Chapter 6 Experimental study using coir geotextiles in watershed management

The fourth research question is answered in this chapter, which presents the results of the field experiments conducted in Kerala, South India, to test the effectiveness of coir geotextiles in watershed management. It also illustrates how participatory research was carried out on the introduction and use of coir geotextiles for soil and water conservation.

6.1 Participatory research using coir geotextiles for embankment protection - a case study in a midland region of Kerala

6.1.1 Importance of participatory research

From the case studies explained in Chapter 4 and the knowledge gained from Chapter 2 and the conceptual framework, it is clearly evident that the involvement of people is essential for the success of watershed management. Through joint experimentation with the people, participation can be enhanced substantially contributing to a project’s success. By participatory research beneficiaries receive training and experience in the design, implementation and evaluation of experiments. In this way their capacity for innovation can be substantially increased (Johnson et al., 2003). Bunch and Lopez (1999), through their study revealed that, for farmers to accept soil conservation technologies, the technology should enhance yields. It is the increase in yield that convinces the farmers of the value of soil conservation. If the yields have increased or costs have decreased, artificial incentives are not required. On the other hand if yields have not increased, no artificial incentive will make the adoption of the technology sustainable. Hence it was decided to conduct the experimental study with people’s participation and the results show that through experimentation with people, people can visualize directly the impact of the introduced technology. In addition it helps to develop innovation capacity both for individuals and communities.

6.1.2 The subject of research

Detention ponds are traditional water conservation structures used for drinking, domestic and irrigation purposes in Kerala, and they are the major water source for the village community. These ponds also act as an infiltration basin or recharge basin, which enhance groundwater recharge. In almost all micro-watersheds there is one village pond which is under the control of the local government called a Panchayat. During monsoon, the side banks of these ponds erode and the ponds get silted up. The same silt from the pond is subsequently used to restore the side banks but it is often eroded before

1 Based on: Vishnudas et al. (2005d, 2006e, 2006f)
vegetation can establish. Hence continuous maintenance is required for deepening and desilting of ponds to maintain their water holding capacity. Neither the local government nor the community may have enough funds for these labour intensive works. Ultimately the ponds get filled up and deteriorate and the area becomes subject to water shortage during the summer season and even during dry spells.

Most watershed projects meant to support communities propose conventional stone bunds for soil and water conservation. However, the majority of the people cannot afford these structures without support from the government. Hence it is interesting to look for an alternative material which is effective in reducing soil erosion, enhancing soil moisture and vegetation growth, and which at the same time is economically attractive and can be manufactured locally. The aim of this experiment was to study the effectiveness of coir geotextiles for embankment protection and to provide an alternative, cost effective option to reduce soil erosion, increase vegetation growth and increase soil moisture availability.

6.1.3 Study area

The Amachal watershed in the Trivandrum District, in the western ghat region of Kerala, has been selected for the experimental study to test the effectiveness of using coir geotextiles for embankment protection. Details of this watershed have been explained in Chapter 4. During the field study, peak rainfall in the experimental period is observed in the month of October (429 mm/month) followed by June (243 mm/month). Rainfall events are generally of high intensity and short duration especially in the southwest monsoon. This rainfall typically is in the form of an evening shower with a clear sky during the day. The mean annual temperature is 26.5°C. The area experiences a humid tropical climate with the relative humidity varying from 62-100% (GoK, 2002d).

6.1.4 Methodology adopted for implementation

A meeting was held on 23-12-2003 with watershed committee members to identify a suitable area for experimentation. Watershed committee members included all stakeholders, government officers, administrative ward members, members of the local government and the members of the User Association. The site chosen for the study was the main village pond (explained in Section 6.1.5). A watershed community meeting was held on 05-04-2004 and a technical session was held on the same day on the application of coir geotextile for erosion control. Experimentation started on the 17-05-2004. The banks of the pond were evened and debris was removed. Training for installation of coir geotextiles was given to selected labourers of the community, who were registered in the Watershed Committee. Installation of geotextiles started on 19-05-2004. Being a new technology, the committee was not fully confident in its feasibility. On the first day, the committee only provided eight labourers and as a result only a small portion of the work
could be completed. Fortunately, there was a heavy downpour on the second day. The entire community saw the effect of the reduction in soil erosion in the treatment plot. On the third day, the watershed committee provided forty labours to complete the work. Work was started at 6.30 hrs and the work was completed at 19.00 hrs, covering the entire area treated with coir geotextile of 1100m². Figures 6.1 and 6.2 show the photograph of the immediate impact on the treated plot and the control plot on the third day of installation.

