



## EFFORTS AND IMPACTS OF SOCIO-TECHNICAL ASSISTANCE FOR RETROFITTING IN POST-EARTHQUAKE RECONSTRUCTION IN NEPAL

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### Abstract

Nepal, in the aftermath of Gorkha Earthquake, has been expediting the rebuilding process of damaged dwellings in a resilient manner. Back in April 2015, the devastating Gorkha Earthquake resulted in nearly half a million fully damaged and another quarter million partially damaged houses. In the wake of the disaster, significant accomplishments have been made in reconstruction of fully damaged houses. More than 55% of the houses identified as reconstruction beneficiaries have been completed. However, the retrofitting of partially damaged houses is lagging behind; datasets show that less than 1% of the eligible retrofitting beneficiaries have completed the required interventions, which is very low compared to achievements of new construction. What's more concerning is that, on one hand, people are demolishing buildings which could easily have been retrofitted and would have saved significant amount of resources, while on the other, there are beneficiaries who have constructed a new smaller structure, yet have not demolished their damaged buildings and are still using it.

With aid of literature review, workshops, FGDs and field based surveys, this paper highlights the issues pertaining to the delay in expediting the process of retrofitting in post 2015 Gorkha Earthquake housing reconstruction in Nepal and the interventions being made by the National Society for Earthquake Technology Nepal (NSET) to provide socio-technical assistance to aid the process. Evidently, the lack of abundant experience and research in retrofitting of rural buildings, especially low strength masonry, which comprise two-thirds of the partially damaged buildings was the major issue, particularly in developing confidence among the stakeholders. This lack of confidence resulted in extensive demolition of partially damaged houses and the transfer of beneficiaries from retrofitting to reconstruction. In addition, delay in information dissemination at the ground level and lack of adequate capacity building and awareness activities also played significant role, much similar to the earlier stages of the reconstruction process. However, learnings gathered prior to the earthquake during strengthening of schools, as well as after the earthquake during the implementation of socio-technical assistance programs for reconstruction provide valuable insight into the probable solutions. Subsequently, NSET conducted comprehensive socio-technical assistance activities; capacity building trainings for engineers and masons, awareness through mass media, model demonstrations and door to door campaigns. As a result more than 50 houses in earthquake affected areas in Nepal have been retrofitted, along with changed perception of local communities towards retrofitting as well as enhanced skills and knowledge of the stakeholders. The change in perception, especially of retrofitting beneficiaries and local elected representatives, is seen as a major impact of the efforts. The collective learnings; of technology, materials, cost and awareness and capacity building approaches have been presented in this paper, which can be useful for devising appropriate technology transfer mechanisms for escalating retrofitting in earthquake affected areas. Moreover, the paper provides recommendations for the replication of the learnings, not only as a part of post-earthquake recovery but embedding it with risk reduction efforts for communities straddling over active yet inevitable seismic hazards.

*Keywords: 2015 Gorkha Earthquake; Reconstruction; Retrofitting; Socio-Technical Assistance; Rural Buildings*



### 1. Introduction

The 7.6Mw Gorkha earthquake that struck the central region of Nepal in April 2015 was the single largest disaster in the country's history with more than 9,000 lives lost. The earthquake had disastrous effects in all sectors; loss of lives and injuries, damages to public infrastructures, private houses, heritage and monuments, rural roads and economic losses due to loss of agriculture and livelihood. Thirty one of the seventy seven districts in Nepal were directly affected by the earthquake, with varying degree of damages. The affected areas included some of the most populous regions of the country including Kathmandu Valley. The earthquake affected districts were categorized into five categories; i) severely hit, ii) crisis hit, iii) hit with heavy losses, iv) hit and v) slightly affected, to ease the process of planning and implementing post-earthquake recovery activities based on the loss and damage incurred and the recovery needs.

