MIT IDEAS Competition

FINAL APPLICATION

SUSTAINABLE SHELTERS: *Converting Adversity into Opportunity*

INTRODUCTION

The project's goal is to educate and empower people, affected by the October 2005 earthquake, to build their own homes and assist in the transition to self-sufficiency in the reconstruction process. This would be achieved through focusing on the dissemination of construction improvements that could make existing traditional housing safer and more sustainable. The construction of a demonstration home, provision of training sessions, and distribution of literature are the key components for educating the population about improvements in construction, which focus on efficiency, resourcefulness, affordability, and adaptability. The suggested improvements illustrate low cost innovations for seismic resistance, thermal efficiency, rain water harvesting, indoor ventilation, and daylighting. These improvements provide the local community with options for upgrading their existing shelters that remain within their financial, social, and environmental constraints.

The three core components of the project are:

1. Provide a physical model of construction solutions with a demonstration home and educate and empower the local community through training sessions.
2. Develop catalogs of cost estimates and product descriptions and construction manuals with design and construction method details to educate about the improved functionality and sustainability of the recommendations.
3. Educate and join efforts with other organizations and stakeholders involved in reconstruction projects in the target village and other areas.

BACKGROUND

Why shelter and housing?

Over the past three decades the number of natural disasters and the associated economic losses has increased tenfold[1]. The number of people displaced due to natural disasters and environmental degradation is predicted to rise to 50 million by 2010[2]. A significant number of this vulnerable population belongs to the developing world and lives in absolute or relative poverty and is in desperate need of shelter while being unable to afford the land, the help, and the materials. The loss or vulnerability of shelter risks their security, dignity, and survival.

Sustainability and reconstruction

The international community has become perceptive of emergency solutions and has supported relief efforts accordingly. However sustaining relief efforts will become considerably difficult as the number and impact of natural disasters increases. Tents and food packages can not be regarded as the panacea since relief provision is only the initial step and may create its own social, economic, and environmental costs over time because of the focus on cheap and quick shelter

[1] *Living with risk: A global review of disaster reduction initiatives,* United Nations International Strategy for Disaster Reduction 2002

[2] *World **Disasters** Report,* International Red Cross 1999

construction. These costs arise from poor management of resources and the increasing dependence on imported solutions for shelter that may not be culturally acceptable and construction which may have initially aimed at improving post-disaster housing may eventually result in poorly constructed, poorly planned, unsanitary, and wasteful permanent housing.

Engineering to accommodate appropriate disaster mitigation in reconstruction and to improve living conditions cannot be separated from the social, economic, and environmental issues. Innovations in housing design and dissemination of improved, affordable, and low-tech construction practices govern the possibility of transforming rubble to monument in communities affected by natural disasters. Mechanisms for income generation can be coupled with the distribution of educational materials to focus on enhancing local capacity through catalyzing financial and human investment and on decreasing the dependence on outside sources.

Why Pakistan?

The sustainability of the reconstruction process in the Northern Areas of Pakistan after the South Asia Earthquake of October 2005, which left 3 million people homeless, poses a tremendous challenge since it not only involves the construction of close to 500,000 homes in the long term but also the rehabilitation of areas which have been buried in the rubble. The reconstruction of homes is critical not only for sheltering the displaced and securing assets since a substantial proportion of the inhabitants' holdings and resources are implemented in the process, but also because of the potential to improve living conditions that had existed prior to the earthquake. Inefficiencies in housing structure and other housing products have been responsible for the increase in expenditure on healthcare, fuel wood, and house repair- all contributing to the poverty burden.

The current situation

Even after a year and a half has passed since the earthquake, 60% of the survivors are still vulnerable because they still live in make shift shelters and are in need of livelihood restoration and amenities such as potable water and sanitation. Further complexities have arisen with:

-the exploitation of scarce resources such as timber

-the lack of management and minimization of waste

-the promotion of materials with a high embodied energy such as concrete and steel which are expensive and not readily available instead of the reuse and recycling of materials from debris in the construction of homes

-the increased dependence on prefabrication, preventing the enhancement of local capacity

These elements have also increased the vulnerability of the community, the housing stock, and the environment during the reconstruction of homes.

