Report – Study on Water Resources in the Sigur Plateau

April 2006

Report Prepared
by
EcoDesign Consultants,
No 8A, GoodEarth Enclave,
Uttarahalli Road, Kengeri,
Bangalore 560 060
Email - ashokeco@vsnl.com
Tel: 0091-080-56907724

Contents

Maps

1. Map of Sigur plateau
2. Map of River courses in the Sigur Plateau
3. Map showing geological features of villages visited

Photographs

Roll 1

Roll 2

Drawings – Soil and Moisture Conservation

1. Mechanical soil and moisture control measures – contour and staggered trenching
2. Basic check dam design modifications and sub surface dykes
3. Basic design for Groundwater recharge – wells

‘

Report – Study on Water Resources in the Sigur Plateau

A. Background – The Keystone-Winrock Project, 2001

The 'Hill Water & Livelihoods- the Nilgiris Water Resources' project was a study on the water resources and use situation in the Nilgiris conducted by the Keystone Foundation during the period between June 2001 and June 2002. The 'Small Grants Program of the Ford Foundation – Winrock International India', supported the project.

The project culminated in a Stakeholders Workshop that brought out a range of issues that needed further investigation. From September 2002 to January 2003, a series of 'Citizens Meetings' were held in different taluks of the district to share the findings of the study and understand their perspectives on local management of water resources. The result of the feedback from the Citizens Meetings is the new proposal titled - The Nilgiris Water Resources Project – Keystone Foundation January 26, 2006. One serious concern was that in spite of water being a common property resource, there is no attempt at the participatory management of water. Furthermore, the erosion of the old water-sharing and management mechanisms of the indigenous hill communities is a 'telling' indication of the neglect of modern society of an age old, functional natural resource management system.

Objective of the New Nilgiris Water Resources Project of 2006

The Primary Objective of the project is to develop a strategy for Sustainable Community-based Interventions through: Action-Research, Innovation & Enterprise for the Conservation & Development of Freshwater Resources.

This assignment is part of the project to understand the ground situation and to carry out a Water Audit, which will provide information to initiate work on the Sustainable Water Management (SWM) in the Sigur Plateau.

Objectives of the Assignment Study

- To prepare a Water Resources Audit report for the hydro-geological features of the Sigur Plateau with specific reference to water resources – ability for conservation, geological features available which would support retention, percolation and recharge.

The specific objectives include

a. The preparation of a 'Water Resources Audit' report, which will be based on a study of the hydro-geological features of the Sigur Plateau with specific reference to water resources. The study will cover the scope for conservation and the geological features that would support retention, percolation and recharge.

b. A resource analysis covering the causative factors of the water crisis, typical patterns if any, and future scenarios under different management options, the conditions and variability across seasons and past trends will be done. Data would be generated to identify freshwater budgets in hill areas (Sigur plateau), which are typically source zones. A menu of options would be available after the audit on "what to do & where by whom".

B. Introduction to the Sigur Plateau

The Sigur Plateau is the northern part of the Nilgiris district with its western and northern boundaries adjoining Kerala and Karnataka. The 300m deep Moyar Gorge separates the Sigur Plateau from the Mysore Plateau. To the south of the Sigur Plateau is the Nilgiris Plateau. The average elevation of the Sigur plateau is 900 m ABSL. The boundaries of the Sigur plateau are the Moyar Gorge in the north, the Moyar River on the east, the Wynad district and the Nilgiris massif in the south.

There are five major streams in the Sigur plateau, namely, the Moyar River, the Sigur River, the Avarahalla River, the Kedarhalla River, and the Gundattihalla River. All these rivers originate in the Nilgiris plateau. The Nilgiris have several valley systems ranging in elevation between 1800 m and 2200 m drained by the Bhavani, Kundah, Hadathoraihalli, Kukailthoraihalla, Sigur, Pykara, and other minor rivers some of which have been dammed up during the last five decades.

The rainfall in the Sigur plateau is quite variable with the western part of the plateau lying in a rain shadow region. West Sigur receives less than 500 mm annually, while the east part receives more than 1000 mm of rainfall. The difference in rainfall also contributes to the dry deciduous forests in the west part of Sigur while the eastern part has more scrub jungle. All along the river courses, dense riparian forest are seen in both the west and east parts of the Sigur plateau. The scrub jungles of the eastern part are traditionally called the Pankadu. The Sigur plateau is a low rainfall marginal land with poor soils and till recent times, also had a low population density. The very fact that the area is largely of scrub vegetation makes it more suitable for pastoral activity. Before the forests became reserved, the area was open to free grazing and used by both agricultural groups from the Nilgiris and the Coimbatore plains.

Sigur has been impacted in many ways by influences from Karnataka on the north and Kerala on the west. The tribal people are predominantly Kasavas, Irulas, Jenukurumbas, Sholigars – they have close linkages with the neighboring states. The non-tribals are also seen in large numbers. There has been a huge influx of migrants from Kerala who have set up businesses and enterprises along the Bangalore – Ooty road. Presently most of the areas have been declared as Wildlife Sanctuary and Reserved forest. Human – wildlife conflicts are common.

There is a strong school of thought that believes that tribal population ought to be displaced from this region for wildlife to progress. For several decades now, field stations had been established by Research institutions such as the Bombay Natural History Society, Indian Institute of Science (Centre for Ecological Sciences) area to study wildlife. None of these institutions have been able to provide effective solutions to the people who have co-existed with wildlife in this area for generations. The area has been identified as a crucial corridor for the Indian Elephant [the largest population in south India]. There is a large extent of Revenue lands. The proposal to extend the Wildlife Sanctuary towards Thengumarda has been opposed by the present population and a stay order has stopped the handing over the reserve forestlands to the Wildlife Warden.

