ARTICLE

Sustainable dissemination of earthquake resistant construction in the Peruvian Andes

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Abstract

This article describes the challenges and initial accomplishments of a project developed by the Pontifical Catholic University of Peru (PUCP) to disseminate technology and to train low-income families in the Andes Mountain region to build earthquake-resistant homes made of adobe bricks. The initiative has focused on improving the livability of households through affordable seismic reinforcement of traditional construction processes to enhance the social sustainability of housing in the area. We selected the rural Andean community of Pullo as a case study because of its preponderance of non-reinforced adobe construction and poverty. The research team developed tools and methodologies for technology transfer, worked with local residents to raise awareness of the high seismic vulnerability of adobe dwellings, and introduced the concept of seismic reinforcement. This article explores the barriers to disseminating earthquake-resistant technology in the study area and presents adaptive measures to overcome these challenges. Initial results demonstrate the positive impact of educational workshops to raise seismic awareness and to introduce earthquake-resistant construction among rural dwellers. The project is deemed to have wider applicability to other communities in seismic areas with similar housing, social, and economic conditions.

Keywords: adobe; housing; safe construction; technology transfer

Introduction

Researchers at the Pontifical Catholic University of Peru (PUCP) and other institutions have been working to improve the structural safety of earthen houses located in seismic areas of Peru for the last four decades (Vargas et al. 2005; Blondet & Aguilar, 2007). Research has resulted in development of reinforcement techniques for reconstruction and training programs by nongovernmental organizations (NGOs) following major earthquakes (Blondet et al. 2008a; Macabuag & Quiun, 2010). Unfortunately, efforts to encourage the uptake of these technologies in local communities have largely failed. People continue to build in the traditional way and not one person in the rural Peruvian Andes has independently built his or her house using the proposed reinforcement techniques (Macabuag & Quin, 2010; Blondet & Rubinos, 2014). In an attempt to solve this problem, PUCP has developed a new training program in earthquake-resistant adobe construction that incorporates a previous educational campaign to increase acceptance among dwellers. This article examines the value and success of this project for disseminating new building technologies.

The research reported here contributes to literature on sustainability education and the social aspects of housing in the Peruvian Andes. The intention is not to assess the sustainability of a single reinforcement technology, but rather to investigate the effectiveness of the technology after educating the population about the importance of seismic reinforcement. In particular, we address the challenges of taking technology from the academic world, where it is conceived in a theoretical way, and implementing it in rural towns, where reality is much more complex and variable. The study area is located in the Peruvian Andes and we focus in particular here on work carried out in the rural community of Pullo, which has been selected because of its high seismic exposure, both in terms of infrastructure and social vulnerability, and the danger signaled by recent seismic events.

This article begins with background on the initiative and the proposed technology, including the technology-transfer tools relevant to the project. We then identify the major challenges of technology transfer that the research group encountered, focusing on issues, pertinent in the rural town, of trust, literacy, cultural differences, lack of permanent personnel, and transportation. The article also highlights the adaptive measures taken to overcome those challenges, such as
audiovisual resources, creative advertising methods, and special private transportation for the equipment. Next, it describes the familiarizing educational experience and concludes with a brief discussion about the proposed technology, the technology-transfer experience, and the initiative’s success.

Background

To provide a more complete picture of the work presented in this article and how it contributes to sustainable implementation of earthquake-resistant housing in rural Andean communities, we describe some of the background context. This section also discusses the relationship between social sustainability and housing to provide a deeper understanding of the importance of communicating about earthquake-resistant construction. We then present the PUCP initiative as an example of the human development-capability approach, which provides an opportunity to apply innovative technology-transfer tools and to critically assess their effectiveness for future projects. Finally, it describes the seismicity of the study area and develops an overall characterization of its housing conditions to create a more detailed depiction of the Andean area of Peru.

Social Sustainability and Housing

Sustainable development of a community is based on achieving balanced economic growth, environmental protection, and social progress (McKenzie, 2004; Adams, 2006). Development should provide an acceptable quality of life, both for individuals and communities, and maintain healthy financial markets while preserving natural resources by assuring that depletion does not occur more rapidly than replenishment (Fisher & Amekudzi, 2011). Balancing these objectives means that the various sustainability dimensions are not isolated, but that an integrated view is maintained. For example, social and environmental aspects of sustainability are interwoven because degraded natural resources can compound social inequity and segregation, conflicts, instability, and dissension (Chiu, 2003).

