum use of cement; framed structures without proper engineering; and engineered constructions. Construction in the last 20 or so years has usually been framed structures, but not necessarily with due consideration to appropriate seismic standards. Most people's perception, however, is that at all new constructions are safe from earthquakes despite the fact that they are designed and constructed with traditional knowledge and rarely meet proper engineering requirements. Recent earthquakes in Pakistan and India have demonstrated the weakness of such framed structures, and even engineer-designed structures with improper seismic provisions.

NATIONAL BUILDING CODE

Although the government of Nepal formulated the National Building Code in 1998 to specify measures for constructing earthquake-resistant buildings, it was implemented and made mandatory only in 2004. Of the five municipalities in Kathmandu Valley, only two, Kathmandu and Lalitpur, formally abide by the code. Even where the code is being implemented, the capacity to do so effectively is limited. Municipal and ward offices are responsible for checking building plans before construction begins, but lack the proper experts to verify the safety of buildings from the structural or seismic plans provided (JICA 2002). Also, buildings are not regularly monitored during the construction period beyond a cursory check that the area covered is as specified in the blueprint. Lack of knowledge, awareness and training in construction techniques, among both government officials and builders, has resulted in the failure of the National Building Code to safeguard people from the risk of structural damage, and even collapse, of new and traditional structures.

BRICK INDUSTRY & ITS IMPACTS

Due to rapid urbanisation, centric industrialisation and the significant increase in vehicular traffic on its narrow and unkempt streets, residents of Kathmandu Valley are especially vulnerable to air pollution and its impacts on their health. Brick production is a large-scale industrial activity in Kathmandu Valley and is a major source of air pollution as well as land-use problems. Since bricks are the Valley's main construction material, brick production and demand are increasing continuously with the growth in the population, and its dramatic urbanisation and modernisation. The environmental and health concerns associated with Kathmandu Valley's brick industry are a serious issue, especially because the industry uses poor-quality fuel and inefficient technology.

The environmental and health concerns associated with Kathmandu Valley's brick industry are a serious issue, especially because the industry uses poor-quality fuel and inefficient technology.

Topographical issues compound many of the Valley's environmental concerns. According to a 1997 emission inventory, conducted by the World Bank under the Urban Air Quality Management Strategy in Asia (URBAIR) programme, the main contributors to the total suspended particles in the Valley are cement factories (36%), brick kilns (31%), domestic fuel combustion (14%), road re-suspension (9%) and vehicle exhaust (3.5%). The concentration of particulate matters less than 10 microns in diameter (PM_{10}) is the greatest concern because these are the particles that are capable of entering the respiratory system. The highest concentration of PM_{10} was found in brick kiln particulates. The study estimated that dust particles in Kathmandu Valley cause 18,863 cases of asthma and 4,847 cases of bronchitis in children every year (Larssen et al. 1997). More recently, records from Kathmandu's hospitals indicate that the number of patients with chronic obstructive pulmonary disease (COPD) has increased significantly over

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the past ten years. To cite the records of just one, Patan Hospital has seen the number of COPD patients double in the past five years and reports the most COPD patients in the winter, when air pollution is also at its peak (Larssen et al. 1997).

Since the URBAIR study was conducted in 1997, Kathmandu's cement factory has been closed, and cleaner, more energy-efficient and more environment-friendly technology for brick production has been introduced. However, there has not been a significant improvement in the Valley's air pollution. Of the 125 brick kilns in the Valley, 90% are inefficient and polluting kilns that use older technology. Although the older technology has been banned for some time, it is still in use and recent studies carried out by Clean Energy Nepal (CEN) in Tikathali VDC in Lalitpur and Jhaukhel VDC in Bhaktapur indicate that the air pollution in brick kiln affected areas is three times higher than elsewhere.

Brick manufacturing also has detrimental impacts on soil and causes a serious loss in agricultural productivity. The majority of brick kilns in Kathmandu Valley utilise soil from nearby agricultural fields, generally after the paddy crop has been harvested. Once the clay is exhausted in one location, the kiln is shifted to another location. Soil in the Valley is characterised by a high water-retention capacity, rich humus and excellent texture, features that make it suitable for agriculture. In 2002, CEN carried out soil fertility tests that revealed that areas with no brick kilns in the vicinity had high concentrations of nutrients, and areas that had been exploited by brick kilns for soil had very low concentrations of essential nutrients. Farmers attempt to rectify this loss in nutrients through application of chemical fertilisers is both an expensive and harmful response. Moreover, excess fertiliser can enter the hydrologic system and pollute water supplies, raising concerns about the quality of drinking water (Tuladhar and Raut 2002).

The majority of the brick kilns in Kathmandu extract huge amounts of water from deep tube wells, an activity which may deplete the groundwater level. According to Haack and Khatiwada (2007), local residents in one brick-producing area estimated that the water table had dropped from 1-2 m to 20 m below the surface. They warn that the extraction of topsoil and water to make bricks increases rainfall-induced landslides that damage structures such as roads and houses. Extraction also leaves the groundsurface uneven, and with raw brick producing dug down as much as a metre or more, makes irrigation difficult.

If air quality is not improved—tourism, which is a major economic activity in the Valley—is bound to suffer.

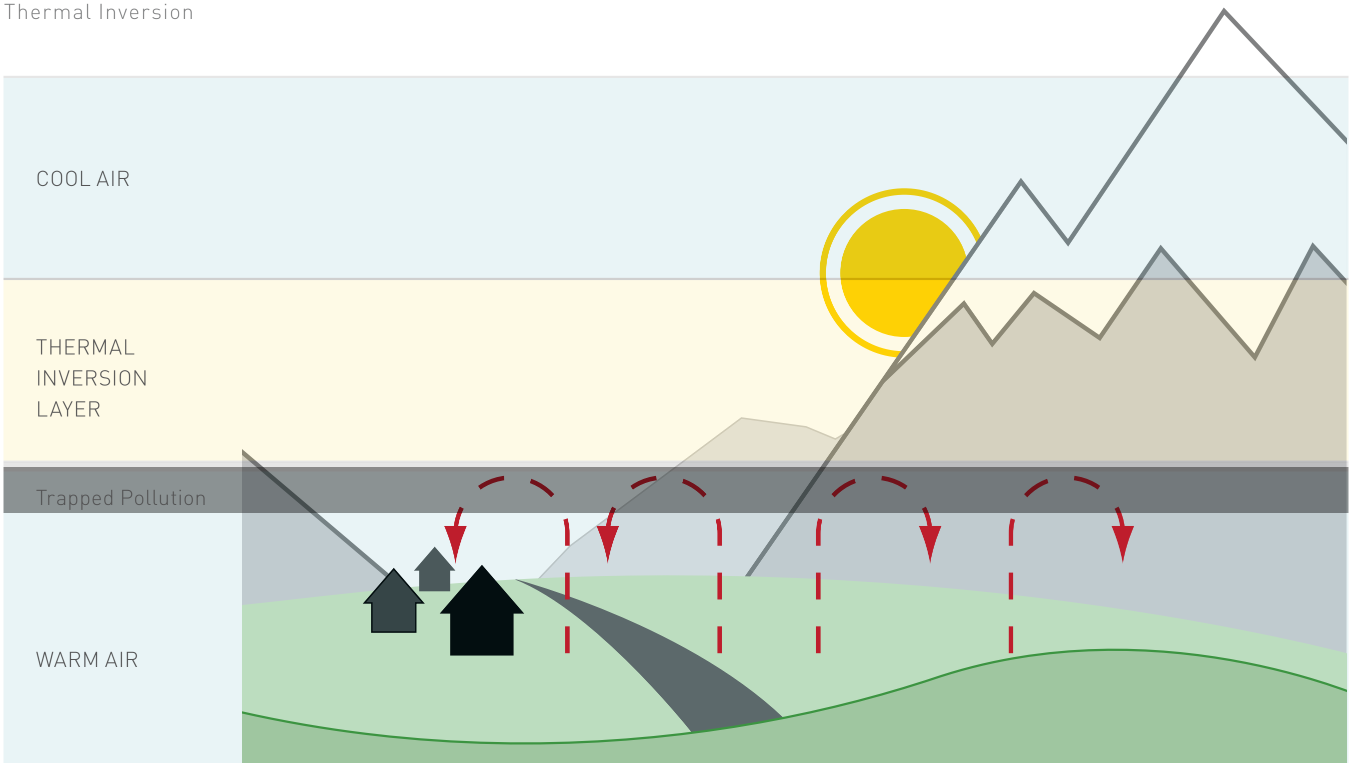
A survey of 1,702 tourists in Kathmandu Valley conducted between May and June 2001 indicated that air quality is the number one area that tourists feel improvement is needed. Data obtained from Tribhuvan International Airport in the east of the Valley shows that in 1970 the number of days with good visibility at height in excess of 8,000 m, decreased in the winter months by more than 25 days/month in 1970 to 5 days/month in 1992 (Larssen et al. 1997). If air quality is not improved, tourism, which is a major economic activity in the Valley, is bound to suffer.

