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Energy Integrated in Rural Reconstruction: A Case at Laprak, Dharche Rural Municipality-4, Gorkha

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Abstract
Quality improvement of rural reconstruction, the need to consider the dimensions and effects of resettlement projects on the sustainability and energy usage of rural communities is important. The present study was conducted to analyze the elements of sustainability especially focusing on energy efficiency and natural resources in the settlements of Laprak and evaluate the sustainability of the existing Laprak settlement, newly constructed settlement by local people and proposed model settlement by NRNA for the better redevelopment of Laprak. The research methodology is descriptive and analytical and the required data were collected using the questionnaire, checklist and mapping tools. The study population was about 4500 people living in existing villages with 573 household. The sample size was 100 household who were randomly selected. This report includes the aspect of land use pattern and energy smartness in the residential area of existing settlement and newly development settlement whereas only the land use and energy smartness strategies of NRNA model settlement are discussed. Three basic aspects in rural reconstruction for a sustainable future: rural sustainability, energy efficient technology and climate smart approach preserving natural, landscape and water resources ensuring universal access to food with a sustainable farming production have been described in this report.
From the analysis of data, about 96% of houses have been constructed after earthquake as temporarily living space which occupies 24% of agricultural land in existing settlement. This seems to be settlement growth in the village but due to landslide in 2056 BS, some household has been shifted to the upper parts of the village. After the earthquake 2015, the residential houses also shifted. About 94% of houses are built in agricultural land haphazardly which shows the slow degradation of land use pattern of that place. Regarding the energy smartness in the village, more than 90% of household use traditional fuel wood for cooking purposes while almost 6% uses fossil fuel. In newly made settlement around 76% of household uses traditional fuel and remaining uses fossil fuel. To project a future scenario for Laprak, observation from Barpak Bazar at present was assumed to offer as the likely direction of development. The developments in Barpak Bazar do not reflect high energy smartness and therefore the development of energy efficient settlement is proposed on the basis of available literature and the sustainable energy uses at Barpak. For NRNA model settlement, modifications recommended take various principles of sustainable land use planning as well as energy efficient technology in consideration.

Keywords
Reconstruction – Sustainability – Energy efficiency – Rural Settlement

1. Introduction

1.1 Background

Nepal is one of the most disaster prone countries in the world. It is affected by many different types of natural disasters each year, such as flooding, drought, landslides, wildfires, windstorms, hailstorms, thunderstorms, global lake outburst floods, avalanches and earthquakes. The country is also at high risk from climate change [1].Throughout history of Nepal, there have been frequent occurrences of great earthquakes causing severe human and physical loss. The April 2015 earthquake (also known as the Gorkha earthquake) killed nearly 9,000 people and injured nearly 22,000. It occurred at 11:56 Nepal Standard Time on 25 April, with a magnitude of 7.6M. Its epicenter was east of Gorkha District at Barpak, Gorkha, and its hypocenter was at a depth of approximately 8.2 km. It was the

worst natural disaster to strike Nepal since the 1934 Nepal–Bihar earthquake. Nepal one of poorest country with scarce resources now has a challenging task of reconstruction ahead. The challenge can also be an opportunity in disguise if reconstruction is laid out with proper vision for sustainable, self-reliant and stronger future. In case of Nepal, Rural reconstruction is really a challenge due to difficult geography and infrastructure problems. The massive destruction of rural buildings wrought by the Gorkha Earthquake is proposed to be responded with an equally massive rebuilding of houses and settlements.Laprak is a Gurung community village close to Barpak, the epicenter of Gorkha earthquake 2015. It lies in Dharche rural municipality-4, in the northern part of Gorkha district. There are about 624 households in Laprak village and has around 4500 population. It has its own culture, tradition and ritual.As Laprak rural settlement has been heavily destroyed by Gorkha earthquake 2015, most of the people are living in their temporary shelters with hard and complicated lifestyle. In extreme weather cases, people are compelled to withstand the severe effects of climatic phenomena. However, in this post earthquake phase, people are mainly focusing on structural analytical part. Many of them are still not aware of building energy efficient homes which economizes the lifecycle cost of their household energy in future. To promote the rapid rural reconstruction, earthquake resistant and energy efficient buildings construction is indispensable. Hence for the sustainable rural reconstruction, not only structurally safe but also the more resilient and self-reliant buildings in rural settlements have to be constructed.