Social sustainability is essential for sustainable development, although there is no consensus on how to incorporate it in practice (Cuthill, 2010; Casula Vifell & Soneryd, 2012). Sustainable communities are places where people want to live and work, now and in the future (ODPM, 2006), and socially sustainable communities need to guarantee access to basic needs while featuring equitable outcomes, diversity, connectivity, and democratic governance to provide a high quality of life (WACOSS, 2002). However, despite the importance of social sustainability, the economic and environmental dimensions are prioritized in planning housing and communities (Woodcraft, 2011) and this neglect of social sustainability is paramount in the case of housing (Dempsey et al. 2011).

The social sustainability of housing can be assessed quantifying the livability of households (internal housing conditions and external residential quality) while also considering equity in housing distribution and consumption (Chiu, 2003). In addition, one of the predominant physical factors needed for a community to achieve urban social sustainability is decent housing (Dempsey et al. 2011), which provides shelter, basic to community well-being (Magis & Shinn, 2009). However, beyond shelter, housing should also promote social integration and safeguard the environment to preserve the ability of future generations to meet their needs (Murphy, 2012). Furthermore, housing only promotes well-being if planners understand what people need from the places in which they live and work (Woodcraft, 2011).

Therefore, to achieve social sustainability at the community scale, housing should promote well-being and not only meet basic needs. This objective can be achieved by improving the livability of structures, where livability is understood to create conditions for healthy, safe, affordable, and secure households within a neighborhood with access to utilities, transport, healthcare, and education (Mitlin & Satterthwaite, 1996). This article concentrates on how to implement safe and affordable housing as a first step to improving the livability of households and thus securing social sustainability in rural communities of the Peruvian Andes.

The PUCP Training Project

The technology-transfer initiative described in this article is part of a larger PUCP training project that aims to provide sustainable earthquake-resistant housing for Andean communities. The effort is based on experiences from a small-scale reconstruction program developed by PUCP and CARE-Peru (a nongovernmental organization (NGO) specializing in development) after the Pisco earthquake of August 2007 (Blondet et al. 2008a). The project is interdisciplinary, bringing together partners from engineering, psychology, anthropology, history, and communications with the goal of achieving acceptance...
of seismic reinforcement among homeowners and residents in Andean communities.

The central idea of the initiative is that people should not be mere recipients of external aid, but become agents of their own development by acquiring the skills to live the life they want (Sen, 2000). In this project, this means that people living in adobe dwellings should learn how to build earthquake-resistant houses by themselves. Therefore, the program consists of training community members in the construction of safer adobe houses using a simple low-cost reinforcement technique. The expectation is that the acquired skills will allow community members to continue improving their housing conditions once the project is over, thus enhancing their quality of life in an ongoing and sustainable way. There is the additional prospect that trained community members could use their acquired skills to earn income as technicians on construction projects.

The PUCP training initiative is divided into three phases to increase acceptance of one seismic reinforcement technique, ease the technology-transfer process, and create a platform where trained people can work on similar projects:

- **Phase One**: Familiarizing educational workshops that include field demonstrations using a portable shaking table and scaled models. The main objectives are to educate community members about the high seismic vulnerability of their dwellings and to show the value of building earthquake-resistant adobe houses.

- **Phase Two**: Training workshops that consist of teaching community members how to build an improved earthquake-resistant adobe house using a simple low-cost reinforcement technique through an illustrated construction manual. The main objectives are to train community members through practical skills and to provide a reference document for future construction. The developed skills (capacities) are applied in the construction or reinforcement of a community building with the collaboration of all inhabitants.

- **Phase Three**: Assessment based on identifying improvements for future training programs. The project’s success is evaluated by the application of the technique beyond the structures built during the training (e.g., the number of independently built or reinforced houses). Another potential outcome to assess is the extent to which local governments have developed similar training programs.