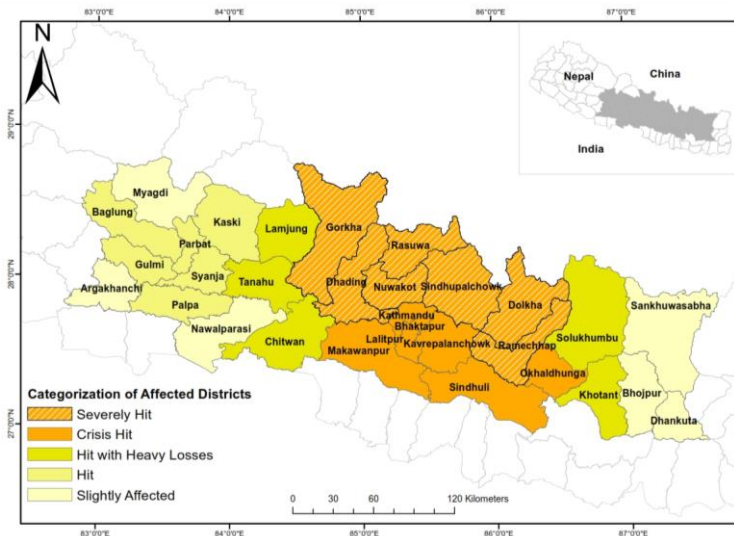


Fig. 1 - Categorization of earthquake affected region in Nepal. © GoN/MoHA

The largest share of the loss and damage was incurred in the private buildings (housing), owing to more than half of the total damage of USD 7.065 billion.

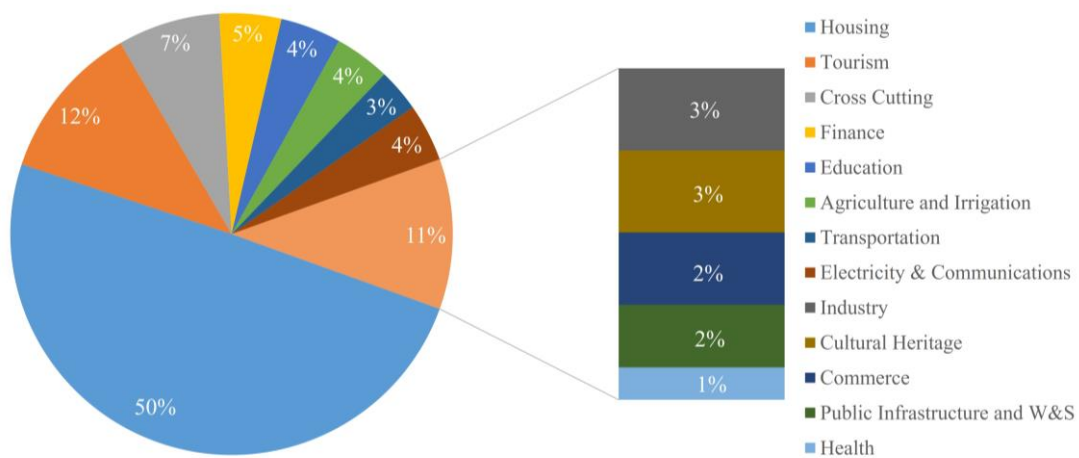


Fig. 2 - Share of damage and losses (in percentage of total) across various sectors [1]

Private buildings, both in urban and rural areas were heavily damaged at a moderate shaking of intensity VI and VII, exposing the underlying vulnerability of the building stock in Nepal. Similar effects



were seen during the 1988 Udayapur earthquake that damaged thousands of houses in the eastern part of Nepal, which had paved way for the development of the National Building Code. However, implementation of building codes was not as widespread and comprehensive as was required and the vulnerabilities of rural villages and urban cities grew with time. Prior to the earthquake, building regulations weren't effectively implemented, trained construction masons and engineers were unavailable and awareness regarding earthquake risk and its mitigation was very low.

## 2. Status of reconstruction

The National Reconstruction Authority (NRA) serves as the apex body of the Government of Nepal (GON) in devising strategies, formulating and implementing policies, managing financial and technical assistance through government and non-government structure with a bid to ensure Build Back Better [2]. The reconstruction is guided by five key strategic objectives as follows,

- a) Restore and improve disaster resilient housing, government buildings and cultural heritage in rural areas and cities.
- b) Strengthen the capacity of people and communities to reduce their risk and vulnerability and to enhance social cohesion.
- c) Restore and improve access to services and improve environmental resilience.
- d) Develop and restore economic opportunities and livelihoods and re-establish productive sectors.
- e) Strengthen capacity and effectiveness of the state to respond to the people's needs and to effectively recover from future disasters.

Among these objectives, the construction of disaster resilient housing is kept at the topmost priority, owing to the huge share of losses in private buildings. To ascertain the reconstruction requirements of private buildings, damage assessments were carried out widely across all the earthquake affected As such, to attain the goal of disaster resilient housing reconstruction, Owner Driven Reconstruction (ODR) approach was implemented, with earthquake affected households, termed as 'beneficiaries' would be responsible to utilize their own resources and make their own choices in rebuilding their damaged structures [2].