The needs

The lack of coordination and cooperation between the Pakistani Government, the dozen NGOs operating in the area, and the organizations involved technically with the reconstruction process is a major obstacle. Most organizations and aid agencies have very different agendas and priorities. While for some, the use of local materials and the improvement of traditional construction methods has been the focus, for others, the use of prefabricated components has been preferred. Although many suggestions have been made to improve traditional construction, very few have been translated into a reconstruction process and have been adopted by the local community because of an ineffective dissemination system.

High quality posters, with textual descriptions, have been produced by some organizations. Unfortunately, the pool of people that can access the information and understand it is comparatively small because of low literacy levels. In more remote areas there is still not enough awareness about building for safety, resulting in the building of homes with little seismic consideration.

Isolated examples of local construction innovations for improved seismic resistance and thermal efficiency exist, but they are not documented. They are not recorded because they are not considered suitable to be scaled and replicated in the reconstruction projects under the government and other organizations because of a lack of high-end engineering.

Thus the community remains vulnerable to future earthquakes, financial losses due to inefficient building practices, and a growing poverty burden. Effective methods of education and dissemination are crucial to prevent such burdens and ensure the long term sustainability of the reconstruction process.

The community to be served

The target community for this project is the population of Bana, a remote village located in one of the earthquake affected valleys of the Rawalkot district of Pakistan. Presently there are 500 households in Bana and most of the affected population is living in make-shift shelters built on the site or next to their collapsed homes. The average size of a household is about five people and a majority of the population's livelihood depends on agriculture and livestock.

The link between community partners interested in an innovative approach towards reconstruction and Bana was the deciding factor in choosing Bana as the focus. Packages Ltd, a Pakistani paper-packaging company that has participated in the relief effort in the Rawalkot region, has pledged to fund and manage the reconstruction efforts in Bana. Packages has partnered with the Kashmir Education Foundation, a non-profit NGO, that has established English medium schools and teacher training institutes in rural areas of Rawalkot in the past. Packages and KEF expect to construct two primary schools in Bana and plan to reconstruct the village over the next five years.

Existing Solutions

Current post-earthquake shelters have used galvanized iron sheets that were distributed as a part of the UNDP effort and other materials salvaged from debris. Residents complain about lack of protection from harsh weather conditions. Many must burn significant amounts of wood to warm their homes during the winter. During the summer, indoor temperatures are extremely high, and during the monsoon season, homes are ravaged by flooding.

Some have rebuilt their previous homes from local materials and heavy earthen roof construction despite the collapsing of such roofs being the primary cause of death during the earthquake.

There have been no educational programs to complement the reconstruction, apart from the training sessions conducted by UN-Habitat and the Earthquake Rehabilitation and Reconstruction Authority (ERRA).

Courtesy Mark Knobil. Image from Wikimedia Commons, http://commons.wikimedia.org.

Fig1. CGI shelter

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Fig2. Traditional house

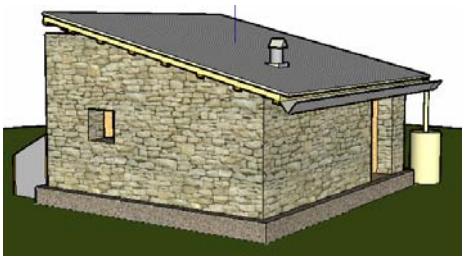


Fig3. Our design: Improved traditional house

Criteria[3]		CGI Shelter	Traditional house	Our design
Design	♦Design of shelter & materials used should be familiar & socially & culturally acceptable		✓	✓
	♦Alternative materials should be durable, practical & accepted			✓
	♦Improved thermal comfort & ventilation			✓
	♦Access to water supply & sanitation facilities			✓
	♦Vector control measures to minimize health hazards			
Construction	♦Locally sourced materials & labor are used without adversely affecting the local economy or environment		✓	✓
	♦Locally derived standards of workmanship & materials are achieved	✓	✓	✓
	♦Construction & materials mitigate against future natural disasters			✓
	♦Construction & materials enable maintenance & upgrade of shelters using locally available tools & resources	✓	✓	✓
Environment	♦Natural resources are managed to meet the needs of the displaced		✓	✓
	♦Products & supply of construction materials & building processes minimizes long term depletion of natural resources			✓
	♦Trees & vegetation are retained where possible to increase retention and minimize soil erosion			

INNOVATION

Dissemination

The local population

Our approach to the dissemination of building methods addresses the affordability of reconstruction and takes into account the reconstruction that has already been initiated by residents. Unlike most other organizations who have presented one unified construction plan, we will provide a series of