Figure 6.1. CGG, third day of installation

Figure 6.2. CP, third day of installation
6.1.5 Experimental setup

(i) Materials

Coir is used in this experiment as a temporary erosion control measure to facilitate the establishment of vegetation and to stabilize steep slopes such as embankments of ponds. Coir matting selected for the study is MMVI with the smallest mesh opening of 6 x 6 mm² and a density of 0.74 kg/m². The tensile strength of fresh geotextile is 13.8 kN/m. The selection of material was based on the steepness of the slopes. Literature shows that for higher slopes, geotextiles with small mesh openings are better to reduce soil erosion and absorb the impact of raindrops.

(ii) Field layout and installation techniques

A village pond in the watershed has been selected for the field experiment. The side banks of this pond become eroded even during summer showers. The type of soil is silty sand. The capacity of the pond is 48m x 123m x 2.1m.

![Figure 6.3. Side of pond with different treatments](image)

The pond has a natural depression on one side. The water level in the pond fluctuates from season to season. The slope of the embankment is 70°. The height of the exposed slope of the embankment is about 3 m. The length of the embankment varies from 3.1m to 3.5m. Erosion is caused by both rainfall and runoff. The limitation for providing a gentle slope to the embankment is that three sides of the pond are surrounded by existing village roads and the other side is a pedestrian road. Beyond the road on two
sides, there are existing irrigation canal. Conventional method using rubble for the protection of the embankment is very expensive and hence the community opts for the vegetative measures. The experiment consists of three treatments (a) coir geotextiles with planted grass (CGG), (b) coir geotextile alone (CG) and (c) control plot (CP); replicated four times along the sides of the pond. Each side of the pond was divided in three equal parts for the three treatments. For all treatments a distinction was made between the upper and lower portion of the slope, because the people indicated that generally there is more erosion from the top of the slope if the slope is unprotected Figure 6.3 shows the side of the pond with different treatments.

![Figure 6.4. Laying of geotextiles on the side bank of the pond](image)

The coir was laid during 17-22 May 2004, just before the onset of the monsoon. The installation procedure followed was generally similar to that used for surface erosion control. All the vegetation was removed and the soil on the surface of the slope was well graded to remove unevenness, since any irregularity may allow water to flow under the matting and thus cause undercutting (Rao and Balan, 2000). Trenches of 30cm x 30cm were dug at the top of the slope to anchor the geotextile. Rolls of the matting were first anchored in the top trench and then unrolled along the slope. Anchoring was done using bamboo pins cut to a length of 25-30 cm, instead of iron hooks used conventionally. Pins were driven at right angles to the slope to anchor the matting. Each roll was given minimum overlap of 15 cm and anchored firmly with bamboo pins spaced in a grid of 1m
spacing. Bamboo pins were also driven at the joints with a spacing of 1m (See Figure 6.4). At the bottom, matting was rolled in two layers and anchored with bamboo pins to hold the soil eroded if any and also to reduce the intensity of runoff. According to conventional practice, trenches were also dug at the bottom of the slope. After installation, matting was pressed to closely follow the soil surface. Trenches were backfilled and compacted.

(iii) Planting of grass

The common grass species *Axonopus compressus* was selected for the study. This species is used as fodder in this watershed. It was planted in the treatment plots at a spacing of 10cm.

6.1.6 Monitoring

Rainfall was measured using a self-recording rain gauge installed in the field. Soil moisture, vegetation, nutrient loss and bio-degradation of coir were measured from all the three treatments directly. A group of 60 people has been selected randomly from the user community living within the vicinity of the pond for monitoring and evaluation. The user community themselves developed indicators for the qualitative evaluation. They included length of grass, colour of grass, uniformity of grass, density of grass and soil erosion.