However, to bridge the gap in knowledge and technical skills in disaster resilient construction, beneficiaries are provided with socio-technical assistance such as capacity building and awareness activities to ensure compliance to standard technical norms. Further, nominal financial assistance is also provided to the beneficiaries in a tranche based system upon compliance to the technical norms. The Owner Driven Reconstruction has been widely preferred as an effective approach for housing reconstruction in developing countries, resulting in high satisfaction and knowledge retention among the reconstructed households at the expense of lesser resources by the state as much of the reconstruction is done by the communities themselves.

The rebuilding in the aftermath of the 2015 Gorkha earthquake is divided into two sectors; 1) reconstruction of fully damaged houses that fall under damage grades DG3(Major), DG4 and DG5 and 2) retrofitting of partially damaged houses that fall under damage grades DG3 (Minor) and DG2. Both reconstruction and retrofitting activities were envisioned since the inception of the reconstruction campaign, the National Reconstruction Authority enlisting households in the two categories based on the assessments of the damage carried out by a team of engineers and social mobilizers. As such, among all identified earthquake affected households, nearly 8% have been categorized as retrofitting beneficiaries [3]. Upon completion of repair and retrofitting of their houses, these beneficiaries are eligible to receive financial grant support of around 900USD from the government, which amounts to nearly 20% of the total cost of retrofitting a typical rural house in Nepal [4]. The financial support along with the prospects of redeeming traditional architecture, usable space and enhancing structural safety at nominal cost would generally lure a large portion of beneficiaries, even those considered for reconstruction to opt for retrofitting. However, the



pace of retrofitting has not been able to speed up as much as reconstruction, owing to different issues and challenges.

The Figure 3 shows the progress of reconstruction in Nepal in the aftermath of the Gorkha earthquake. The difference in progress between reconstruction and retrofitting is visibly evident in the chart. Although with a slow start, the progress of reconstruction has significantly increased over the last two years, with more than 62% of enrolled beneficiaries having completed their reconstruction [3], compliant to government standards. However, out of nearly 70,000 beneficiaries identified for retrofitting, less than 1% of the households have completed their required interventions and acquired the government grant. The data clearly shows the lack of public interest in retrofitting, despite the benefits that were discussed earlier.

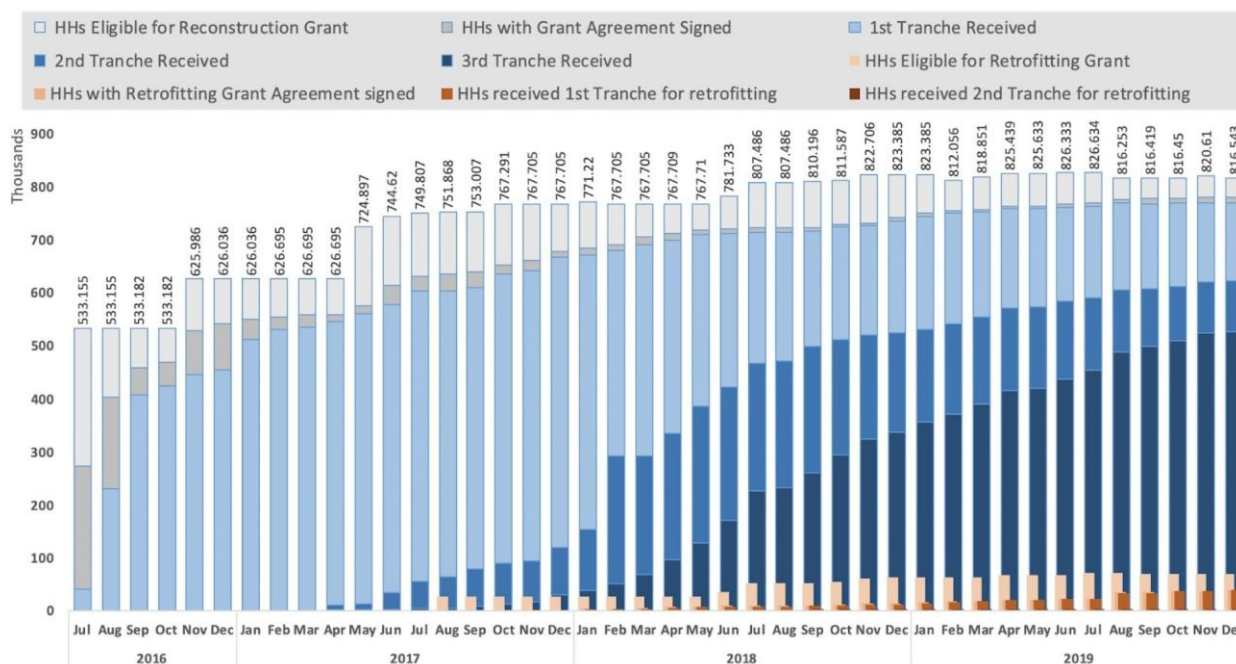


Fig. 3 - Progress status of reconstruction in Nepal as of December 2019 [3]