CLIMATE CHANGE

The topography of Kathmandu Valley and the high levels of pollution have triggered climatic variation. The bowl-like shape of the Valley restricts wind movement and retains pollutants in the atmosphere. Conditions are especially bad during the winter when thermal inversion—when cold air flowing down from the mountains is trapped under a layer of warmer air—creates a sort of lid, sealing pollutants within.

Growing climate variability is likely to exacerbate the existing pressures on urban services, especially the growing demand for energy to heat and cool, as temperatures increase and precipitation and water availability grow increasingly variable. Global circulation model (GCM) outputs suggest that extremely hot days (the hottest 5% of days in the period 1970-1999) may increase by up to 55% by the 2060s and 70% by the 2090s (NCVST 2009). The findings also suggest

Figure 2.5
Thermal Inversion



that extremely hot nights (the hottest 5% of nights in the period 1970-1999) also may increase by up to 77% by the 2060s and 93% by the 2090s. Because the ability of conventionally constructed buildings to retain heat is poor, especially when temperatures are extreme, they are costly to heat and cool. Due to energy shortages, most people in Kathmandu currently suffer extreme temperatures. But with further economic development and increasing temperature extremes, there is an expected increase in demand for heating and cooling, unless building insulation is dramatically improved.

STRAW-BALE HOUSING

Green construction techniques and materials are receiving increasing attention globally and in Nepal due to their potential ability to reduce the environmental pressures associated with brick and cement production, the need to increase energy efficiency (both with respect to construction materials and home heating/cooling) and their potential to reduce the risks associated with earthquakes. Among the materials that have great potential is straw-bale. In fact, straw-bale housing construction meets the future requirements of construction methods quite well, especially in developing countries like Nepal. Straw-bale is natural, non-toxic and offers numerous benefits including energy efficiency and resistance to earthquakes, fire and pests (NEES Consortium 2005). In addition, it is comparatively inexpensive, and construction techniques are simpler than conventional methods.

WHY STRAW-BALE HOUSING?

Sustainability

Straw is an annually renewable natural product. Straw is a byproduct of rice, and since Nepali people eat rice as their primary staple, the crop, and its byproduct—straw—is grown all over the country. Also, residual straw is generated after the paddy crop is harvested, and its lack of purpose generally results in it being burned or disposed of. The use of straw can reduce or eliminate the use of other more environmentally damaging materials such as brick and cement. Moreover, in the event that a structure is built out of straw, the structure can be composted if it is no longer needed. Using straw as a dominant building material could be especially beneficial due to its excellent insulation characteristics in areas where the climate is severe. Because rice is grown in most areas, straw is generally available even where other building materials are scarce. Straw is also a remarkably durable material.

Historical Development

Straw-bale construction techniques were developed and refined in the central states of America in the late 19th and early 20th century. Many examples of houses from that period are still in existence and, in some cases, in use.

Low Cost

A rectangular bale—one foot by one foot by two feet—on average costs about 200 NPR, including delivery from the field. Also, because the building method is so straightforward, it saves labour costs. For these reasons, a straw-bale house is about 16% cheaper to make than a house of the same area, made with brick–and-mortar. In addition, a significant saving associated with a straw-bale housing is the savings on long-term expenditures on fuel for heating and cooling, which are reduced due to the high level of natural insulation of straw-bales. According to our conservative estimate, the thermal conductivity of a two brick-thick wall is almost seven times higher than that of a one foot-thick straw-bale wall.[1] In comparison with modern housing, heating costs can be reduced by up to 75% annually, and the savings accrue throughout the life of the building. In a relatively mild climate like that in Kathmandu Valley, the cost of heating and cooling can be minimised.

Low earthquake risk

In the developing world, there is a large demand for appropriate and affordable earthquake-resistant building solutions. Post-earthquake reconstruction efforts

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primarily emphasise conventional building methods such as reinforced concrete and confined masonry construction. Such methods, however, require skilled labour and materials that poorer populations cannot afford. Furthermore, conventionally built structures are inefficient at maintaining internal air temperatures and incur higher costs to heat and cool (NEES Consortium 2005).

Research has shown that straw-bale houses perform well in earthquakes. Pakistan Straw Bale and Appropriate Building (PAKSBAB) conducted a successful shake test at the University of Nevada, Reno that demonstrated the stability of a straw-bale house when subjected to .82g, twice the acceleration rate of the Canoga Park Topanga Canyon record of the 1994 Northridge, California earthquake (NEES Consortium 2005). The material properties of straw-bales, particularly their flexibility and strength, make them ideal for seismic-resistant structural design, as long as the connections between the bale walls, roof and foundation are adequate.

Low fire risk

The straw-bale mortar-structure wall is exceptionally resistant to fire. The straw holds enough air to provide good insulation, but not enough to permit combustion. According to tests conducted by National Research Council of Canada,


straw-bale walls withstood temperatures up to 1,850 degrees Fahrenheit (1,010 degrees Celsius) for two hours.

Reduced water use and air pollution

Both straw-bale production and construction use much less water than does brick production and construction. Straw-bale production is also very clean and its only byproduct is straw dust. Brick production is the dominant construction method and is a major polluter of Kathmandu Valley's air.

Straw-bales are a suitable material for construction because they are cheaper than conventional materials, reduce the risk associated with earthquakes, use less energy in their production and during construction, reduce long-term heating and cooling costs and have many potential macro-level co-benefits such as reductions in water use, air pollution and related respiratory ailments. Large-scale conversion to straw-bale also has the potential to reduce the dependence on bonded and child labour that is common in the brick industry.

COST-BENEFIT ANALYSIS

The CBA of building straw-bale structures instead of brick and cement-mortar structures, was conducted at two levels. At the household level, the analysis attempts to understand the financial implications of private investment in a new house, not just in terms of the actual construction cost, but at a broader level, the costs and benefits of an adaptation strategy that uses straw-bales instead of bricks. In fact, it is the safety associated with straw-bale—how it can save lives and prevent injuries in an earthquake—not its cost, that is the single most important benefit. However, due to the ethical issues associated with assigning value to life, this CBA does not attempt to calculate this value. Nevertheless, an economic analysis is not the only analysis that makes the case for straw-bale housing. At the governmental and household level, there are actual savings in building with straw-bale. With public investments in straw-bale buildings (e.g. schools), the cost per life saved is negative.