Relief and drainage

The majority of the area is undulating with most of the area [Keystone village areas] at an altitude of 900 m. The land slopes from west towards east with a slight tilt towards the north. On the southern boundary of the Sigur plateau are seen the steep hills of the Nilgiris leading to the high plateau of 2000 meters. Towards the north is a deep gorge that has been cut deep by the river Moyar running west to east. The Moyar Gorge is also the boundary between the states of Karnataka and Tamil Nadu. Bhavani and Moyar are the two important rivers. All the rivers and their tributaries originate from the Nilgiri plateau and were once perennial; the modified water regimes for purposes of power generation and irrigation have rendered some of these rivers seasonal and many water courses have also been altered by new canal systems.

Climate and vegetation

This part of the Nilgiris has the lowest rainfall of 40 cm, which starts with the seasonal rain of April - May. The western most part of this area is just touched by the South West Monsoon. The main rain is from the North East Monsoon. With the average day temperatures never very hot (not going above 32^{o} Celsius and the lowest winter temperatures staying above 20^{o} Celsius) the area is known for its pleasant climate.

The slopes leading from the Nilgiri Hills are covered with grassland on the top and with sholas in the valleys. The Niligiri slopes are covered with ever green to dry deciduous vegetation, while the Sigur plateau is covered with scrub jungle, and the rivers valleys covered by riparian vegetation which include mango, jamun and bamboo forests.

Picture: Scrub jungle in Moyar

Picture: Riparian jungle in Bokkapuram

Soils in Nilgiris

The soils commonly occurring are light yellow to reddish brown clay soils. Humus soils of about 0.5 m thick are confined to the areas covered by thick vegetation. The soils in the Nilgiris district are derived from the decomposition of rocks dominantly composed of Pyroxene gneisses interbanded with Pyroxene granulites and garnetiferous quartzofelspathic gneisses. The relatively low country around the massif is made up of hornblende biotite gneiss, biotite gneisses, micaceous and ferruginous quartzites with emplacement of ultrabasics like dunite, peridotite, pyroxenite, gabrro, and anorthosite. The soils of the higher elevations areas are lateritic in origin and are derived from charnockites known as Nilgiris gneiss. Climatic conditions favour intense chemical weathering of materials. White kaolin clay formed as a result of the decomposition of feldspars can be observed in many areas. The soils are at most times stained with black, marking the presence of ferromagnesian minerals. The soil is scattered with irregular oxidation stains giving it a deep red colour in some places, and yellow where the iron has been leached due to drainage.

Regarding fertility, the soils are generally deficient in plant nutrients and are acidic with pH values of 4.6 to 6.1. These soils contain a large percentage of alumina and iron, which restrict the availability of phosphates to plants. Even the most badly eroded soils have the capacity to recuperate by proper application of organic and inorganic manures and fertilizers. Nutrient content studies show that the soils are rich in nitrogen and potash and low in phosphorus. The depth of the topsoil varies from 0 to 45 cm, on an average and that of the sub soil from 3 to 4.5 m.

Occupation

Since the majority of the area is covered with forests the dependence of the people is based on forests. The area used to shelter a population of more than 20,000 cattle, the caring of these scrub cattle and the collection of cattle dung used to be the major occupation. This has been on the decline due to policy of governing a protected area. Cultivation is prominent in areas like Vazhaithottam with the lands around using water from the Sigur River. The construction of the Ooty Lake by the British was to provide perennial water along the Sigur River, but this water has been diverted to the Pykara Ultimate hydroelectric project. The waters of Pykara are used for generation at Singara and then at Moyar powerhouse, hence these waters are not allowed for irrigation.

C. Geology

Field Study of Geology: During the field visits in Sigur, the rock types predominantly seen were the hornblende-biotite gneisses (in all the villages of Bokkapuram, Vazhaithottam, Anakatti, Siriyur, etc). The only exception was Moyar where garnetiferous quartzo felspathic gneiss, micaceous quartzites (and charnockites, not as exposures) were seen. It seems that some of these like the charnockites and garnetiferous quartzo felspathic rocks may have been transported here.

Picture: Biotite hornblende gneiss - the most common rock type

Picture: Quartzite in Moyar

Literature Study of the Nilgiri Plateau: The geology of the area consists of charnockites of Nilgiri gneiss varying from acid to ultrabasic ones. The geology of the area consists of charnockites of Nilgiri gneiss varying from acid to ultra basic ones. The intermediate syenodiorites are the most common geological formations. The minerals present in the rock are blue quartz, plagioclase feldspar, hornblende, hypersthene, and secondary minerals such as garnet.

The origin of the Nilgiri plateau has long been a subject of detailed studies. Based on the geological structure and geomorphological evidence, a number of geologists have put forth different hypothesis for the origin of the Nilgiris plateau. The prevalent view is that the plateau has come in to existence due to uplift by block faulting. Blandford held the view that this is a relic feature carved out by erosional processes.

The Geological Survey of India carried out pioneering geological work in the Nilgiris district in the 1850s. According to Blanford, the Nilgiris plateau has been formed by three systems of faults along its peripheries. This is based on the prominent escarpments. East North east faults with down throw to the south east of the plateau, parallel to the Bhavani River and a corresponding escarpment north west of Nuvattamed with a down throw towards northwest from the first system of faults. The second system of faults trending northwest refers to the escarpment of Kundah facing Udhagamadalam and another near St. Katerine's Falls near Kotagiri. The third system comprises the northern boundary of the plateau and through short southern escarpment of Kundah.

According to Venkata Rao and Subramaniam (1979), a cyclic upward of the continental crust accounts for the high level deposition of the surface and elevation of co-existing erosional surfaces in the Nilgiris plateau. They consider that mega lineaments whose surface expressions are shears represent faults of Precambrian age along which the Nilgiri hills were uplifted as blocks. Auden (1971), postulates that many of the escarpments in Nilgiris are etched out by erosional processes.