**The Andean Community of Pullo**

Pullo is a small rural community located in the Ayacucho region of the Peruvian Andes (Figures 1 & 2). Earthquakes are relatively common in this area because it sits near the boundary between the Nazca and South American tectonic plates. In August 2014, an earthquake registering 6.6 on the Richter scale injured around 100 people, adversely affected 55 houses, and rendered 30 of these structures uninhabitable (INDECI, 2014). After this event, Cáritas, a local NGO, asked the Academic Direction of Social Responsibility of the PUCP (DARS-PUCP) for relief aid. As a first response, an interdisciplinary team traveled to the community and assessed the post-earthquake situation, in terms of both structural damage and psychological effects. The team also identified community leaders (e.g., local and church authorities and the Commoners’ Association) who might serve as potential collaborators for organizing and advertising future projects (Cribilleros et al. 2014).
Despite the region’s seismicity, almost 80% of houses in the area are made of traditional adobe (sundried mud bricks) and built without technical assistance or seismic reinforcement techniques. Dwellers know that non-reinforced adobe houses have very poor seismic performance (Figure 3). However, sadly, more than 30% of the rural population lacks access to industrialized materials and more than 60% live in poverty or extreme poverty without access to utilities like water and electricity (INEI, 2007). Therefore, adobe is the only affordable and available housing for many families. Furthermore, lack of awareness of construction techniques prevents homeowners from investing additional time and money on seismic reinforcement or repair of existing damage (Blondet et al. 2008b; Macabuag & Quiun, 2010). As a consequence, observed damage corresponds to lack of seismic-resistant building techniques during construction (absence of collar beams and presence of excessive thickness of mortar joints) and insufficient maintenance over the years (Cribilleros et al. 2014).

Technology

Adobe buildings are cheap to build and have good thermal properties, but they are also highly vulnerable to earthquakes (Blondet & Rubiños, 2014). Therefore, several reinforcement techniques have been developed to strengthen adobe dwellings against seismic events over the years (Zegarra et al. 1997; Minke, 2001; Iyer, 2002; El Gadawy et al. 2004; San Bartolomé et al. 2004; Blondet et al. 2006; Turer et al. 2007; Smith & Redman, 2009). However, the availability of technical solutions is not sufficient because this knowledge is mainly limited to academics (Blondet & Rubiños, 2014). Entire communities continue to build houses with the traditional non-reinforced adobe-construction technique, leaving them exposed to extremely high seismic risk (Blondet & Aguilar, 2007). Therefore, the first step toward sustainable earthquake-resistant housing is reducing the communication gap between academia and earthquake-prone communities. The next section briefly presents one simple, low-cost, and highly available seismic reinforcement, the nylon-rope mesh, and the communication strategies and educational tools we developed to disseminate this technology in the Peruvian Andes.

Nylon Rope-Mesh Reinforcement

The nylon-rope mesh is a recent reinforcement technique developed by PUCP (Blondet et al. 2013). In 2013, a pilot project demonstrated that a previously damaged full-scale adobe model could be repaired via mud injection combined with an external mesh made with nylon strings (Figure 4). The reinforcement procedure consisted of covering the walls with a mesh made of horizontal and vertical ropes tightened by turnbuckles; later, the meshes on both faces of each wall were joined together by thinner ropes (crossties). During a sequence of unidirectional earthquake motions of increasing intensity, the structural behavior of the repaired and reinforced model was considered excellent. The external reinforcements worked to maintain structural integrity and stability and prevented the partial collapse of wall portions that had separated during the shaking (Blondet et al. 2014).

The PUCP training project selected the nylon-rope mesh due to its great potential as a sustainable-reinforcement technique for low-cost earthen dwell-
-ings in seismic areas (Blondet et al. 2013, 2014). The reinforcement procedure is considered simple enough to be learned without any previous technical knowledge in construction. It does not require extra machinery, and it produces no additional pollution compared to non-reinforced adobe construction. Additionally, nylon ropes are widely available at local stores, while most natural reinforcement materials are not easily obtained in large quantities in the Peruvian Andes. Furthermore, the nylon-mesh technique costs US$120 at most for reinforcing a typical single-floor two-room adobe house, which is less than other industrialized reinforcements (Blondet & Aguilar, 2007; Blondet et al. 2008a).

**Portable Shaking Table Demonstrations**

The portable shaking table is a tool developed to raise awareness of the high seismic vulnerability of non-reinforced adobe dwellings and to build confidence in reinforced adobe construction among rural communities (Blondet & Rubiños, 2014). During demonstration sessions, two reduced-scale adobe models can be tested simultaneously, with the differences in their seismic performance easily observed (Figure 5). The non-reinforced adobe model collapses just like traditional Andean adobe houses during an earthquake, but the reinforced model does not collapse even though it can suffer moderate or severe damage. Disregarding the magnitude of the damage, the nylon-thread mesh prevents the collapse of the reinforced model as the nylon-rope mesh did on the test program, thus showing the effectiveness of the nylon-rope mesh to protect the inhabitants of adobe houses from earthquakes.