With most of the population of Kathmandu Valley not having witnessed a major earthquake in their lifetime (the last one was 77 years ago and the life expectancy in Nepal is just 62), most households do not prioritise earthquake protection in their decision-making when it comes to constructing a house. As a result, it is estimated that over 20% of all buildings are likely be damaged when there is a major earthquake in Kathmandu. Since the most immediate concern for most house builders is the financial cost of their house, this CBA begins with consideration of the financial implications of using straw-bales for construction. The basic unit of analysis will be a two-storey residential building with three bedrooms.

At the macro level this analysis will look at the large-scale impacts of adopting straw-bale technology and the challenges and opportunities it presents. These include a consideration of the supply of suitable straw and its effects on the cost of construction. Also, it will try to estimate the effects of changing from brick to straw-bale production. Since it is difficult to predict the scale at which the technology might be adopted, exact environmental impacts cannot be established. In most cases, however, we can estimate the expected gains and potential extent of co-benefits which would accompany the complete replacement of the brick industry with straw-bale construction.

RESULTS

The CBA yields a cost-benefit ratio of 2.0 for making a house of straw-bales instead of bricks. This ratio was arrived at using a 12% social discount rate and a project period of 30 years. Since a straw-bale building is 16% cheaper to construct than a brick building, most of the financial benefits are accrued in the first year of construction. Further discounting the future benefits associated with reductions in heating and cooling costs actually increases the cost-benefit ratio, although the net present value of investment does indeed decrease. Therefore, straw-bale construction remains more cost effective at higher discount rates when compared to brick construction. Most of the micro-level financial benefits come from the fact that straw-bales are cheaper than bricks and that their use reduces expenditures on heating and cooling over the long run, expenditures which are likely to increase with the impact of projected climate change scenarios. This means that at current straw-bale prices (200 NPR per bale), straw-bale construction will save, in addition to the 16% on construction, 34% over 30 years on heating and cooling costs at current prices. The strong positive benefit-cost ratio, as previously noted, does not include the value of lives saved.

The most important factor in determining the cost of straw-bale construction is the price of straw. Any increase in its cost will increase the cost of construction. A sensitivity analysis of the CBA was performed at both 12% and 20% social discount rates. The breakeven price of straw is 80 NPR/kg at a 12% discount rate and 70 NPR/kg at a 20% discount rate, while the actual cost at current market prices is just 20 NPR/kg. However, the mass adoption of straw-bale construction will generate a huge demand for straw and raise its price. In the subsequent subsection we will look at the demand and supply of straw to come to a better understanding of the nature of the rice straw market.

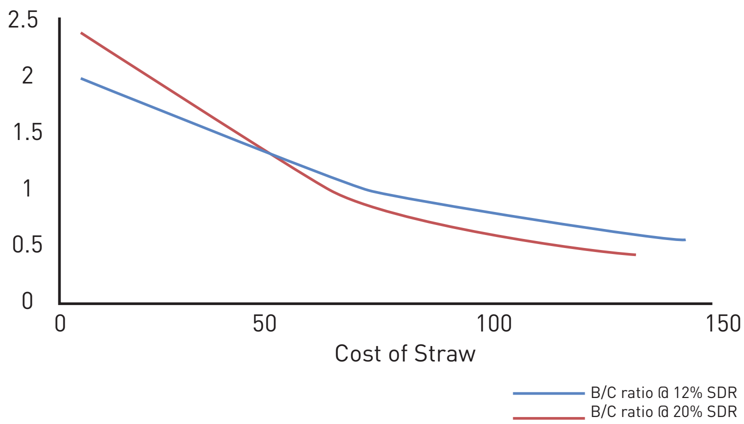
DATA AND LIMITATIONS

It is relatively simple to get market data on the costs of various construction materials. In contrast, it is quite difficult to quantitatively price macro-level effects, such as air pollution and its disease burden, and the effect on child labour, as there are not enough studies or data available. There is, however, enough literature to provide sufficient qualitative information to demonstrate some of the major co-benefits of straw-bale construction at scale.

COSTS

Our comparison of the costs of brick construction versus straw-bale construction is based on a two-storey house that is typical of the new construction around Kathmandu. The costs of materials were calculated using market values in 2011.

Figure 2.6
Sensitivity Analysis to Cost of Straw



Maintenance costs and the cost of the reduction in floor area necessitated by the much wider straw-bale were considered. The fact that straw-bale walls tend to be thicker than brick walls may be seen as a disadvantage in the land-scarce hilly landscape of Kathmandu Valley. The loss of floor space was priced using the rental value of the lost area in suburban Kathmandu. Additionally, there may be an increased cost associated with the repair and maintenance of straw-bales. Instead of a paint job, straw-bale walls may need plastering. The cost of plastering, however, is a precautionary cost and may not be needed in reality. It is possible that straw-bale plaster may last longer than assumed in this model.

BENEFITS

Though the primary benefit of straw-bale housing is the reduction in lives lost, in this CBA we are only considering the financial benefits of constructing straw-bale houses. The main benefit is the saving in construction costs, which is around 16%. The other main financial benefit is the saving on cooling measures in the summer. It was assumed that that half the heating, and no cooling will be required in the projected climatic conditions because the insulation capacity of the straw-bale is seven times higher than that of brick walls. These are fairly conservative estimates, and it is likely that as climate change progresses, these savings will increase significantly. As temperature peaks rise, the need for air-conditioning will rise more significantly in brick than in straw-bale buildings because of poor insulation. Also compounding the cost is that energy prices are expected to rise much faster than temperatures in the near future. Further benefits that would accrue to this intervention would be a result of large-scale adoption.

LARGE-SCALE ADOPTION

The analysis above was for making a single house and largely examined the financial costs and benefits of building with straw-bale (with the proviso that safety is the number one benefit—an immeasurable and undeniable one). Large-scale adoption will have significant benefits besides saving lives and saving pennies. The table below lists these benefits.

Since we cannot predict the level at which straw-bale construction will be adopted in Kathmandu Valley, we will look instead at a few of the co-benefits to demonstrate the potential macro impact of using this technology. These include earthquake protection, agriculture (as a source of straw), reduced air pollution and its disease burden, and the social benefits of reducing child and bonded labour. The estimates below give an upper limit to the co-benefits that can be achieved through 100% adoption and will be helpful in planning for implementation along the spectrum of adoption.

EARTHQUAKE RESILIENCE

Shake table tests of straw-bale house designs have shown that they can withstand an earthquake acceleration rate of .82g without collapsing. In Nepal alone, such a high level of protection can potentially save tens of thousands of lives and

Table 2.2
Large Scale Adoption Benefits of Straw-Bale Construction

BENEFITS	EXPLANATION
Reduced Number of Casualties	Straw-bale structures are earthquake resistant
Increased Rice Production	Brick kilns take up valuable rice production area
Decreased Water Mining	Great amounts of water are used in brick production and construction
Decreased Air Pollution	Brick kilns produce air pollution
Reduction of Heat Island Effect	Straw-bale structures are naturally insulated
Decreased Energy Use	Lower demand for electricity in homes
Reduction of Child/ Bonded Labour	Brick kilns employ child and bonded labour

prevent hundreds of thousands of serious injuries. In fact, the majority of the 18,000 fatalities and 53,000 serious injuries estimated from a major earthquake in Kathmandu Valley can be prevented. The scale of loss reduction will be proportional to the number of buildings built with straw-bale. For this risk reduction to be realised, it is important that the straw-bale building designs are indeed earthquake resistant and that regulations and trainings are put in place to ensure quality and standards. Public buildings such as schools and medical facilities should be prioritised for earthquake-resistant construction as they tend to have highest fatalities, as demonstrated by the recent earthquakes in Kashmir and China. They also would be useful during the post-earthquake recovery stage as shelters and health facilities.