The events of uplift have been timed for the cretaceous and Miocene periods. Blanford considers the upheaval of the Nilgiris in two stages. The first was in the Cretaceous time and the second after the deposition of Cretaceous rocks. Wadia has speculated that the Nilgiris rise synchronizes with the uplift of Ceylon in the tertiary period. The alluvial deposits in Pykara and adjoining valleys are at a fairly high level above the bed stream and denote the uplift of the alluvial formation. Stanford has suggested that these may represent alluvium formed prior to the uplift of the Nilgiris.

It is interesting to note that the higher elevation on the Nilgiris plateau is made up of charnockites while the plains are composed of gneisses, viz, hornblende biotite gneiss and garnetiferous quartzo felspathic gneiss. The rock knoll of 342 Sannakkal Mokkai is constituted of garnetiferous gabbro. Thus the difference in the topographic elevations has bearing on the nature of rock types present.

Landslides are a common occurrence due to the thickness of the weathered rocks and the presence of steep hill slopes. The rate of creep and erosion is pronounced at places along steep hill slopes, road sections and stream courses. To minimize the effect of erosion, the hill slopes are cut into terraces and large-scale plantation is being done. The banks of major streams are also protected by construction of masonry structures.

Lithology and Structure

The main Nilgiris massif is dominantly comprised of charnockites (the reason for the Nilgiri hills being called as Blue Mountain) interbanded with pyroxene granulites and garnetiferous quartzo felspathic gneiss. The relatively low country around the massif is made up of hornblende biotite gneiss, micaceous and ferruginous quartzites with emplacements of ultra basic like dunite, perodotite, pyroxenite, gabbro, dolerites and pegmatites. On the Nilgiri plateau there are a number of lateritic cappings, which are aluminous.

The lithological succession is as follows.

Quaternary	Soil and laterite
Secondary rocks	Magnesite
Intrusive igneous rocks	Amphibolites Pink felspathic granite Dunite Peridotite Garnetiferous gabbro
Metamorphic rocks	Garnetiferous quartzo felspathic gneiss Hornblende plagioclase gneiss Charnockite

The regional foliation trend of rocks varies from ENE-WSW to east west with steep dips varying from 60^{o} to vertical on either side, indicating synforms and antiforms.

A prominent lineament east-northeast is the one from Kundah to Moyar through Udaghamandalam over a distance of 48 kms. This lineament has flexure towards east- northeast. This has been offset by a north- northwest trending fracture in the southwest corner of the district along which the Bhavani River makes the initial flow for 10 kms.

Photo - Joints patterns in Siriyur

1. NNE-SSW
2. NNW-SSE
3. East west
4. South – southwest

The strikes of the joints are towards north – northeast, south southwest, north northwest and east west respectively with steep dips. The first three joints sets are more prominent. The spacing of the joints varies with the degree of shattering or disturbance, which the rock has undergone locally or regionally. The role of joints in promoting rockslides is well known but in the Nilgiris most of the slides are debris slides. It must be noted that all the prominent escarpments are developed along one or more of the three main joint directions.

D. Water

It is important to understand the major watersheds in the area because as in the case of the Sigur plateau, these impact the availability of water in the lower areas.

Watershed: The four major watersheds in the Nilgiris district are

No	Watershed	Area in ha
1	The Bhavani Major watershed corresponding to the Bhavani River Basin	74,800
2	The Moyar Major watershed corresponding to the Moyar River Basin	77,500
3	The Kabini Major watershed corresponding to the Kabini River Basin	47,200
4	The Chaliar Major watershed corresponding to the Chaliar River Basin	52,200

Water Balance and Climatic classification

The rock base throughout the Nilgiris is fairly homogenous and impermeable and this is reflected in the uniform drainage density. However, the spatial and temporal differences of the stream flow, or run off, are considerable. The absence of aquifers, such as sandstone or calcareous formations, and the runoff mainly represents that of 'surface' and 'base runoff' of water that has infiltrated the soil and is released after a more or less extensive time lag, depending on the slope and water retention capacity of the soil. Deep percolation and groundwater runoff must be considered negligible in the Nilgiris. Therefore, annual runoff amounts and runoff regimens are highly correlated with annual rainfall and rainfall patterns.

Hydrological data from the Mysore plateau below the Sigur plateau indicate that average runoff /rainfall ratios may even drop to 15% and individual figures suggest that in some years these areas do not contribute to the stream flow of the Moyar at all. In other words, there is evaporation loss from both local precipitation and water consumed by the gallery forests and bamboo thickets along the banks of several perennial streams descending from the upper Nilgiris.

Block	Groundwater gross recharge HEC	Utilisable recharge HEC	Net draft HEC	Balance Groundwater
Connoor	2395	2036	12	2024
Gudalur	2775	2359	3	2356
Kotagiri	-	-	-	-
Udhagamandalam	4596	3908	27	3831
Total	9768	8303	42	8261

Study of Water Sources and Conservation Structures - Impressions from the Field

During the field visits, wells, borewells, springs and check dams were studied to understand the hydrological and hydro-geological situation and to look at opportunities for designing strategies and activities for a sustainable water management programme. The four water sourcing and / or conservation systems are:

a. Springs
b. Dug Wells
c. Borewells
d. Check dams

a. Springs

The availability of springs within the Sigur Plateau, in comparison, with the other hilly tracts of the Nilgiris is relatively low. During the field visit in the month of February, 2006 (after an unusually high 2005 rainy season), only two surface springs were seen. Technically, many more are present, as a spring is defined as "water emanating at the soil / rock surface. Where the expression of the water table is above the rock or soil surface, a spring can form and these could be perennial or temporal. The evidence indicates that the springs at Anakatti are perennial and dependable low flow springs

Picture: Spring emerging from soil at Anakatti

Picture: Spring emerging from rock at Anakatti

b. Wells

Three wells in the villages of Vazhaithottam, Chemminatham, and Moyar were studied to understand well characteristics like dimensions, yield, water table data, and geology from exposures. The wells sections indicate that the soil thickness (depth to rock) and intensity of fracturing show considerable variation in the Sigur Plateau. This also means that the opportunities for source development as well as water conservation work, which essentially depend on the former, also differ even within small distances.