1.2 Objectives of the Study

The main objective is to learn about ways to create sustainability through integration of energy and natural resources in the planning and construction of rural buildings and settlements. To achieve the aim, the specific objectives are as follows:

1. To study the elements of sustainability especially focusing on energy, water and natural resources in the settlements of Laprak
2. To evaluate the sustainability and energy efficiency of the existing Laprak settlement, newly constructed settlement by local people and proposed model settlement by NRNA
3. To recommend ways of introducing climate smart village consideration

2. Methodology

Qualitative research methodology was used for the planning of Laprak. Since, the main objective is to study the elements of sustainability in rural reconstruction especially focusing on energy efficiency and natural resources in the settlements of Laprak, in such a way that the building settlement using local resources is not reduced but safer and energy efficient reconstruction is achieved. The study methodology employed was exploratory and descriptive which was based on both literature and observation. Therefore, both qualitative and quantitative approach has been considered in the study. For this, the study was focused on sustainable land use and smart energy issues into three characteristic settlement and building of Laprak i.e. existing settlements, newly made settlement by people and the model settlement made by NRNA. Sustainability indicators of environmental, economical and socio-cultural aspects such as land use, built form, orientation, open space, building materials and energy were used. The research method was case study. Observation and literature review were used as data collection techniques. Post positivistic paradigm was followed. The research was based on field visit and community interaction through interview.

Data and information for sustainable planning of water, transportation, agriculture, reconstruction and tourism were obtained from the local stakeholders of Laprak. Photographs, informal interviews, direct observation were used as tools of data collection during the day of field visit. For this, 100 household samples were randomly selected among the population of the villages' residents. The data collection tools were the questionnaires, check lists and mapping survey that were prepared according to the research objectives. In addition to completing the questionnaire, a qualitative approach of field research, case and interviews with the villages' residents and local officials as well as reviewing available documents were used and the information was collected. Descriptive statistics were

used to summarize the results of the survey using SPSS Software

Unit of analysis in my case are the sustainability land use principles like open spaces, walkability, integration of natural resources like water, forest, agriculture, animal husbandry, pasture land and local building materials, Household energy use and passive solar energy are studied to develop energy efficiency in the settlements of Laprak. The components of climate smartness like water smart and energy smart have been included in this study report. The methodological framework is shown in Figure 1.

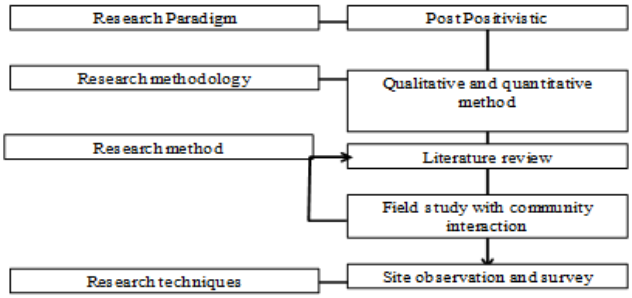

Figure 1: Research methodology process

3. Case Study of Settlement

3.1 Existing Settlement

The existing village is completely residential zone in sloppy land and surrounded by agricultural field. It is the compact settlement with narrow alleys and stone pathway entire the village. No motarable road but has been planning to access 4 wheeler vehicles. Forest and agricultural areas are bit far from settlements.

Natural resources like forest for timber and firewood can be accessible through community forests. Since stone is available people use stone for building wall and foundation. Drinking water supply has been facilitated by Care Nepal in the village through different natural streams.The traditional building of Laprak is made up of stone wall, roof with wooden plank and stone on it to withstand wind pressure. The typical house Open kitchen at ground floor and upper floor is used for bedroom.