[3] The criteria for design, construction and the environment are taken from the 'Sphere Project Standards'

improvements to basic structural elements. For residents who have already begun to rebuild homes, flexible small-scale building improvements allow them to improve on their home, rather than undo the financial investment they have already made in their home. For residents who have not rebuilt, small-scale improvements are less overwhelming and are adaptable to their financial constraints. Presenting various small innovations allows home improvement to become more adaptable, economical, and thereby accessible to residents. The information about improved building methods will be disseminated to residents through the construction of a demonstration home, workshops, and the distribution of pamphlets.

The demonstration home in conjunction with a 4 week workshop serves to raise awareness about need for improved building methods and to teach those methods to the residents. The demonstration house will exhibit the various improvements that can be applied, and will be a guide for the residents' workshops. The actual construction fo the demonstration home will involve the participation of a few interested residents who are interested in further promoting the improved building methods. Details of improved building processes can be learned from watching the construction of the demonstration home. In addition, the demonstration home acts as a standing exhibit for building improvements that can be made.

By using the demonstration home as a reference and guide, the workshops will attempt to persuade the residents about the necessity and benefits of improved building methods. Once the residents are convinced the benefits of new construction methods, it is much more likely that residents will implement these new techniques during the construction process. The workshops will provide residents with the desire to employ these new details and the knowledge to make these changes. Through the demonstration home and workshops, residents can see how to make concrete improvements rather than read about abstract ideas on a pamphlet.

While the sole use of pamphlets will not be enough to promote building methods, it would be an effective for reinforcing ideas taught during the workshop and the presentation of the demonstration home. Unlike many other pamphlets which have tried to textually outline building details, our pamphlet will try to reinforce the essential ideas of safe building practices visually. The use of illustrations rather than text is important since the literacy rate is low throughout rural areas. By conveying only the most essential information rather than providing a step-by-step guide, the pamphlet will be more understandable and accessible to the residents; therefore, it will be more likely to be referenced throughout the construction process.

NGOs

The importance of conveying information effectively to NGOs is crucial as they are the group on site during the reconstruction process and have the power to promote and reinforce building methods throughout the area. Our approach to receiving NGO support will be to present a cohesive strategy of building methods integrated with dissemination. Our idea sets us apart from other organizations by providing a complete package from structural details to dissemination.

For our project, we will contact Packages Ltd. and Kashmir Education Foundation both of whom are working in the Rawalkot area and direct them to our website. The goal of our site is present our integrated approach to the reconstruction process. Information about building and dissemination will be paired with tables and charts showing the social and economic benefits of our strategy and comparing our strategy to previous designs and plans. By including information about many

aspects of reconstruction, the website is not a list of suggestions, but instead it provides organizations with an active plan for the rebuilding process.

Design

The design for a demonstration home is significantly derived from improved construction practices (using local materials and building techniques) that have been observed in the area coupled with the criteria for upgrading the functionality of shelter to include:

-Improved seismic resistance:

1. Use of foundations that are consolidated with wire mesh, mortar and vertical reinforcement would function as base isolation for the structure and hence minimize the transmission of ground motion to the structure.
2. Stone masonry reinforced with wire-mesh and lime mortar would reduce the chances for walls overturning and separating at the event of an earthquake.
3. Use wooden beams and columns and of steel brackets and wooden bracing between them would improve the distribution of loads from the roof to the foundation.
4. Use of a light roof would decrease the dead load of the structure and hence the chances for roof collapse, which was the primary cause of dead during the earthquake.

-Thermal efficiency (better insulation)

1. Use of straw insulation/ agricultural waste/ wood shavings (compressed form or loose) is shown to increase the insulation value of stone and mud wall construction by 3 times, hence less wood needs to be burnt in the winter to keep the home warm.
2. Use of straw insulation/ agricultural waste/ wood shavings (compressed form or loose) does not only increase the insulation value of the roof but allows for lighter roof construction to the traditional flat heavy earthen roofs of similar insulation value.

-Rain water harvesting

1. Use of roof rain water harvesting provides an alternative water source. This solves the water shortage problem (natural springs that the community was dependent on as a source of potable water have dried up due to seismic activity) to an extent, since women may not need to travel long distances collect water from streams and channels in the area.