1. Kishore well at Vazhaithottam: The property has on its western boundary canal 1 m deep and 0.75m wide, which functions as a 'run of the river' providing irrigation water at the upper western part of the Kishore property till December or January every year. The well is on the eastern boundary and further to the east is the Sigur River, which is perennial. The well is 7.5 m by 7.5 m and around 5 m deep. The water level in the well is around 3 m above the stream level. The water level is, now 2.2 m below the top edge of the well.

A cabbage crop with high pesticide use was observed. The rampant use of Endosulfan, Rogar, and DDT- pesticides, which are prohibited in agriculture, is observed. DDT is sold on the sly in Ooty. Larger farmers also practice high fertilizer dosage use.

The person in charge told us there is 4 ft of mud at the bottom which make the water only 3 ft or so. The pumping is done for 4 hrs only now at around 5000 LPH with a 5Hp electric motor and centrifugal pump. The lift is around 40 ft. to irrigate for cabbage. 20klpd. Earlier, cabbage was grown on all 10 acres and the pump worked for 24 hrs a day. Electricity is given free by the TNEB.

Present Water Use
Daily pumping - The well is pumped for 4 hours at 5 klph to a total daily use of 20klpd. The well dimensions of 7 m x 6 m x 1 m = 42 klpd available. Half the water in the well is being pumped daily. In earlier days they used to pump 24 hrs x 5 klph = 120 klpd. This volume of water is not available now. The well needs maintenance including cleaning, desilting, and side protection. This well offers scope for development as a recharge well. Among the risks to this well are new borewells coming up in the vicinity.

2. Dug Well at Chemminatham: The well is around 15 m long, 6 m wide and 12 m deep. Currently the well is totally dry and there is evidence of partial collapse into the well. The well has a volume of around 1000 m3, which is a million litres of storage. From the viewpoint of recharge, this well could prove to be invaluable and will contribute significantly to the rejuvenation of springs in Chemminatham.

The well needs repair, and can function as an effective recharge well by adding a collection, filtration and filling system, which will allow water to flow into the well without damaging the sides. The well also will need the sides to be raised to prevent runoff form entering the well directly. Desilting, side protection and a regular maintenance schedule will ensure that this well could be of great value to the Chemminatham community. The risks that the well could face are new borewells coming up in the locality (since it was reported that influential people are still able to drill borewells due to local corruption). It is recommended that after the completion of works and recharging of the water table, a study be undertaken of the pumping rates, recovery rate of the water table, time and depth, etc.

3. Dug Well at Moyar (Obalinga): The Obalinga well is a 6 m by 6m and 10 m deep well. This well has a borewell placed adjacent (belonging to the same person) at a distance of around 12 m. The well water has been impacted by the borewell. The borewell is also low yielding. The well has not been maintained and the debris of the earlier walls has partially fallen inside the well. The inside of the well exhibits good joints patterns and joint spacing. This can be used as a good recharge well during the rainy season. The well has joints patterns in both horizontal and vertical. The borewell is a low yield well using a 5 HP Air compressor and the yield is around 2klph. The BW is near the well and water level in the well goes down on BW pumping, indicating the connection. Water is also brought to this property from near Moyar village where a borewell yielding more water is in use and probably has a direct recharge from the small Moyar reservoir.

c. Borewells

Though borewells are officially banned, there are reports of borewells being dug on the sly. The borewells seen are the ones in Vazhaithottam on King's Range (a borewell with low output – 2 hP pump 1000 lph), Obalinga Farms (which has three and only one yielding with low yield) There are other borewells in the different Wildlife Tourist Resorts but all are reportedly low yielding, reflecting the nature of the secondary low porosity.

d. Checkdams

Checkdams were constructed in the early nineties to assist local communities and wildlife avail of water during the difficult summer season. The alteration of river courses and changes of vegetation on the slopes starting in the British days and continuing today from endogenous to exotics have had significant impacts on water availability in the lower reaches, the most prominent of which is the Sigur.

Checkdams proved to be of help probably for a few years until the sides were breached or the checkdams themselves were broken by the force of water, which speaks volumes for both design and execution of such projects at the hands of various agencies. Only one checkdam was seen which was still 'whole' at Bokkapuram and the ones at Siriyur, Manavala and probably others constructed along river courses at the foothills where the Sigur shares a boundary with the massifs were all seen to be in stage of damage and disrepair. Even the Bokkapuram checkdam has gaping holes, which will eventually lead to the collapse of the checkdam. The following pictures are of some of these checkdams.

CHECKDAMS

Picture: The checkdam at Manvala showing severe side cutting due to improper design of spill way and inadequate side protection.

Picture: The checkdam at Siriyur damaged – probably the volume of water flow was not considered. The spillway is intact, but one side has collapsed totally

Picture: The checkdam at Bokkapuram – gaping holes, which will lead to its future? collapse.
"A stitch in time"…..