The energy in the settlement is fulfilled by traditional fuelwood for cooking whereas fossil fuel has been used by minority of people. For lighting purpose electricity from MHP supply is being used from 5pm to 8am. No electrical appliances have been used for cooking. Solar panel has been distributed throughout the village after earthquake 2015.Use of ICS is also very low or almost no use in the village. Again due to low temperature proper biogas cannot be produced.

3.2 Newly made Settlement

The settlement is mix of residential zone and agricultural zone in sloppy land. It is the settlement along the road and narrow pathway between the buildings. Motarable road has been planned to access 4 wheeler vehicles. This settlement has been developed after earthquake 2015 by the people. Most of the building has been constructed in agricultural field. No separation between residence and agricultural area in this settlement.

The building of this settlement is made up of stone in foundation and wooden wall, roof with CGI sheet. Open kitchen at ground floor and upper floor is used for bedroom as in existing village. Most of the buildings are of temporary shelters of one storey only and many of people seems just for waiting to stay in NRNA model settlement.

The energy in the settlement is fulfilled by traditional fuelwood for cooking whereas fossil fuel has been used by minority of people. For lighting purpose electricity from MHP supply is being used from 5pm to 8am. No electrical appliances have been used for cooking. Solar panel has been distributed throughout the village after earthquake 2015.The majority of people use solar energy for charging mobiles.

3.3 NRNA Settlement

the master plan has been carried out for the overall utilization of a particular area, including its allocation for residential or manufacturing uses and the corresponding environmental impacts. To conserve the vernacular architecture of this area, the house has been designed to depict the traditional settlement of the village. In Gurung community, the no.12 is of great importance like 12 years, 12 names, etc. in their livelihood. So twelve courtyards have been provided in

the settlement along with the necessary spaces like open and green area, community area, residential area, forest area, water springs and road are efficiently planned to develop safer and sustainable model settlement. The electrical distribution line along road and sanitary pipe layout has been placed according to the site.

The prototype building plan is allowed to build same for all 573 housing units. The rectangular plot size for designed housing is 10.6m x 9.8m each. The toilet, safety tank and soak pits are built at outdoor. Small area for kitchen garden and grain drying also attached in the plot area.

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4. Data

4.1 Laprak settlements

The number of female respondent dominated over the male in overall observation. But in existing settlement of Laprak, the number of male respondent was huge (56%) while that in newly made settlement was very poor (only 40%). This result shows the socio-cultural limitations on social science research in a remote versus a more developed locality, developed in the sense of economic activities, social acceptance of womans' role outside of a family. The land use before building construction in existing settlement and newly made settlement. It can be inferred from the following figures that most of the buildings have been reconstructed in existing land of their own in the existing settlement whereas about 24% houses have been built in the agricultural land. In newly made settlement, about 82% buildings have been built on agricultural land which decreases the agricultural products and food shortage.

The construction of massive stone wall upto attic is drastically reduced after earthquake. Instead of heavy wooden roof tile, the use of CGI roof having light weight is increasing in the existing settlement. The construction of wooden wall with CGI roof has been