Figure 6.5. Pond before treatment
Data sheets were provided for scoring. In parallel, a quantitative study has been conducted with respect to rainfall, soil moisture and nutrient contents of the soil, vegetation growth and bio-degradation of the coir. Figure 6.5 and Figure 6.6 show the pond before and after the treatment.

Figure 6.6. Pond after treatment

6.1.7 Results and discussions

(i) Soil Moisture

Soil moisture was determined by gravimetric method from different treatment plots. Soil samples from 10 cm depth (over the course of a growing season, plants extract about 40% of their water from the upper part of the root zone) were collected monthly and its initial weight was recorded \( (w_1) \). Subsequently samples were dried in sunlight until a constant weight was obtained, which was considered as the oven-dry weight \( (w_2) \). Variation in soil moisture in different treatments with respect to rainfall is presented in Figure 6.7. Soil moisture was found to be declining subsequently during the observation period even with an increase in rainfall events (40-120 mm/day) in the month of October, due to the peculiarity of the southwest monsoon. Soil moisture in CGG is 21% higher than in the control plot during the dry period. In CG, soil moisture is less than in CGG. This is because in CGG, *Axonopus compressus* is well established as a canopy reducing
solar radiation. Whereas in CG, the area was invaded with the same natural vegetation as in the control plot and most of this vegetation consists of shrubs and broad-leaved plants. These plants dried up from December onwards, and less moisture was retained than in CGG. In CP, the density and uniformity of vegetation was much less along with the occurrence of soil erosion and runoff. Hence moisture retention was least in these plots. Soil moisture retained during the dry period in CGG, CG and CP experiments are in the ratio 1: 0.75: 0.21.

Figure 6.7. Variation in soil moisture with respect to rainfall

(ii) Vegetation

Coir matting installed to cover the soil surface provides ample opportunity for the growth of vegetation. Even degraded geotextile contributes to the organic composition of the soil and promotes vegetation. Length of grass, weed intensity, uniformity and density of grass has been considered as measures for vegetation growth. Within nine months, vegetation was well established and the slope was stabilized in the area covered with geotextiles. Average length of the grass of the same species as that in CGG is being measured from all the plots to compare the length of grass. The vegetation was protected from harvesting during the study period.

Figure 6.8 shows the variation in height of the vegetation at all plots. Growth of vegetation in CGG shows greater values than in CG. The control plot shows the lowest value. In CGG, vegetation established well before it started at CG and CP. In CG and CP,
vegetation established with different varieties of weeds, whereas in CGG only *Axonopus compressus* was grown. This vegetation started drying up in December and even at that time the control plots were not stabilized. Intensity of plants per m² was identified from June'04 to Feb'05. Among the grasses *Axonopus compressus* and *Heteropogon contortus* alone survived after December. Maximum intensity was found to be of *Axonopus compressus*. Perception analysis of the response of participants on length of grass is explained in part (vi) of this section.

![Figure 6.8. Length of grass (measured)](image)

(iii) *Biodegradation of coir*

Biodegradation of coir was studied based on ultimate tensile strength of the matting collected from the field during the period. The tensile strength test is carried out using the wide-width strip tensile test for geotextiles, a uniaxial tensile test in which the entire width of a 200 mm wide specimen is gripped in the clamps and the gage length is 100 mm (ASTM standard D 4595-86). Figure 6.9 shows the degradation curve of the geotextile with respect to time. The coir retained 19 % of the strength of a fresh sample after nine months. After seven months, it was observed that tensile strength of geotextiles was reduced by about 70 %. By that time a sustainable erosion control measure by the establishment of vegetation was observed in the CGG and CG plots whereas erosion...
persisted in the control plots. Hence the increase in the rate of degradation during the period did not affect the effectiveness of coir geotextiles as an erosion control measure.

![Figure 6.9. Bio-degradation of coir with time](image)

(iv) **Nutrient losses**

High intensity rainfalls in the tropics result in top soil erosion. Soil samples from the surface (top soil) were periodically collected from the field and tested in the laboratory for Nitrogen, Phosphorous, Potassium and organic carbon. In all the plots, it was seen that loss in NPK and organic carbon was higher in CP than in the plots treated with coir geotextiles. The bio-degradation of coir fibre and reduction in surface runoff contribute to the improvement in the organic content in protected plot.