E. Interpretation

Interpretation from yields of dug wells and borewells

It can be concluded that the four areas of Siriyur, Bokkapuram, Chemminatham and Moyar relatively offer the maximum scope for groundwater development. The open wells where linked to recharge systems like stream flows, and well-developed fractures or joints as seen in Siriyur and Moyar are quite dependable sources of good quality water as long as the water bearing horizons are not subjected to excessive exploitation, especially for irrigation, etc. Where borewells have come up in the vicinity of these wells, the likelihood of the well drying up is very high, and examples can be seen in places like Chemminatham.

The muscovite quartzites in Moyar probably offer good scope for groundwater development but further local studies using geophysical studies like 'Resistivity' interpretation can provide conclusive directions. The flat area in Bokkapuram, which is the wildlife 'drinking water' area with no rock exposures, is another area offering promise; however, this falls in the Reserved Forest area and probably will not qualify for further investigation or development without the concurrence of the Forest Department.. The foothills of Siriyur also offer ample scope for development of water resources.

F. Conclusions

1. Rainfall and water availability in the plateau – The distinct difference in rainfall in the eastern and western parts of the Sigur plateau also determine the availability for use. The western part, which receives one meter, will also have to contend with higher rates of topsoil erosion. The eastern part, which receives only half a meter of rainfall, has low water availability and increased surface storage has to become a critical part of the water management strategy.

2. The groundwater aquifers in the Sigur plateau are small in extent and the expressions of geology at the surface and structural disturbances indicate only a few that offer scope for development. The most promising areas are Siriyur, Bokkapuram, Anakatti, Chemminatham, Moyar, and Vazhaithottam. It is interesting to note most of these are also already the village settlement areas and the tribal communities must have selected them for historical reasons largely related to water availability in the form of perennial springs or stream flow.

3. Currently, the irrigation practices are largely surface based and thus wasteful considering the high evaporation rates involved in the likes of flood and sprinkler irrigation.

4. The wasteful use of water is also seen in cultivation of lawns with exotic high water consumption grass varieties. If lawns are needed at all, then use of local 'conservative water use' varieties must be encouraged.

5. Soil and moisture conservation practices are extremely poor and will need good focus if water is to be retained on the cultivated slopes, even though the fields are quite low slope areas with slope of between 5 to 15^{o} maximum generally.

6. There seems to be wastewater management practice. Sewage and sullage flow out and join the streams from the towns and the situation is exacerbated during the rainy season.

G. Recommendations

1. Conjunctive use of Water – It is imperative that conjunctive water use – the use of both surface and groundwater is introduced. The use of surface water in the rainy season and till the check dams have water in them will provide for the conservation of groundwater till all surface sources are finished. Groundwater sources must be tapped only during the dry months and the focus must be on conservative use. As much as possible, it is advised that tapping of deep aquifer must be avoided so as to prevent the lowering of the water table, especially in areas where the soil cover is thicker. This will also help wildlife to access surface water resources during the summer months, which will also help in reducing situations of human – wildlife conflict.

2. Preparation of Water table Contour Map: A water table contour map indicating soil depth, the water table at different locations and groundwater flow directions could be prepared to help plan water conservation work and improve water management practice.

3. Controlled Use of groundwater for Irrigation - Since groundwater is and will continue to be scarce in most parts of Sigur, it is recommended that groundwater use is kept low to prevent depletion of the limited groundwater aquifers and the resultant consequence on both wildlife and vegetation. The government ban on borewell drilling in the Sigur plateau is a step in the right direction and public awareness and participation must be sought to this end.

4. Increasing water use efficiency – Both Farming and domestic use of freshwater offer scope for increased use efficiency. Keystone could identify all the leakage sources of freshwater such as wasteful surface irrigation (high evaporation loss), etc, and prepare awareness material to disseminate such knowledge among the communities in Sigur.

5. Rainwater Harvesting – Rainwater harvesting for both use and storage during the rainy season must be encouraged and (probably enforced) for all commercial institutions and encouraged in all private dwellings. . Design and use appropriate rainwater harvesting and recharge mechanism in the villages.

6. Tree Planting and management - Increase the planting of endogenous dicots and leguminous variety tree planting, especially along farm contour bunds and high runoff points. Village communities could be encouraged to plant a broad variety of trees as woodlots to meet their fuel wood requirements.

7. Groundwater Recharge – The recharge of water through borewells and dug wells must be taken up with proper designs to avoid both clogging by fine particles and contamination by polluted water.

8. Repair of Check dams – The design of all the check dams built at Siriyur, Bokkapuram, Manavalla, Bokkapuram and others must be reworked and then rebuilt considering both retaining strength and holding volume. The design must incorporate mechanisms for introduction of slats to increase retention and recharge of the phreatic zone during the end of the rainy season. This will increase overall water availability.

9. Greywater Recycling – The greywater component of domestic wastewater can be recycled for irrigating plants and trees around the homes, thereby reducing freshwater use for such purposes.

10. Organic Farming and Improving Moisture Holding – . The soils have low humus content in many places, which has a negative impact on the moisture holding of soils. Promote the increased use and recycling of organic materials including farmyard manure and cowdung in the villages to improve moisture-holding capacity of soils. Deep trenching along contours at specific locations over defined periods of time (3 to 5 years) and refilling with plant debris and soils help build an absorbent soil layer as the material sinks. The bunding of fields also essential. Planting of leguminous trees along contour bunds suggested.

11. Early Warning System for Drought – Introduce an early warning system based on study of rainfall patterns, water table in wells, borewells yields and stream flow monitoring for regulating / reducing water use in difficult years.

12. Improving drinking and domestic water quality - Introduce simple filtration systems to remove particulate matter and leminscate flow forms at end use points for tribal communities to improve stored water quality and acceptability for domestic use in difficult summer months especially during prolonged drought situations.