The unsatisfactory progress in retrofitting also raised question over the actual effectiveness and suitability of the practice in Nepal, which could prove detrimental in earthquake risk reduction activities in regions of the country unaffected by the earthquake. Thus, interventions to understand the underlying issues of retrofitting and their possible remedies was necessary.

### 3. Key issues for delay in retrofitting

There are various underlying issues that hindered the retrofitting of partially damaged houses in earthquake affected areas. A household survey conducted prior to implementation of activities with 1326 retrofitting beneficiaries enlisted by the National Reconstruction Authority in selected wards of earthquake affected districts yielded results as shown in Figure 4. The survey was conducted along with door to door consultation, providing some basic oral information to the beneficiaries regarding retrofitting.

Of the 1326 beneficiaries, 460 beneficiaries were not available for response, mostly having left their partially damaged houses for settlement in other locations, or beneficiaries who were residing elsewhere to begin with. Of remaining beneficiaries, only 49 were interested in retrofitting based on the basic information provided while 710 (82%) of the beneficiaries were not interested in any such interventions, and willing to transfer to full beneficiary status to access the government grant of around 3000 USD to rebuild their houses. Many of these beneficiaries had already applied to the local governments for transfer of beneficiary status from retrofitting to reconstruction beneficiary.



Other key results showed that some house owners had already demolished their partially damaged houses and rebuilt a new one, some were technically unfeasible due to higher grades of damage while some house owners were uncertain regarding the strength, cost and benefits of retrofitting their houses, and required more information to make a decision.