The net loss of nutrients during the study period in CGG, CG and CP are in the ratio 1: 1.3: 6.2 for Nitrogen, 1: 1.4: 3.5 for Phosphorous and 1: 1.4: 4.9 for Potassium. The loss in organic carbon in the three plots is in the ratio 1: 1.4: 2.8. Difference in values in CGG and CG may be due to leaching of nutrients in CG during the initial stage. Figure 6.10 and Figure 6.11 show variation in loss of NPK and organic carbon during the study period in the three treatments.
Figure 6.10. Net loss of NPK in different treatments, between May '04 and February '05

Figure 6.11. Percentage loss in organic carbon in different treatments between May '04 and February '05
(v) Cost analysis

Goshal and Som (1993) cited in: Kaniraj and Rao (1994) have presented an economical evaluation of the use of geotextiles from the Indian perspective. They compared the costs with synthetic geotextiles and conventional methods for typical geotechnical problems in four metropolitan cities of India. Even with synthetic geotextiles, it was found to be economical than the conventional practices. Hence, in developing countries like India, if the efficiency of natural fibers can be effectively utilized, where it is abundantly available, this will prove to be a sustainable and affordable solution in many applications.

In this study, the cost of construction includes materials, transportation and labour charges. By the conventional method of slope protection using stone pitching is 2.50 euro/m². However, by using coir geotextiles, the construction cost are less than 1 euro/m² which includes the cost of geotextile and cost for clearing the site, laying geotextiles and planting grass on the surface. Moreover, unlike conventional structures, this structure provides a means for cultivation of fodder or other crops for the rural poor.

vi. Perception Analysis of the response of the participants

As mentioned in (ii) of Section 6.1.5, people were asked to score indicator performance in the field in the range 10-50, with a maximum of 50 and minimum of 10. A score of '50' indicates 'good', '40' indicates 'more than satisfactory', '30' indicates 'satisfactory', '20' indicate 'less than satisfactory', and '10' indicates 'bad'. As there will always be some impact of any technology in the watershed for soil and water conservation, the score '0' was not assigned. The perception of the people has been statistically analysed by ANOVA. The monitoring was carried out for 9 months, with 3 treatments on 4 areas.

The key criteria in ANOVA for performance analysis are:

1. comparing the treatments A1 (CGG), A2 (CG) and A3 (CP), the degree of freedom (df)² = 2. For 5% significance the F³ value is 3 and for 1% significance F = 4.6. The critical difference⁴ (CD) for soil erosion is 0.9 and for growth of vegetation is 1.1.
2. comparing the effect of treatment over 9 months (B1= June), the degree of freedom (df) = 16 (2 x 8). For 5% significance, the F value is 1.7 and for 1% significance, the F value is 2.0.

a. Perception on soil erosion

In this study the F value obtained for soil erosion in the upper portion is 1763 and the F value obtained for soil erosion in the lower portion is 1684. With a F value of 4.6 at 1% significance, the F value is 1.7 and for 1% significance, the F value is 2.0.

1 ANOVA is a procedure to test for the difference in variability among treatments and between treatments
2 Number of observations (n) in a sample that can vary freely, df = n-1
3 F value is the ratio of the variance between groups to the variance within groups.
4 Critical Difference (CD) is the minimum difference between a pair of means to be significantly different from each other.
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significance, this shows that there is a highly significant difference between the three
treatments. Figure 6.12 shows the mean response of the participants with respect to soil
erosion in treated and untreated plots.

Figure 6.12. Analysis by ANOVA; response of participants on soil
erosion from upper and lower portion of the sides of the pond

