

# **SOIL CONSERVATION IN SERTHI GEWOG - A CASE STUDY**

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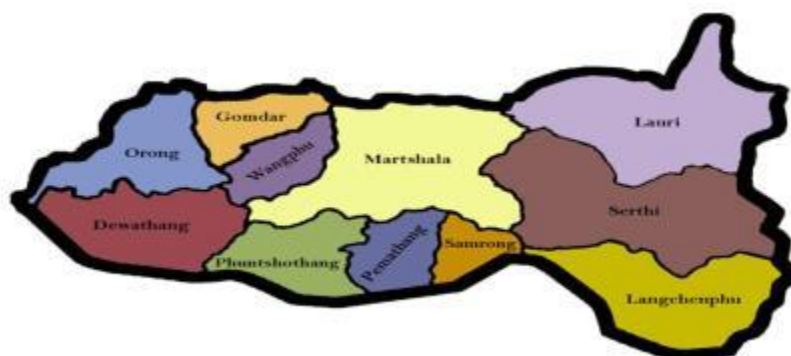


## **Executive Summary**

“The soil is like the invisible mother of the farm. Although its presence is so obvious and its fertility so essential for all agriculture activities, the soil is often overlooked as a limited resource of the farm”, Agricultural Extension Officer (AEO) Serthi gewog. Grass hedgerows in Sakari chiwog, Serthi, Samdrup Jongkhar were established on steep erodible slopes to reduce soil erosion and stabilize the hillside as a pilot impact project established by the Samdrup Jongkhar Initiative (SJI; [www.sji.bt/](http://www.sji.bt/)). The multipurpose grass species will also provide fodder for livestock, construction materials, and religious offerings. This pilot project will serve as a model for other farms in Samdrup Jongkhar.

## INTRODUCTION AND BACKGROUND

Serthi is one of three gewogs in Jomotshangkha dungkhag (sub-district that includes Lauri, Serthi, and Langchephu gewogs) under Samdrup Jongkhar dzongkhag (Figure 1), located in southeastern Bhutan. To get to Serthi from Dewathang, one has to travel from Samdrup Jongkhar town through Assam, India. It takes one half day to reach Jomotshangkha, and another 6 hours from there to reach Serthi. Serthi gewog has 357 households spread across 5 chiwogs (or villages). It is located at about 730 metres above sea level and average night and daytime temperatures are 20 and 27°C, respectively. Most of the houses are located on hills with extreme slopes, making agriculture difficult and highly vulnerable to erosion. Villagers have kitchen gardens and also produce cash crops for local and regional markets. The main cash crops in the gewog are mandarin (*Citrus reticulata*) and cardamom (*Elettaria cardamomum*). Vegetables are important for consumption at the household level, as well as for income generation.



**Figure 1:** Map of Samdrup Jongkhar dzongkhag.

Soils in Serthi are sandy loam in texture and prone to erosion, resulting in a thin or nonexistent A horizon. To reduce erosion during the monsoon, farmers have traditionally grown Napier grass (*Pennisetum purpureum*), in hedgerows following the contours of their farms (Figure 2). Hedgerow planting has been working to reduce soil erosion in Serthi. A pilot impact area was established in Sakari chiwog to expand awareness of soil conservation.



**Figure 2.** Napier grass hedgerow with buckwheat.



Sakari is a small isolated chiwog located in Serthi gewog. The elevation is 730 meters above sea level and has four households engaging in farming. Dryland is the dominate land type and the soil type is mostly sandy loam. Maize (*Zea mays*) is the main staple food. Farmers also grow all the Dru Nag Gu (*nine grains*) like maize, *Yangra* (foxtail millet; *Setaria italica*), *Cherra* (little millet; *Panicum sumatrense*), *Kongphu* (finger millet; *Eleusine coracana*), *Brayma/Breymo* (bitter buckwheat: *Fagopyron tataricum*/sweet buckwheat; *Fagopyron cymosum*), and *Mo* (amaranth; *Amaranthus spp.*), and long beans, except barley and paddy rice. The main cash crops are mandarin and cardamom. The slope of the village is between 45° and 50° (Figure 3) and sheet erosion during the monsoon season is severe. Therefore, soil conservation controls and preventive measures during the summer season are needed.

The AEO of Serthi, Cheten Gyeltshen, during his tenure, has observed many cases of severe soil erosion. He explained, “The soil is like the invisible mother of the farm. Although its presence is so obvious and its fertility so essential for all agriculture activities, the soil is often overlooked as a limited resource of the farm. Therefore, it is very important to conserve the soil and prevent or reduce the soil surface run-off during the summer season”.