![Figure 4](image4.png)

**Figure 4** Full-scale adobe model reinforced with nylon rope mesh.

![Figure 5](image5.png)

**Figure 5** Differences in seismic performance of reduced-scale adobe models.
The Construction Manual

The construction manual is a technical document that describes in detail how to reinforce an adobe house with nylon ropes. Each step of the construction process is described with familiar, simple language and clearly illustrated with easy-to-follow drawings (Figure 6). Furthermore, the manual presents three types of houses that differ in the number of rooms and shows their construction plans in detail. This educational tool is mainly directed to masons and residents of rural areas where informal construction with adobe is prevalent and technical assistance is not easily available.

Dissemination Challenges and Adaptive Measures

The reinforcement systems that the PUCP project team has studied have proven that adobe construction can be earthquake resistant. Indeed, the application of technical solutions would provide enough structural safety to prevent collapse of earthen buildings, thus protecting human life and building social sustainability into their construction design (Blondet et al. 2008b). However, despite the benefits of safer affordable housing, disseminating earthquake-resistant technology faces a number of impediments among dwellers, as discussed below.

Trust

Many adobe dwellers resist changing their building techniques because they dislike external interference in their traditional practices (Blondet, 2011). More important, many rural projects by the government were forced upon residents without their consent in the past, contributing to rejection of external interference in general (Garcia, 2008). Additionally, while assessing the post-earthquake situation in Pullo, informal conversations showed us that the idea of earthquake-resistant housing raised suspicion and skepticism among residents. They considered adobe dwellings extremely vulnerable to earthquakes and only aspired to own masonry structures considered to be “noble” and “resistant” but unaffordable at the same time (Blondet et al. 2008b; Cribilleros et al. 2014). Therefore, the first challenge we found to disseminate earthquake-resistant technology was building trust in the research group and the proposed technology.

We employed two different strategies that attempted to overcome this challenge. First, we presented ourselves to community leaders and carefully explained the motivation for the project and what we hoped to achieve in the community. This allowed us to establish relationships and to build trust with the research group and regarding the project, so that community leaders later helped engage the population (Pérez-Salinas et al. 2014). Second, during work sessions, we included selected motivational and laboratory test videos from previous projects that showed the effectiveness of seismic reinforcement in addition to the live portable shaking-table demonstration.
Literacy

Another challenge we encountered while assessing earthquake preparedness in Pullo was lack of literacy. Most community members only have an elementary school-level education and close to 15% of the population is not able to read (INEI, 2007), requiring explanations using simple language. More importantly, a high illiteracy rate required us to consider inclusiveness in the training program since lack of skills could lead to social exclusion, lack of access, and conflicts (Khan et al. 2015). To overcome this barrier, we planned the educational familiarizing and training phases of the project around audiovisual resources, oral explanations, live demonstrations and exercises, and step-by-step illustrated printed materials.

Cultural Differences

One obstacle during training-session planning was finding dates and schedules that respected the cultural expectations in the Pullo community. A culture is a set of acquired forms and ways to understand the world, to think, to speak, to express oneself, to perceive, to act, to socialize, to feel, and to value oneself as an individual and part of a group (Heise et al. 1994). Peruvian rural villages have different traditions and festivities from each another and from the country’s urban areas. For instance, Pullo has a flag-raising ceremony on Sundays, which also serves as an open space to bring up community issues. In addition, Andean communities have subsistence economies based on agricultural activity and residents prioritize certain times of day to farm and take care of cattle.

In this context, we used several strategies to find appropriate meeting times and places. In particular, we considered the different civil and religious traditions and festivities to respect community beliefs. Special events, such as the chacco de vicuña (a traditional Andean wool-shearing process), were avoided in planning activities, as were agricultural working hours. As a result, two-hour Saturday afternoon and two-hour Sunday morning sessions were validated with community members and main leaders. Additionally, we followed traditional protocol by asking local authorities to welcome participants at the beginning of each session.