In the upper portion of the slope, the difference in the mean score between CGG
(46) and CG (41) is 5, and the difference between CG (41) and CP (18) is 23. The mean
difference between CGG (46) and CP (18) is 28. The critical difference (CD) = 0.9. This
shows that treated plots are significantly different from the untreated plots and also that
treatment CG is similar to CGG in reducing soil erosion from the upper portion. In the
lower portion, the results are similar. The difference in the mean between CGG (47) and
CG (42) is 5, and between CG (42) and CP (20) is 22. The mean difference between CGG
(47) and CP (20) is 27. Figure 6.13 shows the mean response of participants in
monitoring the effect of geotextiles in reducing soil erosion in the upper and lower
portion as a function of time. Considering treatment (A) and time (B1-B9), degree of
freedom df = 16; the F value for 5% significance is 1.7 and for 1% significance F = 2. In
this study, the F value obtained for soil erosion in the upper portion is 50 and for the
lower portion is 26. The figure clearly illustrates that there is considerable difference in
reducing soil erosion from the upper and the lower portion in treated and untreated plots
even at the initial stage. From this, it is evident that erosion persists in the control plots
during the later stages, whereas the slopes of the plots treated with geotextiles stabilized with the establishment of vegetation.

![Graph showing soil erosion response over time.](image)

**Figure 6.13. Analysis by ANOVA; response of participants on soil erosion as a function of time**

b. **Perception on growth of vegetation**

The indicators developed for the evaluation of growth of vegetation were: the height of the vegetation (length of the grass), colour of the grass, uniformity and density of the grass. The height of the vegetation indicates the establishment of vegetative matter. Uniformity and density of vegetation indicates the ability of the surface to hold seedling from washing away. The colour of the vegetation is an indicator related to the nutrient content of the soil. In the control plots, top soil erosion was high and hence less colour of grass was observed. Whereas in treated plots, coir geotextiles acted as a surface cover which protected the slope from top soil erosion from the initial stage and retained more soil moisture than in the control plots. The biodegradation of coir also contributed to the nutrient content of the soil. Figure 6.14 represents the ANOVA analysis of the indicators that represent vegetation growth in treated and untreated plots. For the degree of freedom $df = 2$, the $F$ value is 4.6 at 1% significance and at 5% significance $F = 3$. In this study, the $F$ value obtained for the length of grass is 1321, and for the colour of grass is 1096. Uniformity and density of grass have an $F$ value of 655 and 774 respectively. The mean
response of participants shows that there is significant variation between the treated and untreated plots.

![Graph](image)

**Figure 6.14. Analysis by ANOVA; response of participants on growth of vegetation**

The average length of the sampled leaves, at any period, is assumed to be indicative of the vegetation growth at that period. The ANOVA table for the perceived length of the grass is shown in Table 6.1 (qualitative data).

In the CGG experiment, the length of the grass generally increased over the first four-five months. Minimum response on length of grass was noted in the initial months, and gradually it increased until the month of November. In this study the F value = 10.8, which shows that there is highly significant difference between treatments. Among the three different treatments significant increase in length of grass was observed in geotextile with grass plots compared to control plots.
Table 6.1 ANNOVA table; response of participants on length of grass, whole treatment

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F = 10.8

A- Treatment, A1 = CGG, A2 = CG, A3 = CP respectively, C- Sides of the pond, C1 = North, B- Month, (1 = June)

Since the F value for length of grass is 1321, the treatments are very effective and differences between treatments are highly significant. The mean value for treatment CGG is 44, for CG is 28 and CP is 19. The mean difference between CGG and CG is 15 and between CG and CP is 9, whereas mean difference between CGG and CP is 24, while the critical difference CD = 0.9. This shows that treatment CGG is significantly different from CP, and CGG and CG are significantly different from CP. This shows that variations in the height of vegetation in the three treatments were similar in both qualitative and quantitative analysis. The critical difference for length, colour, uniformity and density of grass is 1.1. In Figure 6.22, difference in mean observation between CGG, CG and CP is much higher than the critical difference. This is mainly because, by the time vegetation established in the treated plots planted with grass, natural vegetation was established in plots treated with geotextile alone. In the control plots, due to lack of protective covering, the slope was not stabilized due to erosion. Figure 6.15 to 6.17 show the photographs of the plots under different treatments.
Figure 6.15. CGG, thick vegetation after 7 months

Figure 6.16. CG, natural vegetation after 7 months

Figure 6.17. CP, less density, non uniform vegetation with soil erosion, after 7 months
6.1.8 Survey analysis

A survey was conducted in the watershed in April 2005 to evaluate the impact of the participatory research. The community revealed that the experiment improved their willingness to adopt a new technology and that it visualized the immediate impact of the technology. They also revealed that if coir geotextiles were used to strengthen the traditional earthen bunds, then they would not require skilled labour. Along with reduction in soil erosion and thereby increase in availability of water, they could plant fodder grass on these structures to feed their livestock.