AGRICULTURE, RICE, BRICK PRODUCTION AND STRAW EQUIVALENT

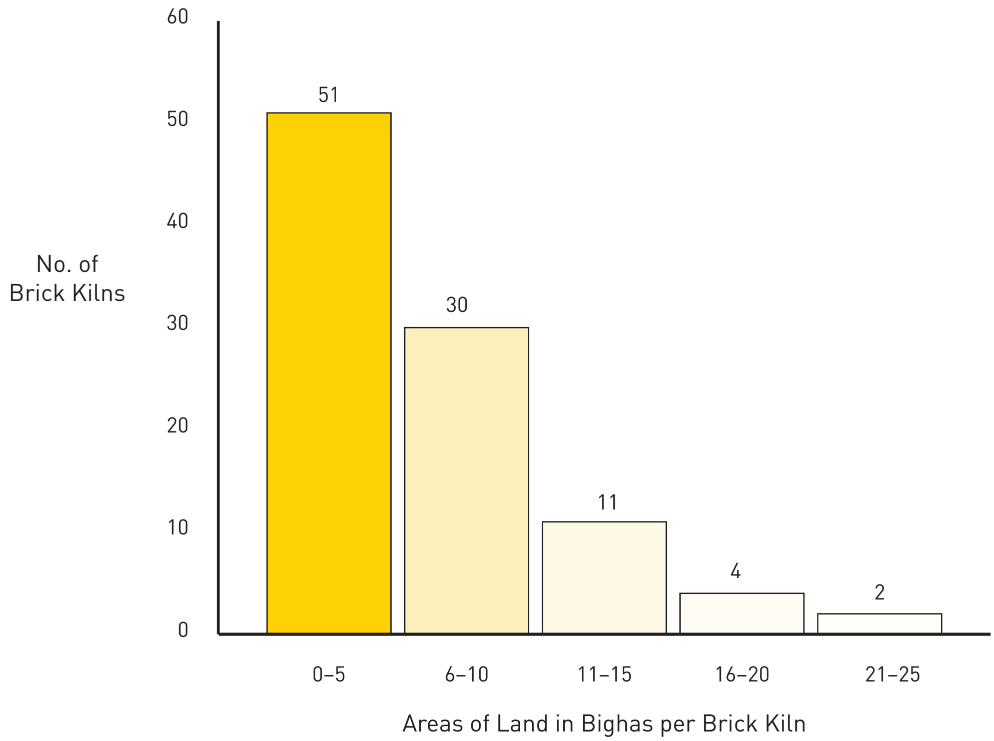
One of the most important questions in adopting straw as a building material is whether there is enough straw to supply the demand accompanying large-scale adoption. Rice straw is considered to be a very suitable raw material for making straw-bales. The annual demand for bricks in Kathmandu Valley is currently 1.14 billion and is growing at the rate of 11% per year. Out of this number, just 2.775 million bricks are produced in the Valley, consuming an area of 404 hectares that could be used to plant rice. Most brick kilns are rotated with rice production—rice in the monsoon and bricks in the winter—because of the suitability of soil and availability of water in rice-producing areas, which results in lower productivity of the land (Haack and Khatiwada 2007).

The area under rice cultivation in the Valley is 17,100 hectares and the yield is 94,143 mt (metric tons) rice and 23,850 mt of straw. If all of this straw were converted to straw-bales for construction, the total number would be equivalent to 2.98 million bricks, or slightly more than the number of bricks currently produced in the Valley. Hence, the supply of straw from rice cultivation alone could, in theory, fulfill the demand. Considering Nepal as a whole, rice straw production is equivalent to 2.6 billion bricks, more than twice the total demand for bricks in Kathmandu Valley.

The large-scale demand for rice straw is bound to raise its price significantly from the current 20 NPR/kg paid in the Valley. To keep prices down, other sources of straw, such as wheat, millet, or even lantana and hemp could be used. Some of these are used as fodder, but lantana is an invasive species farmers would be keen to get rid of and, similarly, hemp is cleared and burnt in huge amounts to clear the ground for other uses. Not only is rice straw available in large volumes, but it is also preferred for construction for the ease with which it can be baled and the quality of the bales produced. As the price of rice straw

Figure 2.7

Areas of Land Occupied by Brick Kilns in Bighas (unit of land area in Nepal)



rises, other types of straw may become a viable option. Alternatively, other substitutes could be found for the current uses of rice straw so that the supply of rice straw also increases. A field survey lists the current use of rice straw as such:

1. Cattle feed/fodder
2. Production of dung fertiliser
3. Mushroom production
4. Carpets (*gundri*) and ropes
5. Housing material (roofs and wall)
6. Cremation
7. Paper production

Most of the above uses of rice straw can be met using alternative materials. When the price of rice straw rises, it is likely that people will turn towards straw alternatives anyway. Even as fodder, rice straw is less preferred to other sources of fodder because of its low nutritional value. The increase in rice straw prices will increase the incomes of farmers who grow rice and, even at raised prices, straw-bale housing will remain cheaper than brick housing.

HEALTH BENEFITS

As mentioned earlier, Kathmandu Valley suffers from very high levels of air pollution and related respiratory ailments. The URBAIR study estimated that in 1997 there were 18,863 cases of asthma and about 4,847 cases of bronchitis caused by air pollution. In point of fact, however, projections suggest that air pollution has worsened significantly. According to Shrestha and Malla (1996), the pollution was to increase five-fold in 20 years under a business-as-usual scenario. However, this has increased even more because of the rapid increase in vehicular emissions. Giri et al. (2007) estimated the mortality linked to PM10 pollution is 0.95%. This means that almost one percent of deaths in the Valley are due to air pollution alone. One study (Larssen et al. 1997) shows that the disease burden (morbidity) associated with air pollution amounts to 209 billion NPR annually. The details are presented in the table below.

Brick kilns contribute to 31% of Kathmandu Valley's total suspended particles and, 28% of it is PM10, which is the primary cause of pulmonary diseases. Reducing brick production will decrease the emission of these pollutants and consequently, the disease burden. Although the disease burden will not decrease proportionately, even a 5% decrease in the health impact will translate into an annual savings of 10 billion NPR.

TABLE 2.3
Disease Burden Associated With Air Pollution.
Source: Larssen et al. 1997

TYPE OF HEALTH IMPACT	NO. OF CASES	VALUE (NPR)	TOTAL (NPR) (Total x 10)
EXCESS MORTALITY	84	340,000	28, 644
CHRONIC BRONCHITIS	506	83,000	41,988
RESTRICTED ACTIVITY DAYS	475,298	56	26,617
EMERGENCY ROOM VISITS	1,945	600	1,167
BRONCHITIS (CHILDREN)	4,847	350	1,697
ASTHMA	18,863	600	11,318
RESPIRATORY SYMPTOMS (DAYS)	1,512,689	50	75,634
HOSPITALISATION (FOR RESPIRATORY ILLNESS)	99	4160	415
TOTAL			**209,051**

LABOUR AND HUMAN RIGHTS

Child labour, defined as work by children under the age of 14, was banned in Nepal under the Child Labour (Prohibition and Regulation) Act of 2000 in accordance with its commitments under the Convention on Rights of Child. Because there is no legal sanction of this practice, it is very difficult to find statistics on how many children are working in the hazardous trade of brick-making. According to a June 2011 article in *The Himalayan Times*, there are around 3,000 underage workers in the brick kilns of the Valley alone. Some estimates say that the number may be closer to 6,000 children. These children typically work 10-hour shifts carrying out excruciating and repetitive routines in hazardous environments and live in abysmal conditions.