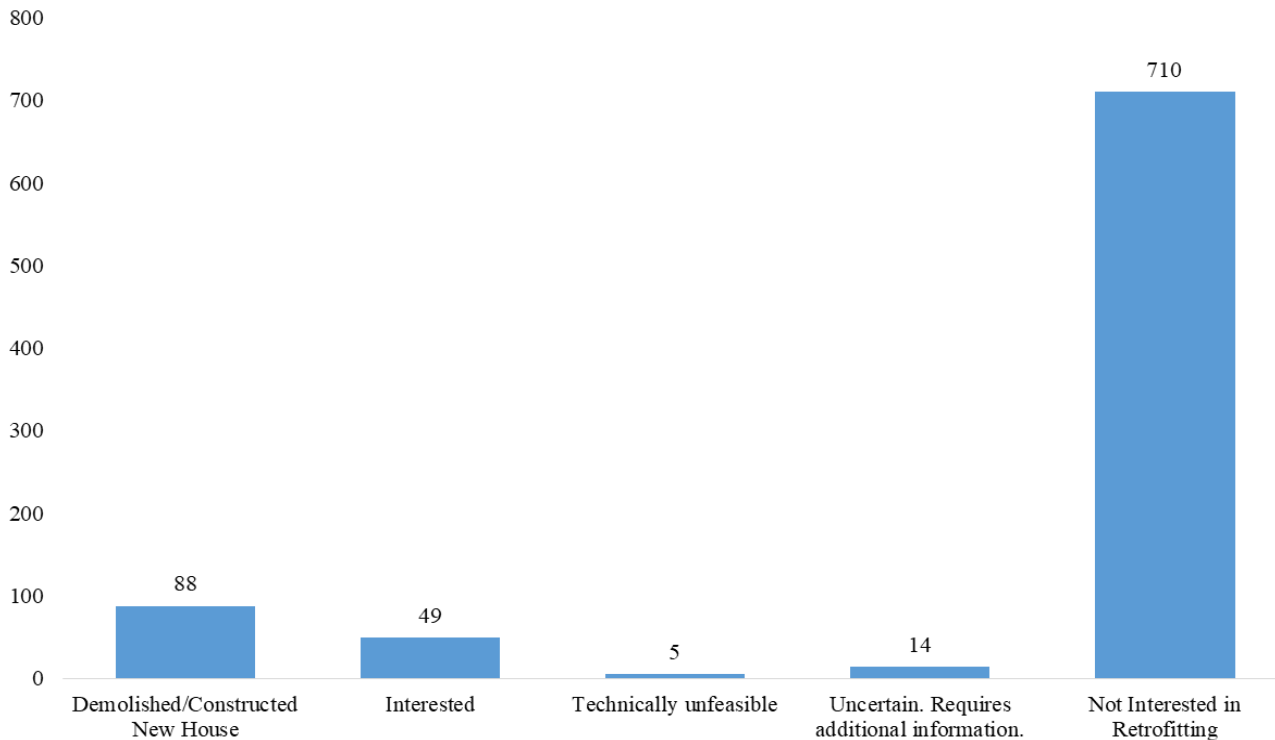


Fig. 4 - Results from household survey with retrofitting beneficiaries in earthquake affected areas prior to retrofitting implementation.

The above figure clearly shows an alarming status of beneficiaries enlisted for retrofitting. Further information into the issues hindering the process, including understanding and skills of the beneficiaries, masons, engineers and local government representatives regarding retrofitting technology, cost and government policy provisions on retrofitting was collected through FGDs, semi structured interviews and workshops. The key underlying issues are highlighted as below:

- Lack of proper understanding on retrofitting:** The major issue with retrofitting was indeed the lack of understanding among all stakeholders (house owners, masons, government officials and even engineers) on the retrofitting technologies, costs and government provisions. Although retrofitting of school buildings and a few private buildings in Nepal had started much earlier before the earthquake, these were primarily focused within the Kathmandu valley and especially targeted towards brick and RC frame structures. Rural stone masonry buildings had not been retrofitted, let alone, communities like the ones that were affected been able to witness or learn about the techniques. Even technical personnel weren't exposed or trained in retrofitting. The gap in level of knowledge and confidence between earthquake resistant construction and retrofitting was clearly evident. Historical buildings and monuments such as temples and palaces in Nepal were built to be earthquake resistant and have withstood the brunt of many large earthquakes. However, strengthening of existing structures was not traditionally inbuilt in the construction knowledge, which led to low confidence among masons and communities alike.
- Delay in information dissemination to community and stakeholders:** With a lack of research on retrofitting in rural stone masonry buildings, information regarding appropriate techniques, materials,



cost-benefits and government standards were not adequately disseminated to the affected house owners. The government of Nepal with support from various partner organizations published the 'Repair and Retrofit Manual' only in July 2017, more than two years after the earthquake. It was during this period that, due to absence and delay in dissemination of any credible information, most of the stakeholders deviated from retrofitting, falsely labelling it as an unfeasible technique for rural houses.

- **Awareness and assistance not focused on retrofitting:** With more than 92% of the total damaged houses enlisted for reconstruction, the government of Nepal and its partner organizations focused largely on providing assistance to the beneficiaries of fully damaged houses to support their reconstruction. This led to the delay of the onset of technical assistance for retrofitting beneficiaries.
- **Anomalies in damage assessments:** To ascertain the reconstruction requirements and ease the process of grant distribution, the government of Nepal conducted damage assessments of the earthquake affected houses by deploying huge number of technical personnel and social mobilizers. While this assessment was believed to provide accurate data of reconstruction needs, it has been seen that in some cases, the damage assessments are not free of anomalies. Houses that could be categorized as partially damaged and recommended for retrofitting were placed in the reconstruction category, owing to various reasons including human errors, lack of proper understanding and undue influence. This created confusion among the beneficiaries as in some communities, houses with similar grade of damage were placed in two different categories, with two levels of government support. This resulted in mistrust towards the government, as retrofitting beneficiaries demanded to be transferred to reconstruction for equal financial grant.



Fig. 5 – Typical stone masonry buildings in rural Nepal, categorized for retrofitting (left) and reconstruction (right) despite similar grades of damage. © NSET