Of the sixty respondents, 5% belonged to a higher income group, 35% to a middle income group and the rest to the economically weaker section. The higher income group did not have any specific preference for the conventional or innovative material for soil and water conservation. The middle income group preferred the coir geotextiles, because it requires less labour for construction and at the same time will provide fodder. The lower income group emphasized the adoption of this technology. If this would become the main-stream technology for soil conservation, user association could organize a society for spinning, yarning and manufacturing of geotextiles, as an income generation activity along with fodder grass cultivation. This would increase job opportunities in the watershed and hence provide a means for poverty alleviation. Again this technology requires only unskilled labour, implying that job opportunities would be available for both men and women. Higher income groups were of the opinion that this technology shall be included in the public works manual of the government, so that vegetated structures are also included in the manual. At present only structural measures are included in the government manual. Also they were of the opinion that if this technology can be successively promoted, coir geotextiles can be manufactured in User Groups and then it can be available at lower costs, so that cost per unit area can be reduced.

6.2 Coir geotextile for slope stabilization and cultivation – a case study in a highland region of Kerala

6.2.1 Subject of research

Soil erosion is a serious problem affecting crop productivity and the income of farmers in the highland region. High intensity monsoon rains, combined with the runoff energy that is generated on steep slopes contribute to high erosion rates. A sloping field is not only vulnerable to soil erosion it may also suffer from moisture deficiency. Slope farmers everywhere face similar problems. Conservation technologies may reduce soil and nutrient losses, and thus preserve water holding capacity and soil fertility, and make possible sustainable crop production on steep slopes, but the construction of physical structure like bench terraces are often labour intensive and expensive since both construction and maintenance requires high investments.
The effectiveness of terraces decreases mainly due to erosion. Hence there is a need for a technology that stabilizes bench terraces, which is simple, effective and economically viable. In this study efficiency of coir geotextile is tested as an alternative for expensive bench terraces.

6.2.2 Background study

Anil (2006) in an experimental study conducted under research condition using multi slot devices illustrated that at 40% slope, the soil loss of a control plot is 12% greater than the soil loss of a plot treated with coir geotextiles (MMA3). Of the total volume of 4.89 m$^3$ of water received as rainfall per square meter, 0.02 m$^3$ was absorbed by coir geotextile, 0.15 m$^3$ was lost as runoff and the remaining 4.72 m$^3$ was assumed to infiltrate into the soil. The plot size was 25m long along the slope and 5m wide. Balan (1995) in his study on the durability of coir geotextiles illustrated that when coir was embedded in soil, coir retained 43% of its strength in alkaline media at pH value =11 and 60% at pH value =3. Degradation was found to be faster between pH values of 6 and 8, the strength retained was 34% and 26% respectively. But the moisture absorption capacity of the geotextile increased as degradation advanced. After one year the moisture absorption of the degraded geotextile was 2.5 times that of the fresh sample. This property is of particular advantage in enhancing soil moisture and vegetation growth. These two studies formed the basis of this study under field conditions.

![Figure 6.18. Conventional bench terraces with dry rubble packed bunds and earthen bunds](image)

In Kerala, terraces are made initially with contour bunds constructed with dry rubble packing of 75 cm to 1.2 m high on slopes. These are constructed in such a way that the lower bund is level with the mid-slope between two bunds, so that a natural
terrace forms after a few years of cultivation. By this time risers become deteriorated due
to erosion and top soil is washed away. The maintenance of these structures was normally
done by constructing earthen embankments on top of risers. (See Figure 6.18).

But these structures breech during heavy rainfall. Hence the conventional method
does not help to enhance vegetation growth or productivity from the slope. A small initial
movement in this unstable slope can trigger further soil water movement resulting in soil
erosion and land slides. Thus cultivation in slopeland became difficult for poor farmers.
Since slopes of more than 20% require physical measures for slope stabilization, in this
study risers of the terraces are eliminated and slopes have been treated with coir
gotextiles.