Even the adults who usually accompany these children often work in a well-established system of bonded labour. Kiln owners use contractors called *naieks* to hire labour (de Groot 2010). At the beginning of the brick-making season, which coincides with the festival season of Dashain, a time when the desire for money to celebrate is great, the *naieks* generally pay an advance, or *peski*, of about 6,000 NPR to each worker. Thereafter, labourers are bound to work in that particular kiln for the whole season to pay off their debts. The contractor system of bonded labour gives the brick kiln owner a cost-effective method of acquiring cheap labour without being directly involved in the illicit practices of bonded or child labour.

Children typically work 10-hour shifts carrying out excruciating and repetitive routines in hazardous environments and live in abysmal conditions.

The prevalence of child and bonded labour in the brick industry is rooted in complex issues and their resolution will require a systemic approach to resolve. However, reducing brick production will reduce the chance of vulnerable individuals falling into the trap of working in some of the most hazardous working conditions in Nepal. To measure the avoided cost of such illegal labour practices would be to underestimate the labour-wage equivalent, as the social benefits in terms of human rights are tremendous. The production of straw-bales can redistribute the economy of brick kilns among a large number of construction labourers who will need only minimal training in bale making. This shift in the construction industry will not only spread the economic returns of the construction industry among workers but also put an end to a very inhuman and unjust system of production. In economic terms, the current value of the brick industry is 9.2 billion NPR per year in Nepal and 22.8 million NPR in Kathmandu Valley. A large portion of this income can be transferred to bale-making labourers, who will also benefit from working in a safe and dignified working environment.

CONCLUSIONS

In this section we summarise results and observations, redefine the limitations of the analysis, and outline an approach to implementing straw-bale construction that is in line with the findings presented.

INSIGHTS

The case for straw-bale construction is strong from the perspective of both saving money and reducing natural hazard risks. If straw-bale construction were made available in Nepal, it would be financially judicious for an individual household to adopt it. Moreover, the ability of straw-bale structures to withstand seismic activity at the scale likely to occur in Nepal is phenomenal. Adoption at scale is not only possible in a rice-producing country like Nepal, but also highly desirable given the substantial co-benefits it brings including reduced air pollution, mitigation of greenhouse gas production and elimination of child and bonded labour. Overall, straw-bale construction is a win-win adaptation proposition for Nepal in terms of reducing climate-related risks and following a sustainable development path that mitigates reliance on non-renewable energy for shelter purposes.

LIMITATIONS

The results of this CBA are based on an *ex ante* analysis of a strategy that has no precedent in Nepal. Its limitations, then, are not set forth in terms of the availability of data or evidence, but rather in terms of the challenge of carrying out a sea change in the construction industry. While the financial factors at the micro level and the environmental and social co-benefits at the macro level have been addressed, the technical and social considerations at the household level, which would be the greatest impediment to adaptation, have yet to be addressed. The political economy of shifting from brick to straw-bale production would also come into play.

In Nepali society, and in South Asian society in general, making a *pakka*, or solid house (in other words, one made of concrete-plastered bricks) is a big step in moving up the social ladder. Thus, there is a good reason to believe that most families would shy away from techniques that would make their homes look similar to traditional structures of mud-plastered walls and thatched roofs. Very

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few individuals fathom that concrete is a major hazard in an earthquake-prone region. As a result, perhaps the most significant factor encouraging widespread adoption of straw-bale technology will not be the cost savings. Adoption during the normal course of events will, instead, depend on design and marketing factors that communicate "modernity" and a high-status lifestyle. Demand would probably be highest following earthquakes when the local population directly sees the benefits in terms of lives saved.

Promoting large-scale adaptation of straw-bale construction will also require looking into seismic-proof designing, quality standards and control, and maintenance. At present, there is not enough demand and probably not enough capacity for straw-bale house design to be a viable private sector activity. Overcoming shortcomings in monitoring and controlling building standards will not happen in the near future without substantial training and experimentation. Any move towards adopting straw-bale building techniques needs to consider these very practical considerations.

The transformative impact widespread adoption of straw-bale technology on earthquake risk and on climate-friendly shelter construction is substantial. For widespread adoption to occur, approaches that start small and address both the socio-cultural aspects of demand (by designing for "modernity") and the technical issues inherent in working with any new building material are essential. Construction on an experimental basis of schools, NGO offices or other similar buildings with adequate technical support from international and regional organisations that have extensive experience with straw-bale construction would be a good place to start. This type of programme could build the capacity, supply chains and experience necessary to respond to a much higher level of demand following an earthquake. The approach would, in essence, be to pre-position the technology and capacities required to respond quickly during post-disaster recovery.

WAY FORWARD

Straw-bale construction needs to be piloted before promoting it wholesale. Piloting would entail increasing design capacities and planning interventions at strategic levels. It is highly unlikely that large-scale adoption will take place before the next earthquake, but it is important to start making strategic investments in straw-bale and other earthquake-resistant technologies.

Good candidates for piloting straw-bale construction are schools and public buildings because they have a powerful demonstration effect and because donors, the government, or both, will provide funds for their construction. In the unfortunate case of a major earthquake these buildings would not only demonstrate the effectiveness of straw-bale construction but also serve as emergency shelters and health facilities.

Given the physical structural vulnerability of the current infrastructure as well as the imminent danger of a major earthquake, pre-positioning investments into strategic locations may be the best option. This would also buy time to test and prove the viability of straw-bale design and construction in a new geography if an unfortunate event should occur.

Given the physical structural vulnerability of the current infrastructure as well as the imminent danger of a major earthquake, pre-positioning investments into strategic locations may be the best option.

ENDNOTES

1 The heat insulation value (R-value) of a two brick-wide wall is 2.6, while that of a 12-inch thick straw-bale wall is 18. R-value is measured in feet squared x degrees Fahrenheit x hrs/BTU.

CHAPTER 3

RURAL QUALITATIVE EVALUATIONS OF COMMUNITY BASED COST-BENEFIT ANALYSIS

Fawad Khan and Marcus Moench

LOCAL AND NATIONAL ADAPTATION PLANNING IN NEPAL

This section presents qualitative cost-benefit evaluations undertaken as part of local adaptation planning in rural Nepal to support the country's NAPA (National Adaptation Plan of Action) process. These qualitative evaluations contrast with the more quantitative evaluations presented earlier and illustrate an approach that is suited to projects where data is limited and investment levels are low.

Nepal is considered one of the most climate vulnerable countries in the world. Due to its fragile ecology people have already started experiencing the differentiated impacts of increased temperatures (NCVST 2009). As a result of international agreements on climate change adaptation, Nepal has responded to these pressures through the creation of a National Adaptation Plan of Action (NAPA), which was endorsed by the Nepali Government in September 2010. At the NAPA inception meeting, participants demanded local adaptation plans of actions (LAPAs) to meet the locally differentiated impacts of climate change. The NAPA is a broad strategic document made up of LAPAs. These LAPAs point towards tangible courses of action that can occur at the local level.

Furthermore, the Nepal NAPA states that the Government of Nepal intends to spend eighty percent of its adaptation resources at interventions at the local level. The climate change policy of 2011 also states that the adaptation planning will support local adaptation and cater to those who are most vulnerable to such climate change.