Table 1- Key issues impeding retrofitting as highlighted by major stakeholders

House Owners	<ul style="list-style-type: none"> <li>• "I don't believe that 'repairing' my damaged stone masonry house will make it earthquake resistant. Perhaps it is only for urban houses"</li> <li>• "We asked the engineers about the repairing. They said they have not been given any trainings about it. How long are we to wait?"</li> <li>• "His house had similar damages to mine, yet he received 'full' support while I am enlisted to 'partial' support. That is why I have applied to be transferred"</li> <li>• "The cost is too high. I will only retrofit my house if the cost falls within the government grant"</li> </ul>
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Engineers	<ul style="list-style-type: none"> <li>"We have not received any training regarding retrofitting nor have been directed for providing support to the beneficiaries."</li> </ul>
Local government representatives	<ul style="list-style-type: none"> <li>"The government has kept us in a limbo for a very long time, so we decided to address the demands by transferring retrofit beneficiaries to reconstruction."</li> <li>"We do not have engineers and masons who are skillful in retrofitting houses in our villages"</li> <li>"No one knows what needs to be done. The government should at least make some demonstrations so that people are able to witness and decide on their own"</li> </ul>
NRA/Central Government	<ul style="list-style-type: none"> <li>"We focused largely on reconstruction of fully damaged houses, we will now also provide support for retrofitting of partially damaged houses."</li> <li>"We took some time to ascertain the technologies and technical standards for retrofitting."</li> </ul>

#### 4. Socio-Technical Assistance for Retrofitting

Understanding this scenario, the National Society for Earthquake Technology Nepal (NSET), started working towards enhancing local and national capacity and awareness on retrofitting as part of the housing reconstruction technical assistance program 'Baliyo Ghar'. NSET collaboratively worked with beneficiaries, masons, engineers and local, district and national level government institutions in helping resolve the issues of retrofitting in a bid to expedite the process. This support was primarily backed by the rigorous involvement of NSET in post-earthquake reconstruction, training more than 12600 masons, 2200 engineers and 140,000 home owners on safer construction practices. Similarly, much of technical learnings for the initiation of the process came from NSET's involvement in design and implementation of retrofitting of school buildings, public buildings and private houses, especially inside Kathmandu Valley, starting in the late 1990s. However, retrofitting individual buildings was very different as opposed to the current scenario.

The key step for the socio-technical assistance was to identify the key stakeholders in the process, and formulate adequate strategies and activities that were most effective in dissemination uniform information, albeit, in different levels of depth. Thus, the interventions primarily focused on conducting door to door orientation and awareness campaigns, trainings, demonstration construction and visits, workshops, use of mass media, support for guidelines, manuals and curricula for the government and market facilitation.

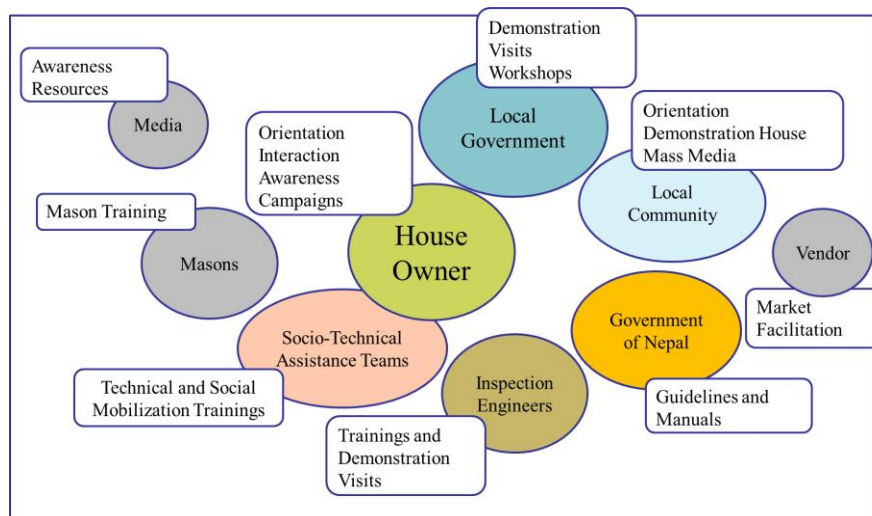


Fig.6 - Different stakeholders and their relevant intervention socio-technical assistance activities implemented by NSET.



#### 4.1 Preparation of manuals, curricula and guidelines

To ascertain the uniform dissemination of knowledge and skills on retrofitting techniques, process and administrative provisions, the NRA led the process of formulating the technical guidelines, curricula and manuals. As such, in July 2017, with the aid of different partner organizations, the "Repair and Retrofit Manual" was published which included detail information on the philosophy and concept of repair and retrofit and detailed technical information on design and construction sequences of retrofitting masonry buildings using Splint and Bandage technique using reinforced concrete, welded wire mesh or wooden elements as reinforcements. The technique was selected based on its structural performance, suitability and cost effectiveness for rural masonry buildings. The manual is the key document to aid the engineers deployed in the earthquake affected communities to provide designs, and supervise the retrofitting of the buildings. Similarly, NSET also worked in standardizing the training for masons and engineers on retrofitting, by developing modular curricula for on-site training for masons and engineers.