6.2.3 Study area

Initially a site was selected in the Attappady watershed for the field experiment. But due
to delays in getting administrative go-ahead from AHADS, the experimental study was
conducted in the Kumbazha watershed in the highland region of Kerala, in Pathanmthitta
District (9° 51' 20"N, 76° 13' 54"E). It is in the western ghat region where 50 % of the
total geographical area is covered by forests. This district is pre-dominantly an
agricultural district with 75% of the people directly engaged in agriculture. The density of
the population is 574/(km)² It has an undulating topography, and hills have steep
gradients. The main crops raised in this region are paddy, rubber, coconut and tapioca. In
some regions, cashew, pineapple and vegetables are cultivated. Tapioca has been the
staple food of this region over the last two decades for the small scale and poor farmers
living upstream. Due to soil erosion, presently this tuber crop is not recommended in the
highland region. Now they use rice as their main food which is supplied by the
government with subsidy.

The climate is humid tropical with two monsoons. The temperature varies from
23°C – 39°C. The relative humidity varies from 62-100% (GOK, 2003). The highest
rainfall recorded in the year 2000 occurred in August (490mm/month) and in 2001 and
2003 it occurred in June (567mm/month) and July (601mm/month). Peak rainfall in the
experimental period was observed in the month of August (419 mm/month) followed by
June (265 mm/month).

6.2.4 Experimental set up

(i) Materials

Coir matting selected for the study was MMA3 with a mesh opening of 6mm x 10.5mm
and a density of 0.70 kg/m²
(ii) Field Layout and installation techniques

In order to ensure acceptance and practice of soil conservation by the farmers, a site has been selected in a farmer's field. Three plots were selected for conducting the experiment. The well demarcated plots were first leveled and debris was removed. Slopes of the risers were shaped to 40% slope and terraces were leveled with a gradient of 3%. The size of the plot is 5m along slope and 25m wide. The terrace width was kept at 5m. See Figure 6.19. The type of soil is forest loam.

![Figure 6.19. Cross section - slopeland cultivation; alternate conservation technique using coir geotextile](image)

A narrow trench was made at the top and the bottom of the slope to anchor the geotextile. A roll of matting was slowly guided down the slope. The geotextile was stapled at regular interval using J-clips. 15cm overlap was provided at the joints. The three treatments were coir geotextile planted with crop (CGC), coir geotextile alone (CG), the control plot (CP).

(iii) Planting of crop

a) Selection of crop

The crop selection was made based on the farmer's interest. Tapioca being their staple food, it was selected as a food crop for the terrace. The crop for the riser was selected based on the following factors:

1. it should not cause any damage to the slope
2. the slope should not require maintenance for a minimum of four years
3. it should provide an income to the farmers
4. it should withstand drought and be adequate for the highland region

Considering the above factors, pineapple (Ananas Comosus) was selected as the crop for slope land cultivation. It is a tropical fruit with a worldwide market. Kerala is one of the major pineapple producing states in India, and India is one of the important...
pineapple growing countries in the world. This crop can withstand drought because of its ability to retain water in the leaves which is used during these periods. This plant has very low transpiration rates as it closes its stomata during the day and opens them during the night.

One main crop followed by two ratoons (basal suckers) is the usual crop cycle followed by farmers in Kerala. The economic life of a pineapple plantation is expected to be around 4 years and after the fourth year the plot needs to be uprooted and replanted. Farmers say that in the past they have maintained 3 to 4 crops over a period of 5 years.

b) Spacing

Tapioca was planted at a spacing of 1m x 1m. For the planting of pineapple the mesh of the geotextile was widened and planting pits were made with a stake. Suckers were planted at 10-15cm depth at a spacing of 45cm x 60cm and after two rows the spacing is 90 cm (see Figure 6.20). Care was taken while planting suckers not to disturb the weft and wrap of the geotextile as it may cause erosion.

Figure 6.20. Slope treated with coir geotextile planted with pineapple and tapioca on the terraces
6.2.5 Monitoring

Rainfall has been measured using a self-recording rain gauge installed in the field. The moisture absorption of the geotextile was measured as 5.6% of its weight. The efficiency of coir geotextile for reducing soil erosion was observed by the farmers in the adjacent watershed where the scientific study was conducted under research conditions by Anil (2006). The impact of the geotextiles on reduced erosion was not measured; it is assumed that it is of similar magnitude in this study. The soil moisture contents at 10cm, 20cm, 30cm and 40cm depth were measured in the treatment plot and control plot using a profile probe (see Figure 6.21) and results were analyzed with respect to the rainfall received during the observation period.