NEPAL RURAL QUALITATIVE EVALUATIONS

The qualitative cost-benefit evaluations described in this section were undertaken by local partners as part of the local adaptation planning process under the Climate Adaptation Design Project-Nepal (CADP-N) programme coordinated by International Institute of Environment and Development (IIED) and supported by Department for International Development (DFID). The local adaptation plans of action developed under this process are intended to support implementation of Nepal's national adaptation plan of actions. The methodology for the qualitative cost-benefit evaluations was developed by Institute for Social and Environmental Transition-International (ISET) as part of their cost-benefit research for the American Red Cross.

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The LAPA development process involves participatory analysis and planning by local communities across rural Nepal. The goal is to develop adaptation strategies that are owned by local communities and can address the impacts of climate change on the poor and other marginalised groups. Because the impacts of climate change affect a wide variety of environmental resources across rural Nepal (such as water, forests and land) and also directly and indirectly affect the livelihoods of local populations, diversified strategies are essential. As a result, the process of developing local adaptation plans of action involves the identification and prioritisation of numerous, often relatively small-scale, activities. Funding for such activities is also often relatively small-scale. The activities typically do not involve large-scale construction or other similar interventions. Instead, they typically involve water, forest and agricultural management projects, small-scale disaster risk reduction interventions (such as the implementation of early warning systems) and capacity building activities.

Quantitative cost-benefit evaluations of small-scale diversified activities at the local level are difficult to undertake. Data is often lacking, activities individually have different factors that influence their costs and benefits and the package as a whole is often more important than the individual components. In this context, which is typical of many rural programmes whether conducted by governments or by non-governmental organisations (NGOs), quantitative evaluations of the cost and benefits of different programme components would be extremely expensive and often inappropriate. The ability to prioritise different activities is, however, important. As a result, approaches are needed that are much lower in cost, require only qualitative information and can be conducted rapidly. The approach outlined below for qualitative cost-benefit evaluations was developed by ISET to meet this need. As further discussed, it can easily be expanded to include multiple criteria.

METHODS

In a qualitative cost-benefit analysis (CBA), communities identify and rank their top priorities regarding climate change, adaptation and risk reduction in a participatory process that is the culmination of a long process of shared learning dialogues (SLDs) conducted by facilitating partners trained in participatory techniques. In the early stages leading up to a qualitative CBA, facilitators sensitise communities to climate change issues and potential climate-related impacts in their area and the communities come up with strategies to make their livelihoods and services more resilient in the face of the changing climate. They also identify those in the community who are most vulnerable as well as those who are particularly susceptible to climate-related disasters.

It is extremely important to conduct such a community based vulnerability assessment prior to carrying out a qualitative CBA for two reasons. First, without local knowledge it is very difficult to theoretically determine vulnerability. Second, at the local level, omission of the distributional aspect of costs and benefits can easily lead to elite capture. For example, building a gabion wall to protect a couple of *ropani* of a large landholder's land will bring good returns but may not benefit the most vulnerable. Only if the most vulnerable are identified can they be actively mobilised to participate in discussions about prioritisation of potential interventions. It is with their participation that the initial set of interventions needs to be identified.

It is very useful at this stage to start discussions of the costs and benefits of various strategies or interventions. Steering discussions toward CBA requires professional facilitation but it takes only a day of training to teach a facilitator proficient in participatory techniques to conduct such sessions. A session usually lasts two to four hours. Where communities are geographically scattered or divided in other ways, such as by ethnicity or gender, it may be necessary to conduct multiple sessions, so-called focus group discussions, with each group in the community. Afterwards, the results of each group are shared with all of the other groups.

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During the CBA exercise each suggested intervention is discussed separately. Costs and benefits are broken into economic, social and environmental categories and a scale of 1 to 5 or 1 to 10 is used to score the costs and benefits of intervention in each category. The facilitator plays a crucial role in making sure that participants understand the scoring and that they keep in mind climate-induced changes while assigning scores. The facilitator should ask probing questions, like how useful an intervention will be if floods became more intense or frequent, to encourage the community to analyse in a forward-looking manner and to incorporate climate change factors in simple sectoral interventions. The facilitator also has to ensure that scores are consistent within each intervention and also across interventions. The latter endeavour—inter-intervention comparison—differentiates the process from simple ranking, though sometimes a simple ranking of all costs and benefits is useful in starting off a discussion.

If the participants in the CBA discussion include a few sectoral experts like a forester, a civil contractor or even farmers, it is amazing how well the economic costs are captured. Calculating social and environmental costs takes more effort and deliberation. Doing so, however, is one of the main purposes of the exercise: making all non-financial costs explicit and generating a discussion that promotes both transparency and the ownership of resilience strategies.

Some additional criteria, such as focusing on gender or targeting certain social groups such as Dalits, may need to be included in the prioritisation process due to local considerations and priorities and sometimes due to the requirements of the funding agency. These criteria can be explicitly incorporated using multi-criteria analysis in which the results of the CBA are considered to be one of the criteria. This type of multi-criteria analysis is very helpful in supporting community-level decision-making. Criteria can be weighted to give some criteria relatively more or less importance than others.

RESULTS

The tables below show outputs produced by the local organisation Li-Bird for an area of planning in Pokhra district. The initial engagement process resulted in the identification of activities such as minimum-tillage agriculture, regeneration of degraded lands and protection of water sources. Through SLDs at the local level, local stakeholders prioritised these activities based on perceptions of their relative costs and benefits using a common ranking scale. Their discussions resulted in highly qualitative and probably relatively robust estimates of the returns on each proposed intervention.

Table 3.1
Cost-Benefit Evaluation

	COST (0-5)				BENEFIT (0-5)				
ACTIVITIES	**ENV**	**ECON**	**SOC**	**TOTAL**	**ENV**	**ECON**	**SOC**	**TOTAL**	B/C
Promotion of minimum tillage operation	0	2	1	= 3	5	4	4	= 13	4.33
Plantation in the degraded and eroded land	0	3	1	= 4	5	5	5	= 15	3.75
Construction of check-dams	1	5	3	= 8	5	4	4	= 13	1.62
Protection of water sources	0	4	3	= 7	5	5	5	= 15	2.14

Source: Unpublished data collected by Li-Bird through the CADP project under ISET's direction. Method design by ISET.

This approach enabled the community to consider environmental, social and economic returns in an integrated fashion, though they struggled particularly with considering long-term social and environmental values. When some criteria, such as the benefits to specific gender and wealth groups, or the overall ranking was considered, the ranking remained largely the same as it was when only economic returns were considered. But when other criteria was considered, the ranking changed due to weight given to additional criteria. Despite the difficulties in assessing costs and benefits, particularly social and environmental ones, the advantage of conducting a multi-criteria analysis was that all stakeholders were involved in considering some of the social inequity implications of different approaches in much more detail than would have been the case if the CBA had been conducted purely along economic lines. Participatory CBAs also foster a much higher level of buy-in than would have otherwise been the case. Also, ownership by all and sundry—not just the elite—is key to sustainability. And the process was easy to carry out: the qualitative CBA required no more than a day's work in each of the involved communities. Subsequent evaluation by the CADP team confirmed the broad validity of the overall rankings arrived at by the communities. Of course, community based CBAs cannot in any way be compared to quantitative CBAs, but with appropriate training, it provides relatively robust insights for prioritising between activities within small-scale projects.

Table 3.2
Multi-Criteria Evaluation

	CRITERIA			
ACTIVITIES	B/C	GENDER SENSITIVITY	REACHING POOR AND VULNERABLE	TOTAL
Promotion of minimum tillage operation	4.33	4 (saves time and reduces drudgery)	4 (technologies can directly reach)	= 12.33
Plantation in the degraded and eroded land	3.75	4 (saves time and reduces drudgery)	2	= 9.75
Construction of check-dams	1.62	1	1	= 3.62
Protection of water sources	2.14	3 (saves time and reduces drudgery)	3 (ensure water availability)	= 8.14

Source: Unpublished data collected by Li-Bird through the CADP project under ISET's direction. Method design by ISET.