-Ventilation

1. Use of vent or cook stove with smoke extraction to prevent indoor air pollution which is responsible for increased respiratory problems, especially for women and children. In Pakistan 180,000 people die every year from indoor air pollution (compared to the 73,000 people that died due to the October 2005 earthquake)

Figure 4. illustrates some of these improvements. See Appendix for construction process for demo house.

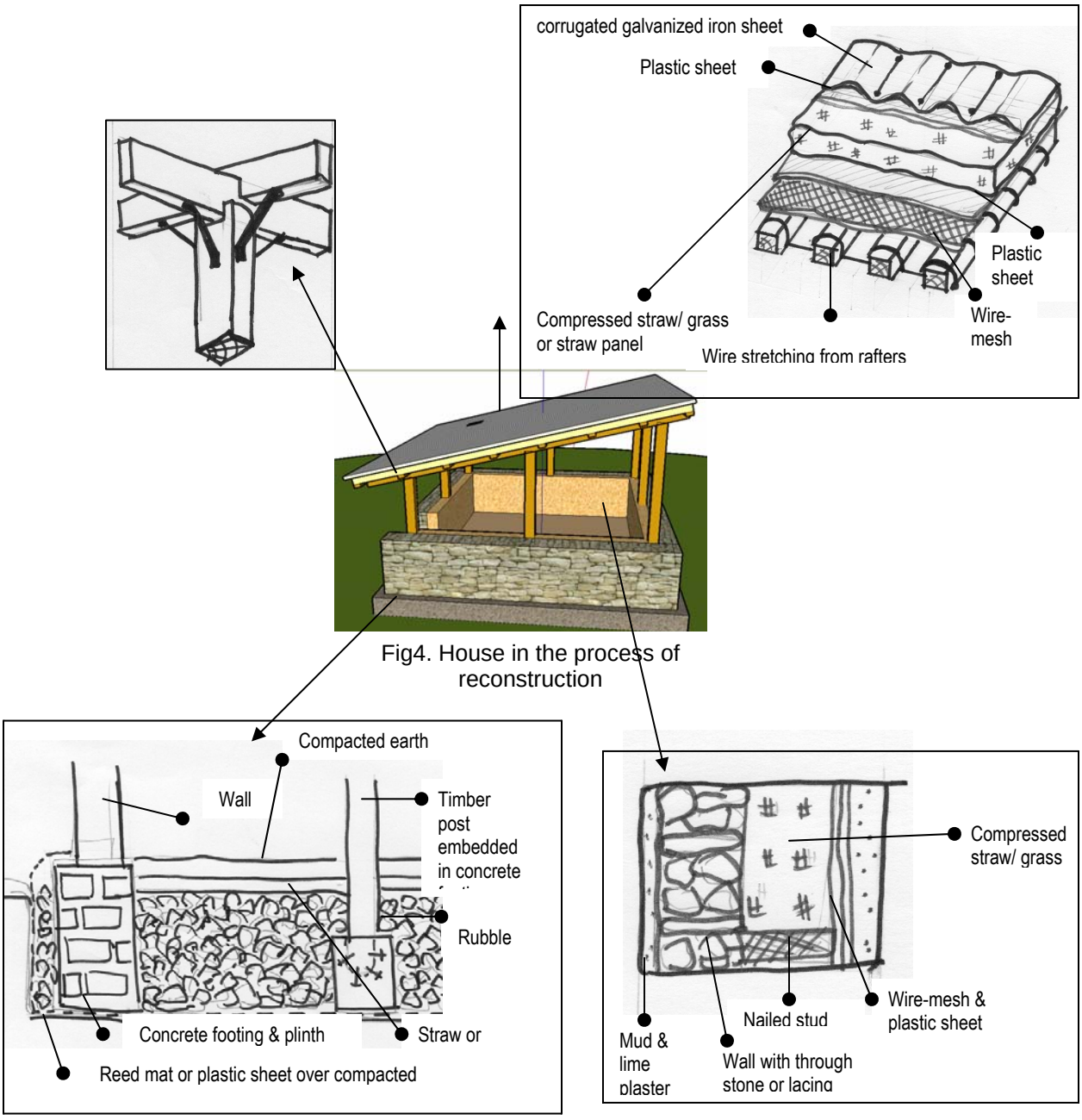


Fig4. House in the process of reconstruction

Encouraging local entrepreneurship

Once the demonstration home is constructed and the supplementary trainings have taken place- the local people involved in the project would have the advantage of engaging in entrepreneurial activities that would assist with livelihood generation. The idea is that through participating in the construction of the demonstration home and the training sessions the local people would becomes skilled in construction techniques that would enable them to be employed by contractors working in the area. If they wish to start up production of construction components (improved trusses, insulation panels, adobe blocks, installing rain water harvesting systems), manage infrastructure for construction (machinery for sawing wood, jointing and riveting or become local vendors for market materials), train other local people in improved construction practices- they will be earning a livelihood which could then