The AEO became specifically concerned about the situation in Sakari during his tenure. He observed that during the summer season heavy rainfall caused the topsoil to be washed away on the cultivated land. The reason for this was due to low/no vegetation coverage prior to the planting of maize. Due to the need for training on the importance of soil conservation and soil fertility management, Cheten Gyeltshen requested assistance in implementing soil conservation practices from the Samdrup Jongkhar Initiative (SJI) during a write-shop in 2013. The objective of this pilot impact project was to maintain soil fertility and agriculture production for future generations through establishing grass hedgerows.



**Figure 3.** Left: Cardamom; Right: Finger millet.

## ***Soil Conservation***

The aim of soil conservation is the stewardship of a productive land base so that it sustains agricultural production. Erosion of soil via water, wind, and tillage are minimized, as well as the overuse and abuse that can lead to the loss of soil productivity. Through a diverse set of management strategies, soil health can be preserved and improved through the promotion of soil biota and the diverse components of the soil's food web. This in turn, nourishes agricultural crops and the people who depend on them.

There are numerous techniques to conserve the soil on slope lands. The following presents some of the techniques listed in the *Agroforestry Technology Information kit*<sup>i</sup>:

**Physical structures:** Contour canal, contour bunds, bench terrace, contour hedgerow, soil trap, drainage/diversion canal, rock walls, and hedgerows.

**Farm management practices:** Crop rotation, relay planting, contour cultivating and planting, use of organic matter, laying crop residues along contours, diversification of farm enterprises, including tree crops, maintenance or establishment of forest at the upper end of the slope, protection of the land with cover crops during fallow periods, and animal confinement.

Of the various techniques used to conserve soil, hedgerow planting, stone bunds, and mulching are currently practiced to a limited extent in Sakari. The aim of the SJI was to improve farmers' current contour farming to prevent soil erosion, conserve water, restore soil fertility, diversify farm products, and increase income generation. The initial proposal suggested four focal projects:

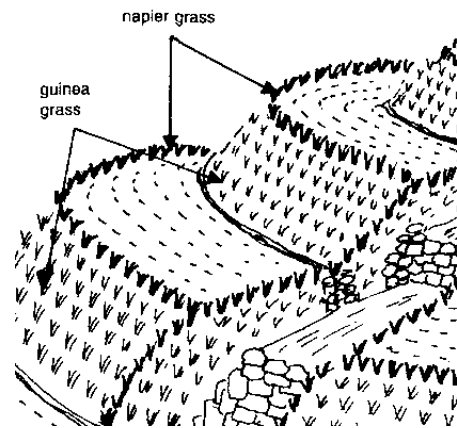
1. Intercropping maize and beans without tillage
2. Establishment of stone bunds
3. Hedgerow plantation
4. Plant sweet buckwheat as a soil improving rotation crop for maize

Of these four projects only the establishment of hedgerows was implemented.

### ***Hedgerow Planting***<sup>j</sup>

Planting multipurpose tree and plant species along contour slopes reduces water and wind erosion and stabilizes terraces. For untterraced land, hedgerows preserve soil nutrients and help to eventually form terraces reducing the work for farmers, while serving as a source of organic matter. Hedgerows can be multipurposed, providing fodder for livestock and construction materials.

Grasses can play an important role in stabilizing sloping areas. Napier/elephant grass (*Pennisetum purpureum*) is ideal for hedgerows due to its soil-binding properties and it is also a good source of fodder for livestock. By planting grasses along contour lines, they minimize surface runoff/erosion, and as soil begins to collect behind the grass barrier, a small terrace will eventually form. Earth bunds in contour may be constructed with grasses to stabilize the bund, which will produce an even better terrace. Trimmings are used as feed for livestock, or as mulch for the crops.



An ideal terrace or bund will have stabilizing grass species on the riser and along the lip to prevent soil erosion and collapse the terrace. Rows of napier grass 40 cm apart along the lip are recommended to protect risers and to discourage cultivation of this vulnerable part of the terrace.

Of the many species applicable for hedgerow plantation, napier grass, broom grass, and bamboo were chosen because they were locally available and valued by the community.