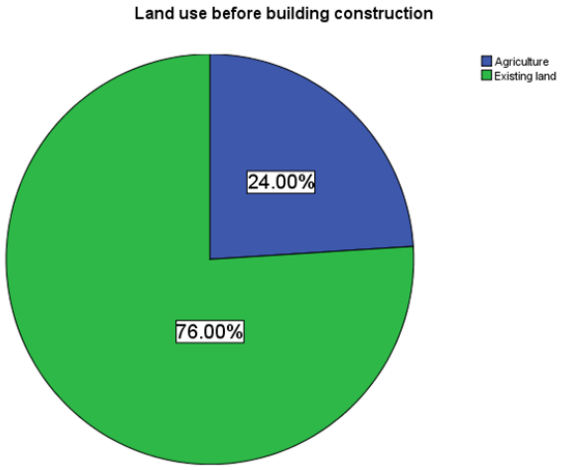

Figure 2: Existing settlement

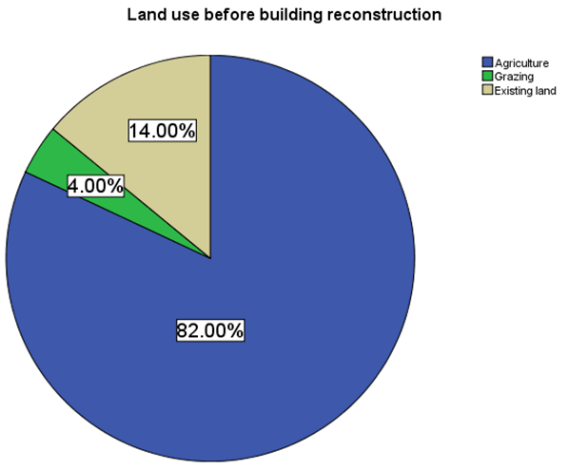

Figure 3: Newly made settlement

increased in newly made settlement by 14% and only stone wall at ground floor with timber structure and CGI roof has been increased by 80%. The local materials in roof are being replaced by material brought from other areas.

In existing settlement, about 94% of household uses traditional fuel and use of fossil fuel is 6%. In newly made settlement, the fossil fuel users have been increased indicating 24% and the traditional fuel users are found about 76%. This shows that the overall settlement mainly depends on traditional fuel for cooking.