The approach described in tables 3.1 and 3.2 enabled integration of environmental, social and economic returns in the cost-benefit evaluation. Local communities struggled particularly with the long-term social and environmental values. When other criteria were considered, such as the benefits to specific gender and wealth groups, the overall ranking remained largely the same in this case, but was changed in other cases. The benefit of conducting a multi-criteria analysis, however, was that all stakeholders were involved in considering some of the social inequity implications of different approaches in a much higher level of detail than would have been the case with the pure cost-benefit evaluation. This enables a much higher level of buy-in than would have otherwise been the case. The overall process required for conducting this qualitative evaluation was no more than a day of work in each of the involved communities. Subsequent evaluation by the CADP team confirmed the broad validity of the overall ranking. This cannot in any way be compared to a quantitative cost-benefit analysis but with appropriate training it provides relatively robust insights for prioritising between activities within small-scale projects.

INSIGHTS

Qualitative approaches to the evaluation of costs and benefits and multi-criteria analysis can generate a robust basis for decision-making and prioritisation within programmes where quantitative approaches would be difficult to implement and prohibitively expensive. As with the quantitative approaches, the process of thinking through the factors associated with different interventions that contribute to their costs and benefits, is of great importance. Also, even though the method is qualitative, it can be replicated to justify investments in large programmes as well. More importantly, it provides a framework that local communities can use to develop a sense of ownership of climate change adaptation activities, articulate their voices and decide on their priorities. It helps them select those activities which can most effectively respond to the impacts of climate change, whether in the interests of the community as a whole or those of a specific, highly vulnerable group. Such a framework also actively addresses many of the political-economic issues that often stymie externally-driven programmes.

LIMITATIONS

The results of qualitative CBAs are not as precise as those of a full-scale quantitative analysis. The technique also needs to be overseen by a trained impartial external professional with strong facilitation skills; it cannot be expected that a community would carry it out on its own. In addition, a community based qualitative CBA alone cannot be used for targeting the most cost-effective disaster risk reduction (DRR) or climate resilience strategies; before interventions are identified, it is essential to engage in community sensitisation, promote inclusion and carry out vulnerability assessments. A multi-criteria analysis with the results of the CBA as one criterion may be needed to target more specific objectives.

Qualitative approaches to the evaluation of costs and benefits and multi-criteria analysis can generate a robust basis for decision-making and prioritisation within programmes where quantitative approaches would be difficult to implement and prohibitively expensive.

WAYS FORWARD

The qualitative CBA has been used to identify a broader range of interventions before ISET undertook quantitative analyses in several projects. Thereafter, this method has been streamlined to be used exclusively (i.e. without the more technical quantitative analysis) to support communities to identify cost effective adaptation strategies and interventions at a local level. The LAPA design stage and piloting has given an opportunity to develop training material, train field staff and conduct a few pilot studies. Thus far, the results have been very encouraging. However, this methodology needs to be tried at scale, as well as verified with sampling interventions in different scenarios and with quantitative analysis to verify the validity of results.

STRATEGIC DISCUSSION

Community-led local-level investment is an important part of a larger strategy to reduce the impacts of climate change in the short and medium-term, especially, where climate vulnerability is already high and the impacts are likely to manifest themselves in unpredictable ways. Carrying out a quantitative CBA for such investments would usually cost more than the investment itself. In addition, one would still need to know if such investments are indeed cost-effective. A qualitative CBA gives a rough but still very usable way to gauge the economic returns of such investments. Although it may not yield a very accurate measure of choosing between two competing investments, it does indicate which set of interventions are worth making and which would cost more than the benefits they yield. From a community's point of view, the ability to make this judgment is very important, as they will want to ensure that they get the best return from the limited resources available to them. In designing some projects, the communities found the returns to certain investments so favorable that they pooled their own resources and made the investment themselves, reasoning that waiting for external funding would involve an unnecessary delay and that immediate investment would bring immediate benefits.

As discussed earlier, it is essential that a community based CBA identify the most vulnerable and include them in the identification of hazards and strategies to prevent disasters and to ensure that the CBA tool isn't misused to cater to any distributional impacts of costs or benefits. In some cases, vulnerable groups may need to undertake this exercise separately and have their ideas later shared with the larger community, as they are often unable to voice their opinions in front of more privileged members of the community.

This method can also be used to help monitor and evaluate large programmes based on the sum total of evaluations of a number of small investments. Using community based CBAs will allow programme managers and NGOs to improve the returns on adaptation investments in subsequent programmes, particularly as it circumvents the difficulty of insufficient data, especially pertaining to weather. Qualitative CBAs can tell us whether our assumptions regarding the impacts of climate change and the co-benefits of interventions were indeed reasonable.

Developing and testing the use of community based CBAs to support autonomous and local-level planned adaptation strategies will help develop programmes that are low-cost, robust and socially acceptable and which address the immediate needs of the most vulnerable. Much more testing of the approach is required, and at some stages a cumulative CBA—one one based on a compilation of the individual CBAs of small interventions—needs to undertaken to validate results and judge their accuracy.

Since neither social nor physical science has yet determined whether it is cheaper to limit emissions or to support those who suffer because of those emissions, we must turn to non-economic considerations in making our decision. On the basis of social and climate justice, there is widespread recognition that the choice is clear: we must support the most vulnerable. The 2010 floods in Pakistan and their recurrence the following year are grim reminders that vulnerable populations already suffer some of the most severe impacts of climate change. While compassion and action in the name of the vulnerable is imperative, so is investing in protective measures. Given the troubled state of the global economy and the scarcity of resources, it is especially imperative to evaluate various options and make the wisest judgment about where to invest.

CHAPTER 4

CONCLUSION

CONCLUSION

Economics is a central consideration in developing strategies for reducing the impacts of climate change. The case studies explored in this report—the Vietnam boat winch project, the climate-friendly straw-bale building techniques in Nepal and the community based qualitative evaluations—demonstrate the use of CBAs in three types of strategies: medium-term "no-regrets" activities; long-term adaptive strategies; and small-scale, local-level innovations. These constitute a

MEDIUM-TERM "NO REGRETS" ACTIVITIES

The first conclusion is that we need to support ongoing "no-regrets" activities that can be easily replicated and scaled up. This is a relatively easy approach in which ongoing activities can be tested for their economic, social and technical viability and supported if they pass. These activities can reduce vulnerability to climate change in the short and medium-term and pave the way for strategies such as livelihood diversification in the long-term. The key obstacle is the lack of robust institutional arrangements for making investments in such activities possible. Strategic partnerships among government, civil society and private interests can make this possible, as we saw in the case of boat winch in Vietnam.

LONG-TERM ADAPTIVE STRATEGIES

The second conclusion we draw from this set of studies is that support is needed for proactive research into technologies that are likely to change development pathways. More specifically, we need planned adaptation with strategic pre-positioning; this will require innovation, planning and testing new development pathways. Innovative strategies must be based on sound economics as well as be socially acceptable and institutionally viable. The results of such innovations may be far-reaching; in the ideal situation, adaptive strategies will actually support mitigation in the long-term. Straw-bale construction in urban Nepal is one such case where risk reduction will accompany mitigation co-benefits.