#### 4.2 Household Awareness Campaigns

As traditional knowledge on seismic retrofitting was non-existent in earthquake affected communities, NSET focused on providing comprehensive information to the affected households by conducting awareness campaigns including door to door visits, information desks, publications and orientation sessions for these beneficiaries. The campaigns was focused largely on providing beneficiaries with detail information on the philosophy, engineering research, past experiences and success, construction procedure and associated cost-benefits of retrofitting through presentation slides, small scale demonstration models, videos and posters. The awareness campaigns also provided platform to collect information on key issues in the field and discussing those issues to possible remedies at the national level.

#### 4.3 Training for Masons and Technology Demonstration

Apart from information dissemination through theoretical media, NSET also focused on demonstrating the procedure of retrofitting by construction of actual scale demonstration models. For this, partially damaged houses which were enlisted for retrofitting were chosen in earthquake affected areas in collaboration with the local governments and assisted in retrofitting through hands-on training for masons. The demonstration house also served as a site for training local masons in the construction process of retrofitting, thus serving dual purpose of awareness as well as capacity enhancement for the local communities. NSET focused on retrofitting a wide range of houses based on size, socio-economic condition of households and geographical locations to portray the suitability of the technique in different aspects.



Fig. 7 – Masons receiving hands on training on retrofitting (left) and Representatives from a rural municipality observing the ongoing retrofitting of a typical rural stone masonry building. © NSET



#### 4.4 Training for Engineers

Being a technically complex intervention, the direct involvement of skillful engineers in the assessment, design and supervision is required to complete the retrofitting process of a building. Hence, training of engineers deployed in the earthquake affected communities on the basics of damage assessments, designs and implementation of retrofitting was another key aspect of the socio-technical assistance. Moreover, the training not only focused on enhancing theoretical knowledge of engineers on basic retrofit design but also conducted on-site visits to actual retrofit sites to enhance practical knowledge and develop confidence among the engineers on the technique of retrofitting. This was seen as a crucial aspect of the technical assistance, as house owners relied a lot on government engineers for credible information and technical support.

#### 4.5 Use of Mass Media

In addition to various trainings and awareness programs, NSET widely used the mass media platform i.e. radio and TV programs to broadcast episodes on retrofitting targeted to a wide coverage of audience. The use of mass media was especially advantageous to create an atmosphere of curiosity among the beneficiaries regarding the process and disseminate important information regarding technical as well as administrative aspects of retrofitting, and increase confidence among stakeholders through documentation of case stories depicting success of retrofit implementation. In the end, the TV program alone was able to motivate a number of beneficiaries to initiate the process of retrofitting.

#### 4.6 Workshops

Creating awareness among stakeholders is crucial for appropriate planning and prompt implementation. Keeping this in mind, NSET conducted numerous talk programs, seminars, workshops and conferences at local, district and central levels in collaboration with the government of Nepal. Such activities provided very good platform for sharing experiences among the professionals; local, provincial and central government officials, engineers, media personnel, academicians, partner organizations, donors etc. Sharing of challenges, successes, failures and learnings provided ample opportunity to develop appropriate solutions and strategies. Further, discourse on retrofitting also helped in developing national/ international linkages with similar agencies, improve coordination mechanism among the stakeholders and keeping updated with the recent global achievements in the field, enabling stakeholders to learn from local and global knowledge for effective strategy planning and implementation.

#### 4.7 Market Facilitation

One of the key challenges during the implementation of retrofitting was the absence of retrofit materials, especially welded wire meshes in local markets in rural areas. As most retrofitting materials are not widely used for new construction, they are not locally available, even in district headquarters. Thus, market facilitation was seen as a crucial step towards supporting house owners in access to retrofit materials at a reasonable rate. Similarly, the facilitation also helped local vendors understand the scope of retrofitting in their communities and provided congenial atmosphere to increase stock of materials, thus helping in reducing the associated costs. This was altogether very essential as cost effectiveness was one of the primary concern of the house owners.

### 5. Impacts

With comprehensive socio-technical assistance activities conducted by NSET for retrofitting during the period of a year from October 2018 to September 2019, the program was able to convince house owners and retrofit 51 masonry buildings in four earthquake affected districts. Moreover, 316 local masons were trained during the construction of these demonstration houses and 488 engineers were trained on design, construction, supervision and inspection of retrofitting. Similarly, 1035 persons including local and central government officials, community people, beneficiaries visited the demonstration construction sites to witness retrofitting. As such, the demand for support for retrofitting has increased significantly, and most importantly, the misconception regarding retrofitting is gradually declining from the beneficiaries. With the



learnings of the program, the Government of Nepal has also initiated special programs to provide technical support to retrofitting beneficiaries, and has started constructing demonstration houses all over the country.