The monthly cost on fuel is maximum for the traditional

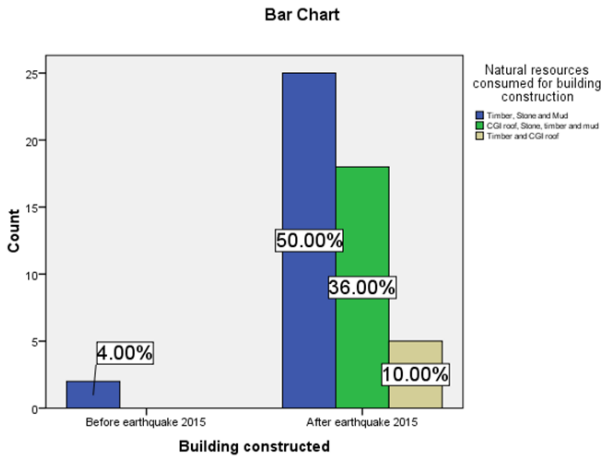

Figure 4: Existing settlement

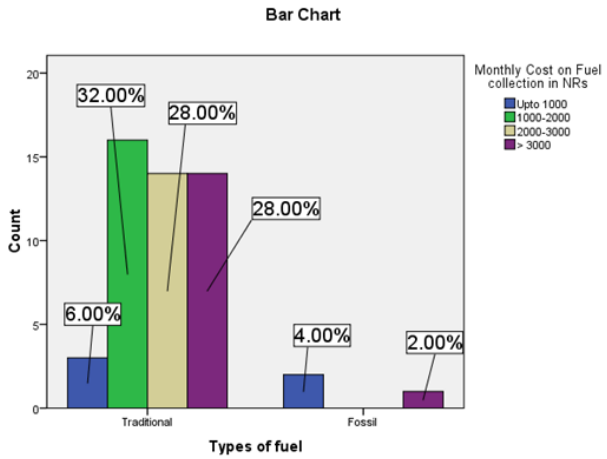

Figure 6: Existing settlement

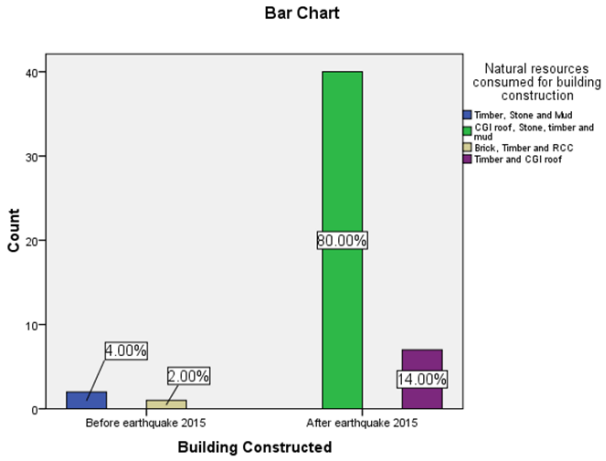

Figure 5: Newly made settlement

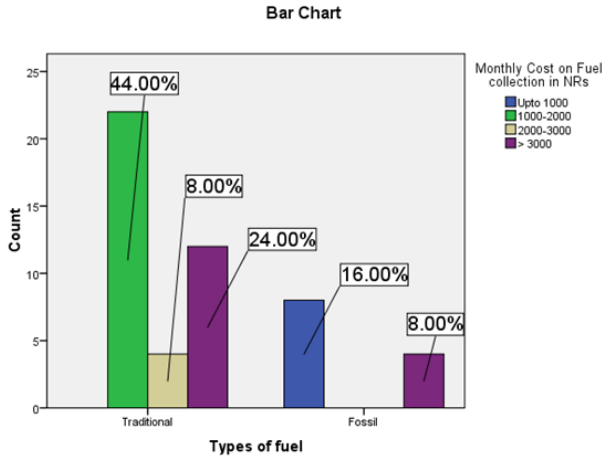

Figure 7: Newly made settlement

fuel in both the settlements but for fossil fuel, the monthly cost is usually upto thousand and some household cross beyond three thousands due to energy consuming activity like making of rice beers, alcohol, etc.

4.2 Data on Land use and natural resources

4.2.1 Sustainable land use

Open spaces: There are different open spaces for community interaction in the village. Some of them are Thulo aagan, Phyapchet and Sano Renjilung. The gatherings of people for community programme, meetings, resting and refreshing etc. are organized

Walkability: Since Laprak village situated in the steep slope, people have to commute almost 600m altitude difference from existing settlement to new NRNA settlement. The walking distance is around 2hr while moving up the hill and 1 hr while moving down the village. As all the necessary daily needs and other services are brought from Barpak, people use to walk more than using any other mode of transport. Though the village has been accessed by motorable road, vehicular transportation is difficult.

Water: The sources of drinking water in existing village from Kalgang (2200m) and Burnigang (2000m),for 52 common taps respectively, in new settlement made by

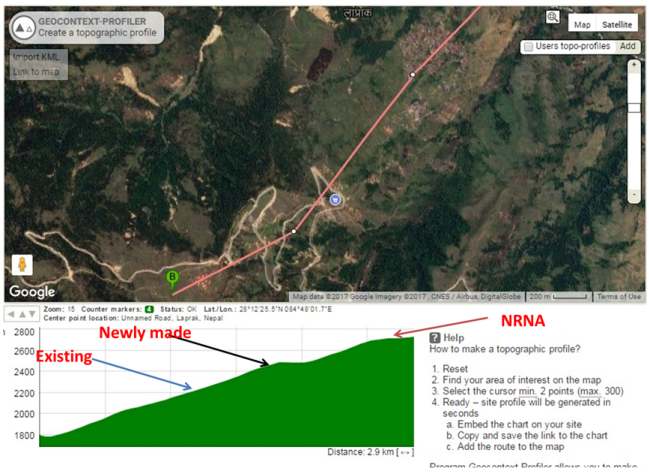

Figure 8: Cross section of slope of settlements

people called Sano Renjilung from Nyalako and Pusta (2500m) whereas the model settlement of NRNA will be fed by Volmechet (3600m) drinking water project for 573 houses launched by the effort of CareNepal and national authority on drinking water. The water for irrigation depends on monsoon. All the drinking water sources are above the human settlement. Hence the water pump and other mechanical equipment have not been used in the village.