#### *Napier (Pennisetum purpureum)<sup>i</sup>*

Napier is a perennial grass that can produce green fodder throughout the year, except under drought conditions. Napier has been introduced into Bhutan and is becoming the main fodder and soil conservation grass species in Samdrup Jongkhar dzongkhag. Napier can grow to >3m in height and is locally burned every few years to reguvinate the plant. Napier is easy to propagate from culm cutting or by slips. For culm cuttings, the culm must be at least 6 months old. To prepare planting stock, clean straight cuts made 3 cm above the node and direct transplanting (2 nodes buried at a slant) into a moist field or a nursery bed are recommended. For slips, it is advised to divide plants that are at least 1 year old, where each slip has at least three nodes. They should be transplanted 6 in deep at a field plant spacing of 1.5-2 ft.



Mature napier grass

#### *Broom grass (Thysanolaena maxima)*

Broom grass is a perennial clumping grass endemic to Bhutan. It is drought tollerant growing easily to >3m wherever it is planted and is one of the few green grasses during the winter dry season available to livestock. Broom grass is also a plant of religious significance

and is also found in numerous folktales. “Old people says” that broom grass is used to subdue the ego mind of evil by Buddha. In Ngarjuna’s (*Gonpo Lhudrup*) biography, Ngarjunas was killed by broom grass. This cultural significance is manifested in everyday life and plays a significant part in religious rituals. Flower panicals are harvested, dried, and bound to make brooms for the house. In Buddhist practices, like the fire puja, cremation, and practicing meditation broom grass is also used.

### *Bamboo<sup>ii</sup>*

Bamboo is endemic across Samdrup Jongkhar and is traditionally wild harvested for construction of building and hosting prayer flags. Since it is locally abundant, plantations are nonexistent. However, with increasing population and pressure on forest resources, integration of bamboo into agricultural systems will become increasingly important.

Bamboo plantations require adequate water supply. In high rainfall areas, giant bamboo, local name leeshing (*Dendrocalamus strictus*) and local name saw (*Dendrocalamus halmiltoni*) grow best. Soil should be moist but free draining and high in organic matter and nutrients. Spacing should be fairly wide (5 m) to allow plants room to mature. Direct plantings of cuttings, offsets or nursery-raised cuttings, or seeds may be sourced as planting stock. Directly planting cuttings is possible early in the monsoon. Cuttings (2-4 nodes, preferably with visible root primordia) can be placed in a horizontal, vertical, or slanting position. For horizontal planting, laying the cuttings horizontally with buds sideways to the planting holes is recommended. Holes



Brooms made from broom grass



Local bamboo



should be filled with 10 cm top soil to cover the cuttings and water and mulch should be added to the cuttings as needed.

Nursery-raised, one-node culm cuttings are desirable for large plantations. Culms are collected during the rainy season. Each cutting has a branch with a prominent swollen basal portion. Cuttings are set in a slanting position with the branch stub at the upper side of the node and a portion of the culm internode and the branch node exposed. While ordinary garden soil or sandy loam soil is acceptable, faster and easier rooting is possible using a sand bed with a misting system.



## APPROACH

Through funds provided by the International Development and Research Centre (IDRC), of Canada, with collaboration of the Ministry of Agriculture and Forestry (MoAF), District Agriculture Officer (DAO), and the Agricultural Extension Officer (AEO) of Serthi, the SJI has facilitated the planting of:

1. 100 broom grass divisions
2. 1500 napier slips
3. 300 bamboo cuttings

in the pilot impact area of Sakari village, established on 2<sup>nd</sup> of June, 2014.

Since the initiation of the pilot project, Mr. Cheten Gyeltshen, the AEO of Serthi, has trained 35 farmers and 2 local leaders on soil conservation practices including, how to grow soil conserving plants, as well as how to maintain hedgerows.



Farmer training

### *Training Objectives on Soil Conservation by AEO*

1. To prevent land degradation due to excessive runoff during summer season
2. To create awareness to the public on soil fertility and its management
3. To maintain the soil fertility and increase the production of crops in future
4. To reduce work of farmers in future

### *Budget spent during implementation of soil conservation*

1. Daily Allowance (DSA) for 37 heads > Nu. 10,500/- + Nu 3000/- = **Nu. 13,500/-**
2. Lunch and refreshment for 37 heads > Nu 10,500/- + Nu. 600/- = **Nu. 11,100/-**

Total amount for DSA, lunch, and refreshment > Nu. 13,500/- + 11.100/- = **Nu. 24,600/-**

#### *Materials*

Napier Nu.2/- per slip × 1500 no = **Nu. 30,000/-**

Bamboo Nu.30/- per stem cutting × 100 no = **Nu. 3000/-**

Broom grass Nu.2/- per rhizome × 300 no = **Nu. 600/-**

Total budget for materials procurement >

Nu. 30,000/- + Nu. 3000/- + Nu. 600/- = **Nu. 33,600/-**

Grand total budget for implementation of soil conservation with training and awareness to farmers:

Nu.24, 600/- + Nu. 33,600/- = **Nu. 58,200/-**

*Monitoring and evaluation: 8<sup>th</sup> of July, 2014*

Training on soil conservation practices, including methods of material collection and planting was conducted during the previous month. During the monitoring and evaluation planting materials were collected and hedgerows were installed (Figure 4).