be used to payback the initial loans in installments. The dissemination of improved construction practices would also be reinforced through this process.

Since the project starts off this summer, there are no projected sales unless the construction products being manufactured locally enter the market for construction materials to be used in other reconstruction projects (which is expected to take a few years to start off). The idea of providing loans to start entrepreneurship in the earthquake affected areas could be pitched to companies such as Packages, which are interested in the sustainability of the reconstruction process.

Feasibility

Work to date

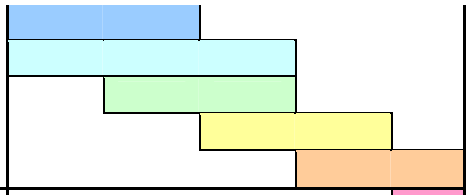
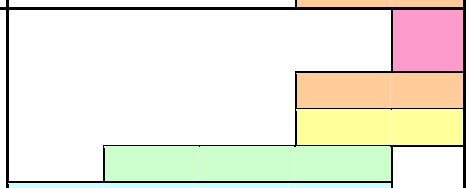
Elements of this project have been addressed through a UROP by Zehra Ali (Summer & Fall 2006, spring 2007) and Jean Li (Spring2007). Thus initial research regarding community needs, demographics and innovations in post disaster reconstruction programs has already been conducting. The community partners have also been kept in close contact to provide on the project proposal. The other tasks have been illustrated below.

	Task	***Summer-Fall '06***	***Feb***	***Mar***	***Apr***	***May***
Initial research	set up initial survey					
	dissemination needs					
	contact organizations					
	research area/land					
	arrange warehouse for materials					
	develop adoption plan by companies					
	research of local innovations					
Preliminary design	demonstration house design					
	dissemination materials					
Initial testing	demonstration house review					
Website	Build website and advertise					

Implementation Plan

The details for the implementation of the project have been sequenced and presented below:

		Jun	***Jul***	***Aug***	***Sept***	***Oct***
Networking with organizations	meet w/organizations					
	gather volunteers/engineers					
	arrange warehouse for materials					
	develop adoption plan by companies					
Research/ Surveying	research area/land					
	demo house survey- consult villagers					
	re-assess demo home design- w/engineers					
	finalize demo house design					
Home	gather construction team					

construction	organize warehouse for materials gather materials train construction team model house construction test model house	
Education/ training	convert demo home into education center pamphlet distribution orientation of built model Evaluate possible entrepreneurs (?) update website	
Finish up	pass demo house to organizations Help entrepreneurs begin (?) update website	

Challenges

The challenge of dissemination is to provide our research and implementation strategy to the NGOs, which will then filter down the residents. This process requires that information is appropriately presented to each group in an accessible, understandable and persuasive manner.

Support Network

Packages Ltd. and KEF are a part of our main support network and their roles in the implementation of the project have been described previously. Two other organizations that we would like to collaborate further with are the Association for Development of Pakistan (ADP) and the Aga Khan Development Network. ADP is a volunteer driven organization that has partnered with grass root level initiatives to address the lack of proper shelter in the earthquake affected areas where the government and relief agencies have been unable to offer assistance. The Building Construction and Improvement Program (BACIP) which is run by the Aga Khan Development Network has been providing training to craftsmen and villagers in Northern Pakistan to improve the quality of building components using indigenous materials.

Scope

This project aims at addressing the multi-faceted aspects of the reconstruction by focusing on the dissemination of construction practices that aim at reducing social, environmental and economic costs. We believe that the core components of design and dissemination are equally important for the construction of the demonstration home and the localized improvements in housing in Bana. Beyond Bana, the success of the project would lie with pitching the idea to other organizations involved in the reconstruction and collaborating on improvements in design and their efficient delivery.