SMALL-SCALE LOCAL-LEVEL INNOVATIONS

The third conclusion is that it is critical to support small-scale local-level innovations that build resilience. Although providing such support is the most dynamic and by far the most effective means of supporting resilience in the short-term, it is very hard to standardise this approach. Local strategies are small but highly responsive to changes. They work within spheres characterised by high levels of uncertainty and by limited knowledge beyond what is available locally. It is not economically viable to conduct a CBA of such innovations beyond using the common sense of local households due to its cost and the unavailability of data. Simplified methods such as community based CBAs can be used in such cases as is demonstrated by the case study on developing LAPAs in Nepal.

range of responses to climate change and attempt to raise the resilience of those vulnerable to climate change.

Given such a wide array of approaches and levels of operation, inevitable is the question of whether one approach is better than another. This is probably not the right question to ask. Instead, we should make sure that investment in all three approaches produces a positive return on reducing the impact of climate change on vulnerable populations. The challenge is to spread investments, taking care of immediate threats while also developing medium-term strategies for diversification and embarking upon long-term actions that define a path of change in the development trajectory. It must also be ensured that each approach is economically viable and that depending on the capacity of the country, the selected approach informs the best possible return.

To make such decisions, methods are needed that allow economically sound investments. While CBAs can be fruitful for this purpose, it does have two key limitations: with respect to large investments, the distribution of benefits is an issue, while for small investments, the cost of the analysis may be prohibitive.

This study analysed three cases and three approaches, each of which yielded robust results in areas with severe data limitations as well as even more severe potential threats to human lives and livelihoods. All three cases demonstrate that investments at different scales can yield positive economic returns. The cases also demonstrated that instead of making CBAs more rigorous to overcome analysis limitations, it may be more appropriate to adapt CBAs to local capacities and resources rather than drive it towards complex mathematical challenges. Making such an adjustment will facilitate its ability to provide useful support for investment decisions in data-scarce environments. Using the process of SLDs, a participatory, community based method both less complex and more practical than a formal CBA ensures that social and climate justice prevails and that local preferences are catered to. The SLD process not only makes a powerful case for making an investment, but also takes into consideration local preferences and political economies and adds transparency to the process of developing adaptation strategies.

In short, this set of case studies shows that the use of complementary methods and innovation helps overcome the limitations of economics, specifically those of CBAs, to understand and address the impacts of climate change. Simply put, with some adjustments, an economic tool—CBA—was used in restricted environments to yield results that can be used to make decisions about investments. Even though in all cases information was scarce and resources limited, each case study demonstrates that sound economic decisions about climate change adaptation can be made.

SUMMARY POINTS

Results of the cost benefit analyses undertaken in all three of the cases presented in this report demonstrate that investments in disaster risk management can generate substantial returns as part of adaptation planning under a range of scenarios. The costs and benefits of any disaster risk reduction intervention depend heavily on the nature of that intervention and on the local context. The three cases demonstrate the role both qualitative and quantitative approaches to cost-benefit analysis can play in identifying where interventions are likely to be viable.

On a more specific level the report also demonstrates the following:

1. Boat winches: For coastal cities or rural regions where small fishermen are a part of the population, mechanisms such as boat winches are highly effective in reducing disaster risk for vulnerable communities. Boat winches of the type investigated in this study can be installed and are likely to reduce risk substantially in any area where small boats are at particular risk from storm damage. Boat winches can also serve as a viable income generating mechanism during normal times due to their utility for repair and maintenance. Boat winches are highly replicable, small-scale investments that make a large difference in risk to recipient fishing communities.

2. Straw-bale construction: The analysis conducted in this report demonstrates that the use of straw-bale construction techniques could substantially reduce earthquake risk and generate large benefits for users because it is both less expensive than conventional construction and is far more climate and environmentally friendly. Achieving these benefits, however, would require additional investment in design and piloting of straw-bale techniques to ensure that they are culturally acceptable and widely replicable in the Nepal context. This would require an initial programme of investment in design and piloting before large-scale implementation. While significant adoption could occur in rapidly growing peri-urban areas, the largest adoption might actually take place following a destructive earthquake if sufficient straw-bale structures had been constructed in advance so that a newly aware population demands the technology. Work prior to any earthquake would be essential in order to build the capacities of the construction community so that they would be able to respond rapidly to increased demand following an earthquake.

3. Community based qualitative cost-benefit analysis: The community based qualitative cost-benefit analysis conducted in Nepal demonstrates that for many small scale adaptation and disaster risk management projects, sufficient information can be gained through rapid qualitative techniques to prioritise investments and guide returns on a project level. In typical disaster risk management or adaptation programmes, relatively small investments in diverse activities dominate. A quantitative cost-benefit analysis, if done properly, is expensive and would be difficult to justify in this type of programme. Qualitative approaches such as the ones demonstrated in this report are much less expensive, can be conducted using the capacities of staff typically available in local NGO and government programmes, and can engage local communities. These approaches can also provide a realistic basis for prioritising investments and ensuring adequate returns.

The activities for which cost-benefit analyses were conducted in this report emerged as a result of a systematic analysis and planning process at the local level. This may also be reason that all the selected interventions had a benefit-cost ratio greater than one (not all adaptation interventions are expected to be cost-effective). Establishing such a process as a core part of practice for organisations like the Red Cross is important in order to ensure programmes have internal consistency and are not a scattershot of fragmented activities. Developing and refining a package of methodologies to support this is an important next step.

Beyond the need for systematic approaches to adaptation and disaster risk management planning, it is important to recognise that the cases and analyses conducted for this report suggest thee different modes of intervention that have important implications for programme management by organisations such as the Red Cross. Programmatically, implementation of highly replicable and unitised activities similar to the boat winches can be done with minimal programme management and little need for long-term engagement. In contrast, while the adoption of straw-bale techniques as a basic approach to building in Nepal would truly transform the risk landscape, achieving this benefit requires sustained presence and the willingness to invest in innovation, piloting and training. This can only be done through a programme that has sustained relationships with local partners. Finally, the qualitative cost-benefit analyses are useful in the more common context typical of many NGO projects. These involve relatively short duration engagement with local communities and investment in a diversified set of relatively small activities.

An ability to adjust programming approaches in ways that enable organisations such as the Red Cross to respond to these different types of opportunities is important. Opportunities for targeted investments like boat winches are important but relatively rare and will not transform the overall risk landscape. Similarly, brief engagements with diversified investments can have a significant impact in the short-term and are attractive programmatically but are unlikely to transform the risk landscape. Achieving truly transformative change is likely to require the types of long-term engagement that would be required in the straw-bale case.

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Economics is a central consideration in developing strategies for reducing the impacts of climate change. Investments in disaster risk management can generate substantial returns as part of adaptation planning under a range of scenarios. The costs and benefits of any disaster risk reduction intervention depend heavily on the nature of that intervention and on the local context.

The case studies explored in this report—the Vietnam boat-winch project, the climate-friendly straw-bale building techniques in Nepal and the community based qualitative evaluations—demonstrate the use of cost-benefit analyses (CBAs) in three types of strategies. These include: long-term adaptive strategies, medium-term "no-regrets" activities and small-scale, local-level innovations, all of which constitute a range of responses to climate change and attempt to raise the resilience of those who are most vulnerable to its impacts.

"Understanding the Costs and Benefits of Disaster Risk Reduction under Changing Climate Conditions: Case Study Results and Underlying Principles" summarises a set of activities that were conducted as a result of a systematic analysis and planning process at the local level. Beyond the need for systematic approaches to adaptation and disaster risk management planning, it is important to recognise that the cases and analyses conducted for this report suggest three different modes of intervention that have important implications for programme management by organisations such as the American Red Cross (ARC), the primary donor who supported this project. An ability to adjust programming approaches in ways that enable organisations to respond to these different types of opportunities is important. Achieving truly transformative change is likely to require the types of long-term engagement that would be required in the straw-bale case.