**Figure 4.** Material collection, land preparation, and planting of hedgerows.



*Farmer Field Day 9<sup>th</sup> of December, 2014*

One of the 16 farmer participants, Tshewang Dorji said, “growing more plants and grass will hold soil from erosion and help feed our cows. Growing more will benefit us more!” After visiting the napier, bamboo, and broom grass saplings (Figure 5) it was concluded that they were almost all successful, with 97% survival.



**Figure 5:** Recently transplanted broom grass, napier, and bamboo (from left to right) saplings.



**Figure 6.** View from Sakari village, newly constructed farm road toward Lauri gewog.

## **LESSONS LEARNED AND RECOMMENDATIONS**

### *Factors Affecting Degradation of Land*

During the Farmer Field Day one of the participant farmers, Samten Dema said, “rain falls here continually for three months and rain is very heavy and all nutrient and topsoil washes away. We were concerned there might be a landslide that will take the village, but growing hedgerows seems to slow down the running water, so it really benefits us”.

Landslides have taken place since the beginning of the farm road contraction (Figure 6) to Serthi and Lauri gewogs in 2003, so the impacts of human activities is fresh in the minds of villagers. The farm road construction remains incomplete and is expected to increase erosion. While it is unknown if the village is at risk of landslides, the sheet erosion observed in Sakari is a consequence of improper agriculture practices, e.g., ploughing down the slope and lack of crop rotations and soil cover. Readily accessible practices could be

initiated to halt erosion and begin the process of renewal and regeneration. Additional works project will have to address the larger-scale erosion issue caused by road construction.

Types of erosion can be subdivided into two general categories:

1. Landslides are usually greater than 250 mm in depth and typically require large-scale remedies usually not affordable for small isolated villages.
2. Soil or surface erosion events are <250 mm in depth and typically less noticeable than landslides. This type of erosion is for the most part completely avoidable provided certain precautions are taken.

If poor runoff management is an issue in this village, care should be taken to address it. Observation of gullies or excess pooling of runoff water in one area of the village should be noted. The construction and layout of appropriate runoff diversion channels in areas at risk of landslides can be found online<sup>1</sup>.

#### *Benefits from pilot impact project*

1. Soil conservation
2. Future terrace
3. In the future more cereal and vegetables can be cultivated
4. Knowledge and skills to manage soil gained
5. Source of fodder for dairy cows

#### *Challenges of implementation*

6. Awareness
7. Labour to establish
8. Raw material collecting
9. Knowledge of agroforestry and the breadth of soil conservation practices

#### *Recommendations*

The establishment of perennial hedgerows will take time and an expenditure of effort. The observation of benefits will remain anticipated for some time. The patience of farmers will be rewarded, however, with more productive agricultural systems and a model for regional soil stewardship. Strengthening of soil conservation and agroforestry principles through continued trainings by the AEO, as well as, facilitating farmer-to-farmer knowledge transfer will help reverse land degradation. The SJI will continue to plan with the gewog administration to help facilitate trainings on land and nutrient management. The AEO of Serthi is adamant about this transition: “we'll try to train them about how to make a terrace. Implementation of terracing represents a one-time investment for the farmer, which will pay off in the long-term with reduced soil erosion and improved soil quality”.

## **ECONOMIC DIVERSIFICATION AND UPSCALING**

Farmers inherently understand the importance of soil in supporting their livelihoods, but have not generally adopted soil conservation practices, possibly because many have only recently transitioned from shifting to permanent settlement agriculture. There appears to be a need for these techniques in Sakari, Serthi, and across Samdrup Jongkher. Potential expansion through extension trainings in other gewogs will likely have similar impacts and adoption rates as seen in Serthi, since most of Bhutan's agricultural land is on highly erodible slopes and faces high rates of soil erosion. A wide diversity of planting material is locally available at no cost, except for the labour of collecting and planting. Once established, these stock plants can be divided and slips or other propagation materials transplanted. At the time this case study was written, the establishment of propagation nurseries could be upscaled along with soil conservation principles disseminated widely.