Community Connection & Impact

The purpose of the demonstration home project is to serve the members of the earthquake affected community of Bana by providing options in building or improving a sustainable, stable home and the education to implement the solutions. Instead of waiting for the Pakistani government or NGOs to build their homes, the village members will be able to make educated decisions about the construction of their own homes. By observing and following the construction process of the demonstration home, by

participating in the training sessions, and by being involved in the building of the demonstration home, members of Bana will be empowered. The villagers will be able to take action and make decisions independently rather than depend on outside sources to fulfill their housing needs.

After learning the reasoning and building processes behind different attributes of the demonstration home, some villagers may choose to apply their skills to build a business and earn a living. Local industries could be developed allowing for more economic stability. Entrepreneurial individuals would have an opportunity to use traditional building methods, with which they would be familiar, and local materials, which would be accessible, available, and less expensive than imported materials, to develop scientifically sound dwellings. By learning about the basis of the solutions shown in the demonstration home, an awareness of basic engineering concepts and long-term sustainability will be created such that budding entrepreneurs will be able to improve their construction and business practices.

Many young village men tend to move to urban areas to work, sending money back to their families, wives, and children. Most village members are dependent on agriculture for livelihood. The training sessions will give women an opportunity to learn skills in areas of work typically not open to them. After learning about the materials and construction methods needed, women entrepreneurs would have the ability to build businesses around providing local materials, renovating parts of homes, or constructing new homes.

Also, with the development of more sustainable homes, the community would be less vulnerable to factors such as weather and natural disasters. Therefore less time would be needed in rebuilding and the families could concentrate on the growth of the community.

In addition to the Bana community, other villages could also visit the demonstration home and learn from the dissemination materials and training sessions so that more demonstration homes could be built and knowledge would be open and free. Organizations would also be free to learn from the demonstration homes and incorporate improved engineering designs and building practices into homes built during reconstruction and/or renovation projects.

The goal of the project is to act as a source of awareness and knowledge for communities and organizations. The demonstration home will show how to balance between the financial, social, and design aspects of building homes and communities.

SUMMARY (TOTAL COST: Rs. 455,300 or $ 7500) conversion rate: Rs. 60.7 to $1

Demonstration Home **(Rs. 94,800)**

-Cost of purchasing and transporting construction materials: Rs. 60,000 (see below for breakdown)

-Cost of labor: Rs. 9,800 (see below for breakdown)

-Cost of storing material: Rs. 15,000 (construction of warehouse from GI sheets mounted on wooden frames)

Training session **(Rs 46,000)**

-Utility costs: Rs. 10,000 (electricity)

- Salary of training staff: Rs. 21,000 (3 people for main training session)

- Costs of materials and literature for the training session: Rs. 15,000

Initial surveying and future evaluation and monitoring **(Rs. 280,000)**

- Cost of printing and distributing literature: Rs. 90,000 (expand outreach to 1000 households)

- Cost of transportation for team: Rs. 160,000

- Cost of accommodation: free (staying at the KEF hostel in Rawalkot)

- Cost of food: Rs. 30,000 (for 10 person team over a period of 2 months)

- Other communication costs: Rs. 5000 (phone cards etc)

Preliminary Financing **(Rs. 30,000)**

- Subsidizing materials to be used in housing construction: Rs 10,000 (aim for Rs. 50,000+ later)

- Loans to local entrepreneurs: Rs. 10,000(aim for Rs.60,000+ later)

- Cash for work for self-help construction: Rs.10,000 (aim for Rs. 55,000+ later)

MATERIAL COSTS

MATERIAL	COMPONENT	COST
Wood (1000 Kg)	columns	20000
	beams	
	joists	
	lintels	
	bracing	
	dowels	
Straw (300 ft3)	roof insulation wall insulation	11000
Wire mesh (200 Kg)	foundation reinforcement	6000
	wall reinforcement	
	roof construction	
GI sheets (300 ft2)	Roof construction	8000
	Temporary shuttering	
	livestock shelter	
Cement (500 Kg)	Concrete footings	3000
	Mortar	
	Washing area platform	
Lime (1000 Kg)	Plaster	4000
	Mortar	

(Assume that sand and stone are readily available , otherwise there shall be additional costs. If materials are salvaged from the existing debris then the total costs for straw and wood would decrease. The estimate cost for purchasing, transporting and storing the construction materials is around Rs. 60,000).