Fig. 8 – A typical 2 storey and attic stone masonry building before and after retrofitting. Beneficiaries are especially attracted to the low levels of architectural interventions thus ensuring adequate usable space.

## 6. Learnings

- Selection of appropriate techniques and materials:** There have been several researches and studies on the retrofitting of masonry buildings using various techniques and materials. However, it was learnt that selection of appropriate techniques and materials, owing to a number of factors including the building typology, cost of materials and its transportation and the economic status of the beneficiary is very important. As such, the splint and bandage technique using welded GI wire mesh was found to be most cost effective during comparative estimation [5]. However, as this technique requires that the mesh be covered with plaster, communities without access to roads and where sand is not locally available, such as higher hilly and Himalayan regions in Nepal, are not attracted towards the technique. Similarly, the locally available material, wood is not of good quality so as to be used as splints and bandages in the outer face of the walls. As such, people are deterring away from retrofitting. Furthermore, in some communities, the designs prescribed in the manuals does not conform, as the dimensions and typologies of the houses are different, and unique.
- Comprehensive awareness campaign is necessary:** One of the major challenges in retrofitting is the negative response of house owners, local representatives and even technical personnel on the concept of retrofitting, especially on the increase of strength and the cost-benefit of retrofitting a damaged masonry building. Hence, Baliyo Ghar Program identified and prioritized several areas with high number of retrofitting beneficiaries for carrying out the assistance. As such, integrated and comprehensive social awareness campaigns were conducted in these areas, with orientation programs, video demonstration, door to door campaigns, and coordination and orientation meetings with elected representatives, participation of elected representatives in district and national workshops and conferences etc. so as to create an atmosphere of positivity towards retrofitting. As a result, in some earthquake affected



communities, even house owners who are enlisted for rebuilding and full grant support have opted to retrofit their damaged houses.

- **Cost of retrofitting:** As learnt during the construction of demonstration models, the cost of retrofitting is a key aspect in the decision making process of both the house owners and designers. In terms of materials, after required analysis of strength and comparison of cost, it was found that for similar strength, cost of retrofitting using Welded GI mesh splint and bandage is 25% lesser than using RC splint and bandage [6]. Similarly, per unit built up area cost of retrofitting of a masonry building varied from \$4 to \$8. Retrofitting per unit cost varied with the number of floors, with smaller houses costing much more in unit built up area than larger houses. Therefore, a much more accurate index of calculating the cost of retrofitting would be through wall area calculations, which lies around \$2, irrespective of the number of floors of the building.

## 6. Conclusion

There is need for immediate action to accelerate the retrofitting of damaged houses, not only for the completion of the reconstruction process but also provide knowledge and skills to local communities to enhance their seismic safety by implementing these interventions in undamaged, yet unsafe, structures. Importance must be given to comprehensive awareness campaign on retrofitting including meeting and workshops with elected representatives and showcase of retrofitting success stories through audio visuals and media. Similarly, demonstration houses must be built across all earthquake affected areas to increase confidence of communities in the technique. Similarly, market hubs must be established in earthquake affected areas to facilitate the transportation of materials so as to decrease the cost of retrofitting.

In higher settlements untouched by roads, cost of transportation of retrofitting materials like cement, sand and wire mesh is not a feasible option. Hence, several other designs on retrofitting must be studied and prescribed so as to cater to the needs of different communities. Further, retrofitting requires specific interventions depending upon the building typology and architecture as well as house owner needs. Thus, specialized trainings on some key technical issues, such as adjoined houses, slope land etc. must be provided to the technical personnel for effective assistance.

In addition, errors during damage assessment can create huge confusion among earthquake affected communities, as seen in the current scenario. Scrutiny of the damage assessment is necessary, and surveyors must be well trained and oriented regarding the proper recommendation after an assessment.

With much of the country lying in high seismic risk zone, and considering the existing vulnerabilities of structures, it is important that retrofitting not be seen only as a part of the current reconstruction campaign but also a base for learning to be applied for future disaster preparedness activities. Thus, it is essential that this opportunity is adequately utilized to sensitize other at-risk communities towards the techniques and cost-benefits of retrofitting and also, if suitable, enhance local capacities by sharing of experience, knowledge and skills among different communities.

## 7. Acknowledgement

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