13. Water Quality Testing – Periodic water quality testing for both chemical and biological parameters is important and will provide information links to the morbidity and mortality of both people and animals. The use of agricultural chemicals, especially for control of pests, is dangerous and the testing of surface and groundwater for organic chlorides and organic phosphates will provide clues to the kind of action to be taken on ground. Water from the coffee estates runoff must also be tested to build a pollution map.

14. Hygiene and Sanitation – Create awareness about hygiene and sanitation and start work towards the introduction of sanitary toilets (twin pit, etc) to reduce / prevent open defecation and contamination of water sources.

15. Spring Development – There is scope for development of the freshwater springs in places like Anakatti and proper and separate enclosure for drinking and water collection points for people and animals can be designed and built cost effectively.

16. Grey water Treatment in Towns – Towns like Masinagudi also release their wastewaters, especially in the rainy season into the local rivers and streams. The introduction of appropriate designs to increase separation of particulate matter and to increase turbulence will help in improving water quality before final release.

17. Reduce the use of chemical fertilizers and pesticides: The considerably extensive use of agricultural chemicals, both permitted and banned, has contributed to significant levels of chemical pollution of the surface ad groundwater. Awareness building and providing alternatives and a focus on making Sigur 'organic' could be part of the strategy of both NGOS, the Forest department, Agricultural department and communities to create better environmental conditions for both people and animals, including wildlife.

Detailed Recommendations

1. The check dams at Siriyur, Bokkapuram, Manavalla, to be redesigned and rebuilt to store water and enhance surface recharge.

2. Prepare a complete well inventory with all specifications of diameter, depth, water table during rainy season and summer, yield, etc. The wells could also be converted to serve as recharge wells. Locations are at Chemmanatham, Moyar (Obalinga Farm), Kishore Farm at Vazhaithottam towards end of rainy season.

3. Design an organic development plan for the farm areas of Sigur and make provisions for the related works of soil and moisture conservation, soil fertility building, and pest and disease control.

Annex 4: Soil and Moisture Conservation Work

A. Farm land

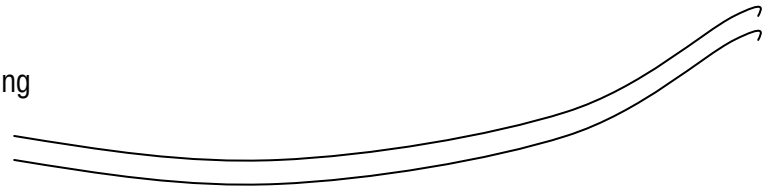
In agricultural land in Vazhaithottam, Chemmanatham, Anakatti, Moyar, Bokkapuram

Purpose: To control soil erosion and increase moisture infiltration

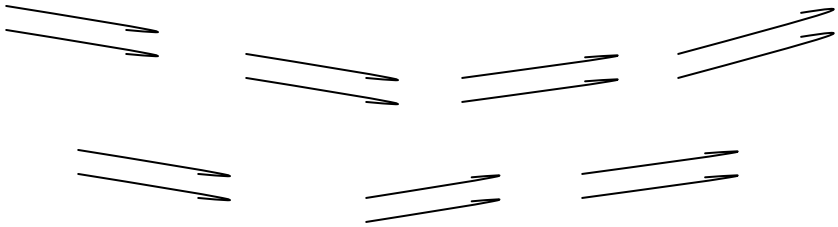
Works: Bunding – earthen, vegetative

Sloping lands – contour trenching, staggered trenching see diagram
Planting on trench bunds

Contour trenching



Staggered trenching – excess flow from one contour gap gets trapped on next level



The planting of trees or bushy plants will be useful in increasing humus, which in turn will increase moisture holding in soils.

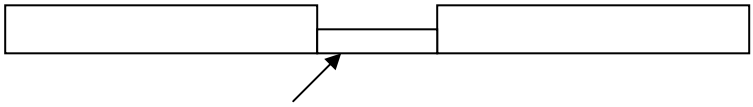
B. Along river courses

Works: Checkdams and subsurface dykes

Checkdams basic repair and complete to new design considering flow rate, weight of water column and adequacy of spillway
Provision for end of rains additional wooden slat to increase storage

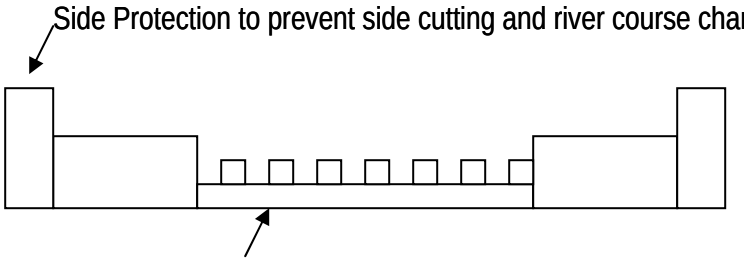
Surface dykes with 0.5 m above river base level to reduce load on checkdam – to be built before check dam to increase infiltration and reduce sedimentation load on check dam.

Present Design of Checkdam



Spillway inadequate

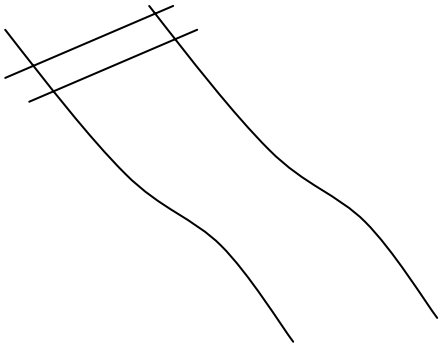
New Design of Checkdam



Wider Spillway with provision for end of season storage increase with wooden slats