Forest: Forest covers approximately 50% of total area. Gobre salla is indigenous tree of that area. However there is abundance of rhododendron as well. Along with trees, there are some other herbs like Saduwa, Jatamasi, Panchaunle and Yarshagumba. The community forests are Taramchar, Bhomemandali, Rupchet, Thalkim and Nadang. People are allowed to collect timber for buildings through purji system after paying NRs.1500 to District Forest office (DFO). The consumption of forests for fuel wood is more in the village as most of the people use traditional fuel wood for cooking and preparation of wine. The forests also serve as water catchment area for different water resources that supply drinking water in the village. The timber from nearby community forests are used for constructing houses.

Agriculture: People cultivate the maize, barley, wheat, millet, beans, potato and other vegetables in between forest areas and in fields. But paddy is not grown due to steep slopes and absence of irrigation. Rice is brought from either lower village like Barpak or from Gorkha Bazar. In the existing settlement, people have kitchen garden nearby their house whereas their agricultural field are few kilometers far away from the settlements. In newly made settlement, as the settlement has been formed in agricultural land, the mass of agricultural land has been encroached slightly by building construction after earthquake.

Figure 9: Agricultural land nearby houses

In Laprak, according to ward chairman, Dharche-4, Mr. Raj Gurung, there are 250 animals' shed. It requires many grazing land and people used to graze in nearby high hills called lekh at the time of summer and around the village during winter. So, Gupshipakha was one of the grazing areas for them. But due to snowfall occurs, significant animal grazing could not be done. Also the walking distance from Laprak settlement is quite long than other areas. Cattle grazing are also done round Sano Renjilung.

Local building materials: All the houses in the village were built before earthquake by massive stone masonary wall and foundation. Typical houses are of 2 storeys with wooden plank roof and oriented mostly to the east direction for sunlight. The whole building is tied up by wooden posts and raftersin absence of seismic bands. After earthquake, the buildings were made with seismic bands and light CGI roof instead of using wooden planks. The post earthquake houses have massive stone wall with bands in ground floor and wooden wall envelope in first floor or attic floor. The building materials are collected from the nearby natural resource whereas for RCC building, all the materials are brought from outside the village.

Figure 10: House before earthquake

Figure 11: House with seismic bands after earthquake

4.2.2 Energy efficiency

Existing settlement Household energy used: More than 90% of household use traditional fuel for cooking. About 6% of household use fossil fuel. The time taken for collecting fuel wood from nearby forest is upto 2 days for those who cannot go to forest and let other for collecting fuel wood and 1 day for those who themselves collect from forest. As the cost for fuel wood is Rs.100 to150 per doko or vari, people have to just go to forest for collection. Even this, the daily cost on fuel collection is mostly about Rs.100 to 150 which seems expensive than using fossil fuel.

Passive solar energy: The constructed houses are built with passive solar techniques. According to the sun direction, most of the houses are oriented to east and north direction with openings. The typical house is basically of two floors. The average dimension of house in plan is about 6m x 4m. each height is of 6ft to 7ft whereas the dimension of plan varies according to the size of family.

Newly made settlement by people Household energy used: More than 70% of household use traditional fuel for cooking. About 24% of household use fossil fuel. The time taken for collecting fuel wood from nearby forest is upto 3 days for those who cannot go to forest and let other for collecting fuel wood and 1 day for those who themselves collect from forest. Open spaces: There are different open spaces for community interaction in the village. Some of them are Thulo aagan, Phyapchet and Sano Renjilung. The gatherings of people for community programme, meetings, resting and refreshing etc. are organized.

Passive solar energy: Almost all the houses are constructed due to earthquake. The land use pattern has been changing in fast rate. The constructed houses here are also built with passive solar techniques. According to the sun direction, most of the houses are oriented to east and north direction. The typical house is basically of one floor. The average dimension of house in plan is about 6m x 4m. Each height is of 6ft to 7ft whereas the dimension of plan varies according to the size of family.