Lack of Personnel in the Study Area

Perhaps the biggest challenge that we encountered during this initiative was the lack of university representatives in the study area. Institutions organizing educational workshops would benefit from local familiarity and the ability to assemble 80 to 150 people (InWent & Mesopartner, 2005). Lack of such an institution made it difficult to coordinate and advertise educational and training sessions when other communication was limited.

The project team implemented several strategies to overcome this problem, such as conducting personal and group interviews with community leaders to enroll their help with advertising; greeting participants upon arrival and departure using a megaphone; placing posters with simple, familiar, and inviting language in strategic places such as the main square and local stores; making regular telephone and cellular calls to remind community leaders of upcoming sessions; and finally, using some specific field trips for promoting the events. However, these adaptive measures had to be continuously assessed to improve less successful components.

Transportation

Transportation was a logistics challenge on our first trip to the Pullo community because of the number of different legs required to reach the village. The trip entails a seven-hour bus ride from Lima to Nazca, a two-hour minivan ride from Nazca to Acari, and a four- to six-hour truck ride from Acari to Pullo. The duration of the truck part of the trip depends on the different routes, including dirt roads frequently closed due to mudslides during the rainy season. More importantly, transportation became a bigger dilemma while transporting the portable shaking table, which was too big and heavy to take in the bus or the minivan. We had to hire special private transportation for the first trip, and on following journeys a truck replaced the minivan.

The difficulty reaching Pullo also highlights the need for this project. External aid from the government, NGOs, and other institutions is minimal due to Pullo’s remoteness, and so its inhabitants must rely on their own wherewithal in the face of earthquake emergencies (Cribilleros et al. 2014). However, knowledge of the attendant risks, and ability to anticipate and reduce potential consequences of a disaster (resilience), could increase the speed of recovery after an emergency (Fitzgerald & Fitzgerald, 2005).

Familiarizing Educational Experience

In May 2015, we began the PUCP training program in earthquake-resistant construction in the
district of Pullo. We assembled an interdisciplinary team, which included three civil engineers, one psychologist, and one communications professional, to travel to the community. The main objective of the trip was to conduct a familiarizing educational workshop with participants from all ages and genders. Attendance was free and voluntary; participants did not receive any form of compensation. However, to increase community interest in the educational workshop, we conducted a small promotional campaign on arrival.

Fifty-three community members, including men, women, seniors, and children, attended the two-hour familiarizing educational workshop. First, we presented ourselves and the results from the evaluation conducted during the first visit, then we presented the motivation for the project and what we hoped to achieve in the community. We were careful to avoid misunderstanding or misinterpretation: participants would not be given construction materials but would receive training in earthquake-resistant adobe-construction techniques.

As an introduction to the familiarizing educational part of the workshop, we showed a video from the 1970 earthquake in northern Peru. The team asked participants open questions (e.g., “How did you feel watching the video?”) that allowed community members to express their thoughts—and fears—about earthquakes and how they perceived their adobe houses. Participants confirmed the need for safer housing in Pullo. They regarded adobe to be a brittle material, but the only one they could afford; thus, they feared losing their households and their lives to earthquakes.

Next, the project team elicited responses to one specific question: “Do you believe construction with adobe can be earthquake resistant?” Participants unanimously answered in the negative. Expecting this answer, the team showed previously selected technical and motivational videos displaying the effectiveness of seismic reinforcement, while adding commentaries and questions for the audience. The final video presented the full-scale adobe model reinforced with the nylon-rope mesh and tested in the full-scale shaking table at PUCP. Some questions from the participants showed their interest (e.g., “How thick do the ropes have to be?”) while others showed skepticism (e.g., “So those thin ropes are going to protect my house from earthquakes?”).

We later conducted the shaking table test on the reduced scale models in front of all the participants. This live demonstration allowed community members to observe up close the expected seismic performance of a non-reinforced adobe house during an earthquake (Figure 7). When we asked them which house behaved like theirs during an earthquake, they identified the non-reinforced model. After the shaking table test, they commented on the importance of seismic reinforcement for the enhanced model. Finally, we repeated the description of the PUCP training project and its main objectives and asked participants if they wanted to register for future training workshops.

Figure 7 Dynamic test with the portable shaking table.