Subsurface dykes

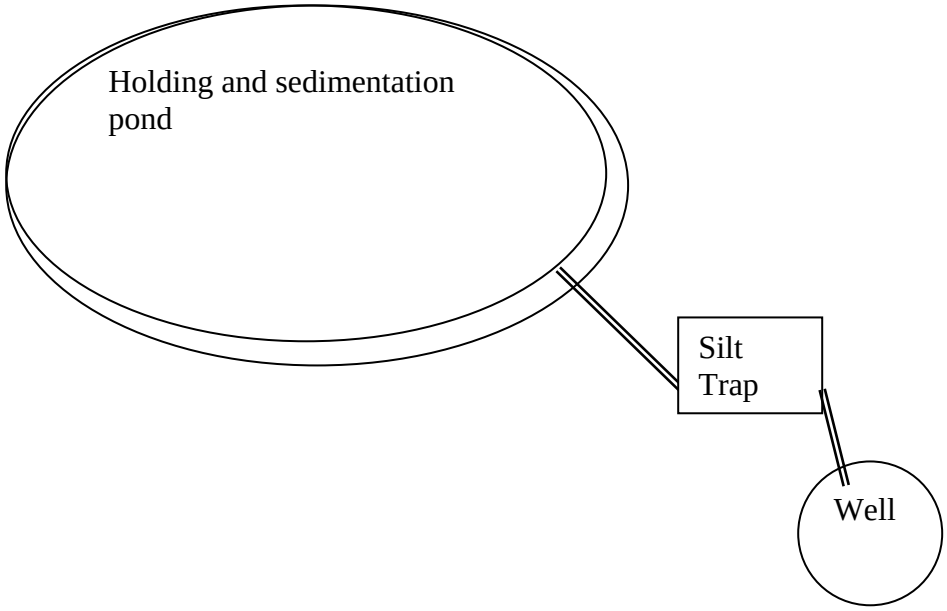
Along longer stretches at the beginning, will reduce silt load on Checkdam, provide additional storage and increase in filtration



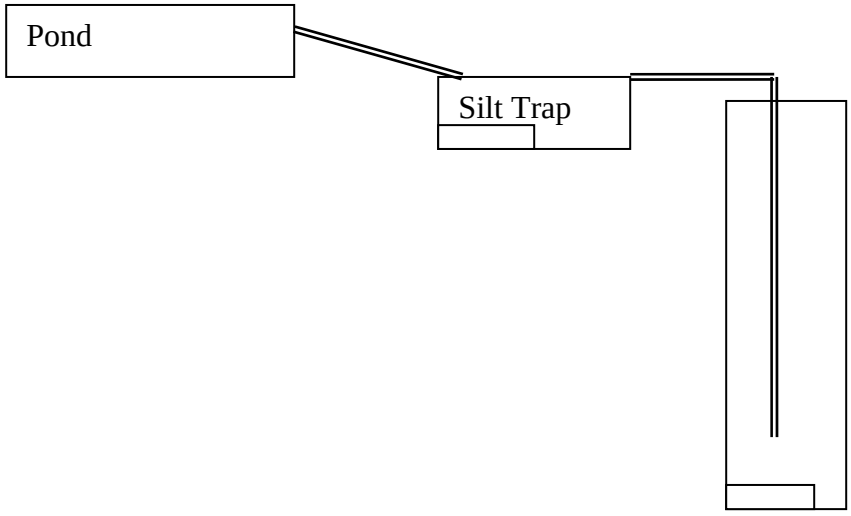
C. Recharge system for dug well

Include silt trap, sedimentation pond with earthen bund, piping, earthen bund around well, side protection to prevent collapse.

Plan



Section



Note: Baffles of granite slabs are to be placed to break the force of water at all reception point and prevent churning.

Annex 1 - The Water Resources Study Assignment - Terms of Reference of a Hydro-Geologist

1. To prepare a Water Resources Audit report for the hydro-geological features of the Sigur Plateau with specific reference to water resources – ability for conservation, geological features available which would support retention, percolation and recharge.
2. Detailed maps would be drawn of the Sigur Plateau highlighting the geological conditions prevalent.
3. Field visits to villages will be undertaken to specifically investigate the water situation vis a vis hydro-geological conditions and opportunities.
4. The report will consist of a resource analysis – causative factors of water crisis, typical patterns if any, and future scenarios under different management options, the conditions and variability across seasons and past trends. Data would be generated in this, which would identify freshwater budgets in hill areas (Sigur plateau), which are typically source zones. A menu of options would be available after the audit on "what to do & where by whom".
5. All available data will be given to the Consultant. Keystone Field Team from Sigur will assist the Consultant during fieldworkzxc.
6. Consultant shall complete all work and give the final report to Keystone Foundation in 10 days time. He shall be paid a professional fee after receiving the final report of Rs. 3500 per day X 10 days = Rs. 35,000. All other expenses of travel, boarding and lodging will be paid by the Organization. All tax liabilities will be borne by the Consultant.

The assignment will be completed before end of March 31st, 2006. The Consultant has to be based in the Field Station at Vazhaithottam in the Sigur plateau where the office cum residence is situated.

Annex 2: Initial discussion with Pratim and Senthil on 25 2 06 at Vazhaithottam Keystone office

Discussion, 25 Feb 2006
Pratim, Senthil, Ashok

- Maps of Sigur with boundaries of study area
- List of villages and Key areas
- Toposheet - location and study of contours and prospects for watershed development.
- Geology, Depth to bedrock, Outcrops patterns, Fracturing patterns, surface expressions and implications
- Scope for surface and groundwater development
- Water survey
- Points missing – water availability and quality qualitative data
- Qualitative data on fresh water sources
- Scope for Grey water management and recycling
- Vegetation – hillsides
- Springs, seeps, streams, lakes, swamps, wetlands

Annex 3: Notes on Field Visit and Discussions, 24 Feb to 28 Feb, 2006

Day 1 - 24 Feb 06, Friday

Traveled from Kengeri, Bangalore to Mysore by bus. From Mysore by taxi picked up by Puneet and drive to Vazhaithottam where Keystone has a field office. Received documents and maps. Stay arranged at King's Range. Reading documents and one visit to Sigur river and bridge area to look at geology and stream flow.