The grass species chosen for this pilot impact project were not only desirable for hedgerows, but had secondary benefits as well. Napier had been promoted by both the AEO, Livestock Extension Officer (LEO), and Forestry Extension Officer (FEO) for soil conservation and as a fodder source for livestock. Dairy, including butter and cheese are important income sources for these small-scale farmers. Farmers also generate income from selling brooms made out of broom grass flower panicals and construction and basket weaving materials made out of bamboo. Farmers were much more receptive to planting familiar plant species with economically valuable attributes in this pilot impact area.

## **CONCLUSION AND RECOMMENDATION**

According to the Renewable Natural Resources Census (RNR 2008), the most significant challenges to farming in Bhutan were soil fertility and erosion. Under agricultural conditions, it takes approximately 500 years to form 25 mm of soil, whereas under forest conditions it can take 1000 years to form the same amount of soil. In other words, soil is the foundation of any agricultural system and once the soil is squandered, so too follows the civilization that depends upon it. Therefore, it is vital to maintain a healthy and productive soil if agricultural systems are to function optimally. An increase in soil organic matter, through addition of farmyard manure, compost, mulches, intercropping with legumes and other bioaccumulating plants will increase productivity without having to develop an unsustainable reliance on expensive imported fertilizer inputs. Soil fertility is ultimately dependent on soil mineralization rates, which are directly related to soil microbiological activity, and is thus, interconnected with the available organic matter. A disturbed ecosystem would break the natural cycle of interdependency<sup>iii</sup>. In other words, the soil-plant system is interconnected and should be protected.

### *Final Recommendations*

#### *Recommendations from farmers*



1. With the support of the AEO, additional projects planting improved varieties of grasses and local grasses on the edge of slopes will not only bind the soil, but will also provide a rich source of fodder for livestock and income generation too.

#### *AEO recommendations to the SJI*

1. Budget to conduct additional trainings across Serthi gewog
2. Request coordination with the DAO to host expert on soil conservation

#### *The SJI's recommendations to the AEO*

Consideration should in time be given to additional soil conservation practices and plant species. There are numerous local species (see Ministry of Agriculture and Forests RNR) to consider and affordable methods of soil conservation like stone bunds, terracing, green manure, composting, zero tillage, mulching, intercropping, and increasing winter cropping that farmers can do with use of available indigenous resources<sup>i & ii</sup>.

1. *Stone Bunding*



**Figure 7.** Stone Bunds in Gomdar gewog.

A stone bund is basically a pile of stones along the contour line of the slope. Bigger rocks are placed on at the base and smaller ones piled on top. This wall of rocks helps to prevent soil erosion and can eventually form terraces (Figure 7). Rocks and stones are typically abundant in the slope lands of Samdrup Jongkhar. Traditionally, a practice locally called *Tshekpa*, or a pile of stones in a row, was used by farmers to intentionally reduce erosion around the house



**Figure 8.** Tshekpa in Gomdar gewog.



(Figure 8), i.e., a retaining wall. In some cases they formed what would be described as stone bunds, eventually forming terraces. Currently, the AEOs of the region are training farmers to deliberately create stone bunds and terraces across their farms not just around their homes.

## 2. *Terracing*

Terrace structures will utilize bunds made out of stone if they are available. The most level terraces are located closest to the dwelling for vegetable production. Crops are grown on land with increasing slopes and the terrace angle will be less than for the kitchen garden



**Figure 9** Terracing in Gomdar gewog.

(Figure 9). The riser is planted with grasses and leguminous fodder trees for fodder. Where steep slopes limit terraces, or annual crop cultivation ( $>50^\circ$ ), fodder trees, fruit trees, and bamboo are planted (Figure 10).



**Figure 10.** Terracing on a >50° slope in Gomdar gewog.



**Figure 11.** Traditional compost pile.

### 3. *Green Manures and Compost*

Compost is much more than farm yard manure left to rot. (Figure 11) (Sogshing) A balanced and healthy compost includes: manure, weeds, crop residues, kitchen waste, wood ash, and leguminous crops used as green manure. Once a well-decomposed compost is prepared (6-9 months with monthly turning, maintaining moisture throughout) should be applied discriminatly to row and tree crops. For maize, it is advisable to make pits (20 cm deep x 25 cm diameter), 25 cm apart, in rows 75 cm apart and to mix existing soil with compst. Seeds should be sown, two on each side of the pit and thinned to one on each side. This method can be used in conjunction with the incorporation of *in situ*, i.e., field produced (rice bean, *Sesbania*/dhaincha) or *ex situ*, i.e., endemic species wild crafted from waste areas (Adhatoda, Artemisia, Albizia-Sershing or Khirthangshing) of green manures.