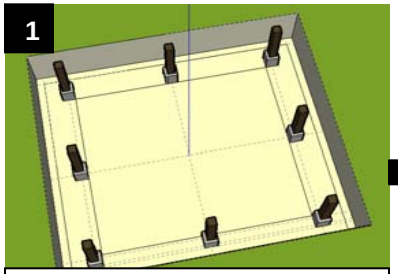
LABOUR COSTS

Labor	Cost of hiring per day	Two week period
masons (1)	300	4200
construction worker (2)	400	5600

TRANSPORATION COSTS

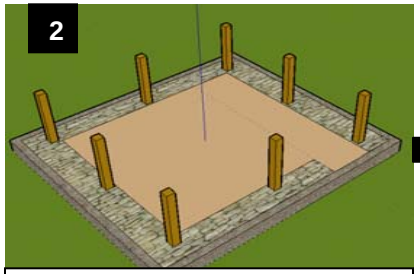
In country travel	30,000
Air fare for two team members	130,000

1



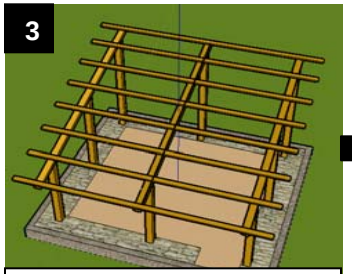
a) Dig pit for foundation & compact ground
b) Use plastic sheet to waterproof pit
c) Treat wood columns and place in concrete footings
d) Position footings in pit

2



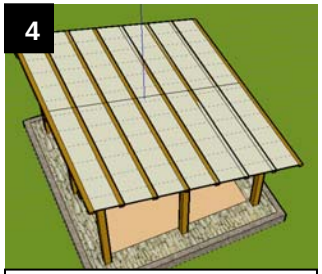
a) Add rubble to pit
b) Add layer of compacted earth on top
d) Build the plinth to 1 feet using stone consolidated with wire-mesh and mortar
e) Finish off the interior floor with mud or salvaged material

3



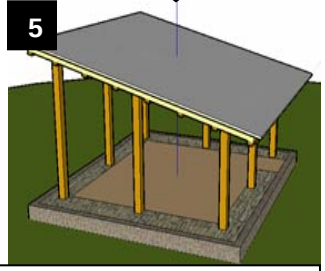
a) Assemble the beam and columns (connect using steel brackets or wood dowels)
b) Layout joists and connects them to the beams
c) Secure connections

4



a) Extend wire-mesh over joists and cover with plastic sheet
b) Add layer of straw over plastic sheet and compact
c) Attach GI sheets

5



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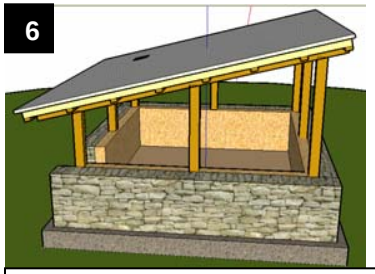
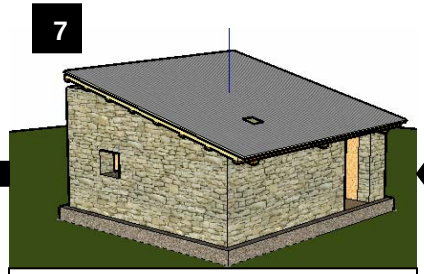


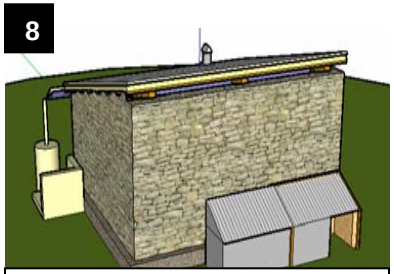
a) Start constructing masonry wall to level of 3 ft. Reinforce masonry using wood bracing, wire-mesh and lime mortar
b) Apply initial insulation (straw, wood shavings) to the interior wall.
c) Use temporary shuttering for the remaining exposed wall
c) Temporary door added

7



a) Complete construction of insulated masonry wall to desired height
c) Position openings (windows, vent & door) to maximize on ventilation & daylighting

8



a) Add permanent door and window
b) Fit drain from roof and add water storage tank
c) Add livestock shelter
d) Construct washing area

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