4.2.3 Climate smartness

Water Smart Rainwater harvesting: Since the existing settlement lies at the sloppy lower level of Laprak, the rainwater harvested may be used in kitchen garden and in some field. But majority of agricultural field lies to the distant upper hills. Also the newly made settlement lies just above the agricultural field. The harvested water can be accumulated in plastic pond for irrigation purpose to its downward agro land. Similarly, the water harvested from NRNA settlement which lies at upmost part of Laprak if accumulated, it can serve as sources of irrigational water as well as water for cattle.

Water collection and irrigation in agricultural land: As Laprak receives more precipitation, the reservoir of harvested water can be proper alternatives for water supply and irrigation during dry season. Thus collected water enhances sustainable agriculture. The community management for water from natural resources can play major role to distribute drinking water to both human

and cattle. The reuse of kitchen waste water collection can be used for irrigating kitchen garden as well.

Energy Smart The energy in Laprak is fulfilled by traditional fuelwood for cooking whereas fossil fuel has been used by minority of people. For lighting purpose electricity from MHP supply is being used from 5pm to 8am. No electrical appliances have been used for cooking. Solar panel has been distributed throughout the village after earthquake 2015. The majority of people use solar energy for charging mobiles. For the space heating inside the building, fuelwood is used and clothing for warming body. Hence, the demand of fuelwood is more in the villge.

The quantity and collection time for firewood consumes high cost and lasts only for few days. The more energy efficient technology has not been used by the people. Use of ICS is also very low or almost no use in the village. Again due to low temperature proper biogas cannot be produced. In this case, the energy smartness is quite under developed.

Future Energy Scenario: One of the major projects named Gham Power already initiated in Barpak. Since the different renewable energy practices have been done in Barpak which is the closest village of Laprak, the future energy scenario of Laprak will be influenced by the renewable energy technology (RET) established in Barpak even though the energy scenario in Barpak does not meet high energy smart.

Figure 12: Technicians from Gham Power, installing a 120-watt solar PV system kit on top of one of the few houses in Barpak, Gorkha, that are still standing.

5. Analysis and Discussion

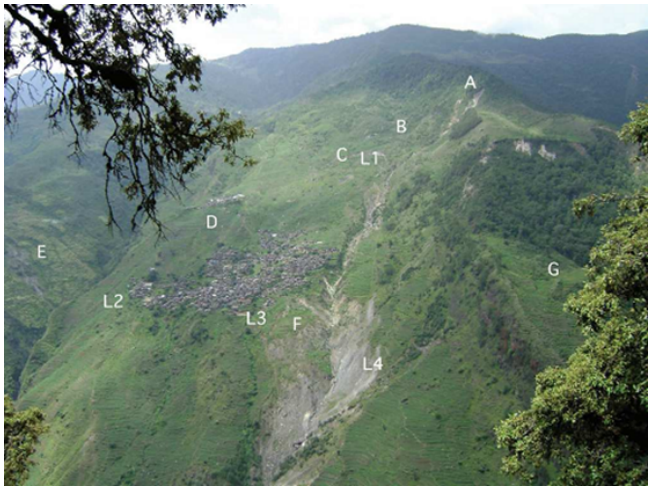

Figure 13: Landslide zone in Laprak

Following a continuous rainfall for more than 24 hours, Laprak Landslide took place on 3rd July 1999 (19 Ashad , 2056) sweeping away one woman, 5 houses and some 2 hectares (40 ropanies) of cultivated land along sides of the Chhelong Khola and ever since, the Landslide is posing a great threat to the entire Laprak village.

[2] A is area of planar rock slides at the head of Chhelong gully B is quartzite boulder field C is active headscrap, D is area of stable shallow bedrock and the village school E is typical Translational slide developed in thin soil on a foliation dip surface F is recent rotational landslide component associated with widening of Chhelong gully G is older stable landslide of unknown age L1 through L4 mark the approximate locations of soil samples collected for laboratory analysis

Present situation of the Landslide Though the Laprak Landslide first took place in July 1999, it is still active and continuously expanding, especially during the monsoon period. According to the classification of Landslide, it is a complex one. There are rotational as well as translational Landslides. Particularly the soil deposit along the sides of the Chhelong Khola is moving down year after year and the houses at the vicinity of this Khola are more vulnerable.