### 4. *Mulching and Zero-tillage*

Mulching is basically using vegetative matter to cover the soil surface. This helps to maintain soil moisture and can increase the infiltration of water into the soil. Mulching prevents weather-induced soil erosion, soil crusting and, ultimately, nourishes the soil with decomposed organic matter. Once the soil structure improves, zero-tillage should be used in tandem with mulching. Zero-tillage coupled with mulching minimizes soil disturbance, reducing erosion caused by rain and wind, and cultivation labour, and maintains soil moisture.

### 5. *Intercropping*

Maize is extensively produced on the slopes at most risk of erosion. Wide spacing leaves ample space for intercropping with soil improving legumes (velvet bean, common



bean, jack bean, rice bean, lab lab, soybean, *Sesbania*/dhaincha, crotalaria, and dhal), bioaccumulating species (hemp and buckwheat), or vining cover crops (sweet potato and squash), which would decrease the potential for erosion and improve soil quality.

Cardamom in Sakari is also planted at wide spacing in full sun without noticeable shade. Cardamom is a shade loving plant and is ideal as an understory crop in an agroforestry system. *Alnus nepalensis* (Gamoshing) is a recommended tree species because it is fast growing, fixes nitrogen, and moderates soil temperature and moisture. Integration of this or other locally adaptable tree species should be considered for integration in Serthi.

Intercropping millet with *Crotalaria* or *Sesbania* will help to mediate the crops high nutrient demands, because they fix nitrogen, produce a large amount of biomass, and help improve soil structure. At the time of millet transplanting the legume is broadcasted. After 60 days the legume is cut while flowering, with a potential biomass yield of 28 T/ha with 100 kg N/ha produced.

## 6. Soil cover days

Soil cover days is a measure of indirectly tracking both soil and water quality. The more soil is covered—either by a crop, or sod, or mulch—the more likely that the soil is being conserved, and that water quality is being protected. The difficulty across Samdrup Jonghkar is the high rainfall during the summer monsoon season and scant rainfall during the winter months. Cropping system studies should be sought or implemented to evaluate the feasibility of relay cropping wheat, barley, or cool-season legumes like chickpea, pea, fava bean, or lentil to extend soil coverage as long as possible before soil moisture becomes limiting. For this to be successful, however, increasing organic matter will be a prerequisite, as higher organic matter equates to higher water holding capacity of the soil. In conjunction, improving irrigation facilities and water access would allow expansion of vegetable crops during the food insecure winter off-season. An ideal cropping rotation that maximizes annual soil cover could be maize, wheat or pulse crop, and *Sesbania*/dhaincha incorporation prior to another season of maize.

A guide for extension officers addressing soil erosion and facilitating local solutions has been published online<sup>i</sup>. The first question to ask is “what processes are causing the site to erode”. Draw out a diagram of the site, its classification and appropriate solution, taking note of specific erosion events, and ask farmers. Determine the slope angle, slope length, soil drainage, and site moisture. Remember vegetation can stop surface erosion, but it can also increase infiltration and increase the risk of landslides.

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<sup>i</sup> Soil and Water Conservation Technologies and Agroforestry Systems. <http://www.nzdl.org/gsdImod?e=d-00000-00---off-0envl--00-0----0-10-0---0---0direct-10---4-----0-0l--11-en-50---20-help---00-0-1-00-0-0-11-1-OutfZz-8-10&cl=CL3.18&d=HASH0e60c689ba42d668653f64.10&gt=1>

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<sup>ii</sup> Regenerative Agriculture Technologies for the hill Farmers of Nepal. <http://www.nzdl.org/gsdImod?e=d-00000-00---off-0hdl--00-0---0-10-0---0---0direct-10---4-----0-1l--11-en-50---20-about---00-0-1-00-0-0-11-1-OutfZz-8-00&a=d&cl=CL1.15&d=HASH011a9b592cb4b8b846cbd46d.2>

<sup>iii</sup> Wangchuk, T. 2006. Seeing with the third eye: Growing up with Angay in rural Bhutan.