Discussion

The Technology

Nylon ropes are well known, available, and affordable in rural areas, unlike other industrialized materials such as polymer mesh or wire mesh with cement mortar. On arrival in the Pullo community, the team found the nylon ropes needed to reinforce a dwelling at two different local stores in various colors and sizes. While reinforcing with the nylon rope-mesh technique increases a dwelling’s cost by US$3–4 per square meter, this is considered affordable, as very poor and poor families in Peru have an average income of US$700–1,000 per year and usually invest US$20–30 per square meter in constructing their dwellings (Macabuag & Quiun, 2010). However, the team noted that the metal turnbuckles used in the laboratory tests are relatively unknown and expensive for the Peruvian Andes; additional research at PUCP suggests that residents could replace them with knots (Mattsson, 2015).

The nylon-rope mesh and other reinforcement techniques studied by PUCP researchers have only been developed for one-story buildings (Vargas et al. 2005; Blondet & Aguilar, 2007). However, in the rural Peruvian Andes, building adobe dwellings without
technical assistance often leads to the unregulated construction of two- or three-story earthen buildings despite their illegality under the Peruvian Building Code. Therefore, the team was concerned when community members asked if this technology could be applied on their already existing two-story dwellings. Unfortunately, as of now the nylon-rope mesh has only been used to reinforce one-story dwellings and further research is needed to examine if this technology can also be used with similar results for multi-story dwellings.

Educational Experience

The educational workshop applied many strategies to sharing knowledge about earthquake-resistant construction in the Peruvian Andes. The schedule for these events and the small promotional campaign was aimed at increasing the number of participants. In addition, the live portable shaking table demonstration and the selected audiovisual materials were focused on overcoming barriers to trust while also avoiding social exclusion due to illiteracy. Using the portable shaking table as a communication tool generated a playful environment that raised interest and confidence among community members. After the live demonstration, the team asked participants to raise their hands if they believed earthquake-resistant construction with adobe was possible. The answer was affirmative and unanimous (Figure 8). Later, through informal conversation, participants confirmed this belief to the different members of the team. This interaction appeared to successfully motivate Pullo’s inhabitants and establish relationships with the team. Moreover, by bringing elements of research into the field, the team was able to show people the efforts made by PUCP to find sustainable housing solutions for them. Therefore, we considered the educational workshop successful as it increased confidence in the nylon-rope mesh as seismic reinforcement and raised interest in upcoming training workshops.

Despite the initial success overcoming barriers to trust, the number of participants represented only approximately 1% of the total population of Pullo, much of which is scattered across farming lands. Therefore, we plan to repeat the educational methodology using the live portable shaking table demonstration to reach a wider audience and to reinforce trust with community members.

Success of the Initiative

In the long term, the success of the PUCP training project will be measured by the number of repaired houses and new houses that use nylon rope-mesh reinforcement. Full assessment of the technique’s acceptance is not possible at this early stage, but one optimistic indicator occurred at the end of the educational workshop, when 32 out of 45 adult participants signed up for upcoming training sessions.

The registration process involved community members writing their full names, providing identity-card numbers, and signing; illiterate participants could dictate their information to team members (Figure 9). In total, over 70% of participants committed to the training program.

Conclusion

Technical solutions to reinforce adobe dwellings exist although they vary in cost and accessibility. The main challenge is not to develop affordable and more sustainable solutions (Ness & Akerman, 2015), but rather to disseminate these alternatives to communities. Greater emphasis must be placed on developing
educational tools and methodologies that can handle the difficulties and unexpected challenges that arise during the technology-transfer process.

Our initial success reaffirms the importance of a familiarizing educational phase to achieve sustainable dissemination of earthquake resistant construction, as dwellers must trust seismic reinforcement in order to incorporate it into their building practices. The educational workshop succeeded among inhabitants of Pullo as it raised awareness and willingness to participate in future training sessions and learn the nylon rope mesh technique. Therefore, we recommend that future studies and training programs include a familiarizing educational phase when working with technology transfer in rural communities. More importantly, the project team envisions that, if the project succeeds, the communication and educational tools that we have developed might be applicable or adapted to be used in other seismic areas where people build with earth—specifically in poor areas of western South America, Central America and southern Asia—with the hope of improving household livability for more families.

Our work has not been easy and is not finished. The project team continues to conduct research in rural Andean communities and this ongoing learning process is aimed at planning and improving appropriate workshops. Without such understanding, community members are unlikely to adopt the proposed technology despite its benefits. However, the people involved in this initiative are optimistic that their efforts will lead to improvement of household livability for many families and contribute to social sustainability of housing in the Peruvian Andes.

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