Presumably because of the Landslide, before earthquake 2015 almost more than 90% existing houses in Laprak village have suffered many cracks on the floor and wall and the foundation has gone under the differential

settlement. Since the landslide is deep and is slipping from the interface between the rock and soil mass, controlling it at this stage means investment of a huge sum of budget and if the measures are not applied correctly, there is a high probability of such landslides which may occur in the future. On the contrary, they should be encouraged to displace in order to enjoy higher living standards so that they are ensured that resettlement is on their behalf to improve their conditions. To that end relocation of village is also a possibility.

NRNA settlement The planning of NRNA settlement is based on scientific planning of settlement with integration of revised building construction act of Nepal after the earthquake 2015. During the planning phase the basic infrastructures and services have been planned with approved width of road to the settlement and open spaces for social interaction to save the rural livelihood and culture.

Although the NRNA settlement planning is well engineered settlement it has some weakness to tolerate the local architectural style which may be due to geographical situation. The connection with the existing village is also affected by the longer walking distance. Due to this, the villagers get difficult to go and return from their fields which are nearer from the existing village. Gupshipakha was one of the grazing area for them. But due to snowfall occurs, significant animal grazing could not be done. Also the walking distance from Laprak settlement is quite long than other areas.

The sustainability approaches in this settlement are:

1. Proper use of open land into residential area with standard norms approved by Nepal government
2. Local natural resources utilization to promote the natural environment of Laprak as the water spring routes are preserved according to their natural flow.
3. Building design with more energy efficient technology as well as earthquake resistant
4. Opportunity of small business entrepreneurship for the people
5. Local people are engaged in building construction which creates the harmony among the existing village and NRNA model village

6. Conclusion and Recommendation

6.1 Conclusion

The natural resources found in the natural environment still provide an important base for many livelihoods in Laprak. This is most obvious in relation to farming activities that still characterize much of the rural space. In Laprak, the harvesting of water can be the alternatives of irrigation in the sloping lands which lies below the settlement areas and promotion of alternative forms of irrigation like sprinkler and drip irrigation. Agriculture is the priority sector of the rural communities in Laprak. The need to encourage farmers to adopt suitable farming system technologies for sustainable agricultural production and for soil and water conservation and rehabilitation of degraded lands is important.

The basic role of the building is to provide comfortable indoor environment protecting occupants from harsh external environment. Thus the energy integrated rural reconstruction will fulfill its vision if there is consideration of rural sustainability, energy efficient sustainable building design along with the concept of climate smart village. For the holistic development of climate smart village, buildings should be run through efficient energy technology using passive solar techniques in economic way that enhance the balance between social and natural environment.

6.2 Recommendation

6.2.1 Existing Settlement and Newly Made Settlement

1. Dissemination of ICS for cooking and space heating than with traditional fuel wood
2. Provision of technical knowledge of passive solar techniques
3. Water supply and irrigation should be planned to optimize the water collection from natural resources and rainwater harvesting
4. Ecotourism development is necessary like developing homestay and other economic

activities as it lies in the trekking route of Manaslu

5. Pathways, alleys and open spaces should be managed properly for easy access to all

6. However the geological condition is inappropriate for settlement, efficient disaster risk management technology should be maintained.

7. Traditionally, agenu (open fire with an iron tripod) and chulo (closed mod/stone stove without chimney) stoves have been used for cooking and heating purposes in Nepal

6.2.2 NRNA Settlement

1. Buildings with nature friendly in material and technology should be constructed

2. Climate responsive building orientation and building insulation should be adopted.

3. Less energy consume and more benefits to the household in buildings is necessary to achieve smart energy integrated rural reconstruction

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