6.2.6 Results and discussions

Figures 6.22-25 show the variation of the soil moisture in the three treatments with respect to rainfall at varying depth. At 10cm depth during the dry season, the moisture content in CGC was found to be 32% more than that of CP. In the initial stages soil moisture in CGC was higher than CG. But in later stages, after 6 months, the moisture content in CGC is approaching that of CG. This is due to the absorption of moisture by the crop which grows better in CGC over the course of the growing season. The moisture content at 20cm, 30cm and 40cm are at higher rates in CGC and CG than in control plot. The variation in soil moisture is largely depending on the rate of transpiration and the
establishment of the root zone. This effect is uniform in all the treatments till the permanent wilting point occurs. But this condition did not happen here and hence even in the summer season, crops can be sustained without irrigation.

Figure 6.22. Variation in soil moisture at 10cm depth

Figure 6.23. Variation in soil moisture at 20cm depth
Figure 6.24. Variation in soil moisture at 30cm depth

Figure 6.25. Variation in soil moisture at 40cm depth
The higher percentage in moisture content in the treated plot is due to the mesh opening in the geotextile. It provides a large number of miniature porous check dams per square metre of soil. It slows down and catches runoff so that sediment settles and water passes through the matting and infiltrates into the underlying soil. As the geotextiles degraded, they acted as mulch and conserved moisture for plant growth. The hygroscopic property of the geotextile also contributed to the increase in soil moisture. Hence from the experiment it was observed that coir geotextiles can retain moisture in the root zone and promote cultivation on the slopeland.

6.3 Conclusion
Field experiments, involving a local community in Kerala, have clearly demonstrated the effectiveness of coir geotextiles to stabilize banks of hydraulic structures and particularly the steeply sloping banks of a pond. The community was very enthusiastic about the effectiveness of the coir, particularly in combination with a local grass variety. The coir with grass appeared to be the most effective to prevent erosion, to retain moisture and nutrients and to facilitate grass growth. Moreover the slope with grass was productive in providing fodder. The degradation of the natural fibres over time did not result in any loss of effectiveness. On the contrary: the fibre contributed to the natural fertility of the soil after the vegetation cover was well established and the geotextile was no longer needed for bank stability.

The qualitative analysis shows that the perception of people on various indicators is significantly different between plots treated with coir geotextiles and control plots. The analysis proves that the perception of the user community is similar to that obtained from the quantitative analysis. This demonstrates that through participatory research, farmers can work in close association with researchers and gain knowledge through their involvement in the experiments. As a result, they study the direct impact of the new technology themselves and more readily adopt successful technologies.

The experiment in the highland region aimed at providing an alternative for bench terraces to stabilize the slopes for cultivation. From the results it is evident that the slopes treated with geotextile and crops have the highest moisture retention capacity followed by geotextiles alone and then the control plot. The application of geotextile on slopeland increases moisture availability in the soil and enhances infiltration. Since the slopes were stabilized with the application of geotextiles, sediment deposits on the terraces due to erosion were minimized and hence cultivation is possible both on the slopes and terraces. As the poor and marginal farmers occupy the highland region, this method provides an economically viable option for income generation and food security along with slope stabilization. This method can also be applied to wasteland cultivation in the highland region.
Persistent poverty and environmental degradation demand a constant effort to improve the effectiveness and impact of agricultural and natural resource management research. Poor farmers are often trapped in situations where they are degrading their natural resources and lack access to more productive and sustainable technologies. The main reason for this is that available technology is often unsuitable for them given their objectives and constraints. Farmers readily adopt a technology when they have experienced the positive research outcome. This reduces the adoption time, and can bring significant increase in yield, or decrease in labour costs, helping to enhance productivity, sustainability and improvement of livelihood. The relative cheapness of the material and the potential for producing and laying the matting with local labour makes the use of coir geotextile a very attractive option for sustainable development scenarios in watershed management.