Day 2 - 25 Feb 06, Saturday

Visit to Kishore Farm. Sigur

On western boundary a canal 3 ft deep and 2.5 ft wide, run of river for the stream gives water in Dec and Jan.

On the eastern boundary there is a well west of the above the stream. The water level in the well is around 10 ft above the stream level. Need to Prepare Water table contour map.

The well is 25 ft by 20 ft and 15 ft deep. The water level is, now at 8 ft below the top edge of the well.

A cabbage crop with high pesticide use observed. The rampant use of Endosulfan, Rogar, and DDT-pesticides, prohibited in agriculture is seen. DDT is sold on the sly in Ooty. Larger farmers also use fertilizers.

The person inc charge told us there is 4 ft of mud at the bottom which make the water only 3 ft or so. The pumping is done for 4 hrs only now at around 5000 LPH with a 5Hp electric motor and centrifugal pump. The lift is around 40 ft. to irrigate for cabbage. 20klpd.. Earlier they used to grow cabbage on all 10 acres and pump for 24 hrs a day. Electricity is given free by the TNEB.

The well water - 4 hrs pumping at 5 klph – 20klpd
Well dimensions - 25 x 20 x 3 = 7 x 6 x 1 = 42 klpd available. Pumping half.

Earlier they used to pump – 24 hrs x 5 klph = 120 klpd.
The stream flow in this month is = check
Width of stream, depth at centre and sides, speed of flow.
2005 rainfall good
get all rainfall data
well data and well inventories to be made
1000 to 1200 - Read the Report on Water and Livelihoods of Keystone, well done doc
1200 to 1430 – discussions with Pratim and Senthil in the Keystone office, collection of maps from computer, lunch

Gist of discussions

Keystone wants a broad picture of geology and how geology could help in water conservation and use.
Scope for development of water resources and sustainable management of water and natural resources
1500 to 1600 – rest and reading
1600 to 1815
Visit to Manavalla with Senthil – studied rock outcrops and exposure on road sides, joint pattern lithology – banded biotite gneisses, predominant joint N10E S10W, 70 deg west, 0.5 m to 1 m and more spacing in different exposures.

Visit to Chemmanatham – saw well 40 ft deep. 50 ft long and 25 ft wide. First 12 ft built up due to collapse, second 15 ft hard soil and last 13 ft weathered rock. No water. Collapsed soil in well and scrub growth almost all around.
Visit to river, rock exposure follow same trend of joint pattern N10 E, vertical joints, The banding is east west.

Most places observed shallow soils of 2 to 3 ft in most and few exceptions of 10 to 30 ft deep soils near valley parts.
Many rock outcrops of gneiss all along; soil is only a thin veneer.

The joints are anywhere between hairline crack to around a mm wide and have a spacing of 0.5 m, seen in one area on the road between Manavala and Vazhaithottam. The indications are low yielding borewells. The water table is practically non-existent during summers.

The vegetation is largely scrub except along the watercourses where it is riparian.

Soil and moisture conservation practice extremely poor and will need good focus if water is to be retained on the cultivated slopes, even though these are quite low slope areas with slope of between 5 to 15 degrees max generally.

First Glance
Measures to improve water holding in soils in the Sigur plateau

Organic cultivation return of all organic matte including dung , etc, to soils FYM, deep trenching along contours and fills in plant debris and top fill soils build the layer as the material sinks. Bunding of fields also essential. Planting of leguminous trees along contour bunds required.

Perennial pigeon pea- thogari on bunds also useful.

More focus on tree crops,

Mulching practices

Reduce potato and cabbage. The first for soil loss problems and the latter for chemical pesticide use.

Removal of cowdung to estates and sale to Kerala across the border must be stopped. The consequences of nutrient loss are much too great.

Use of chemical fertilizers also consumes humus, compacts soils, decreases moisture holding capacity of soils. This must be reduced systematically and a return to organic agriculture must begin if the water situation has to improve.

Day 3 - 26 Feb 06, Sunday

Visit to Anakatti
Irula tribals and Jenukurubas
Artemesia cultivation with support from HOPE Foundation, Ooty
Irrigated by stream water
Photos of springs
Photo bush beans photo silk cotton tree
Man's house – Irula tribal
Calculate water outflow for each of the hallas rivers- Sigur
Will be useful to show how much water comes in.
See topo sheet A15, A11 of 58 make Xerox
Sigur – 45000 ha
Forest – 35000
Agri settle – 10000 ha
Total rainfall
400 mm
E-W 90 cm x N-S 25 cms
45 kms x 12.5 km =562 sqkm x 100 ha = 56200 ha
56200 x .4 = 22480 ham = 22480,000 cum = 22,480,000,000 lts
approx
10,000 pop

per capita availability – 2,248,000 lpy
100 lpd x 365 = 36500 lpy
per ha = 100 x 100 m x 0.4 = 4000 m3 = 4 million lts.
Per Sqm – 400 ltpy

Kishore farm – no Soil & moisture conservation
A new perspective for water management in Sigur villages
Checkdam, farm pond
Lakes, lined
Soil and moisture conservation -- trenching, bunding contour trees lines
Also add water coming from hills
Visit to Siriyur
Saw temple and river, joint patterns
34 houses – 8 Jenukurba families
Rich riparian vegetation along river course
Siriyur ammani temple
Photo 6 to 11

Fractured rocks are exposed on eastern side of temple next to river course, Sirur halla
Also horizontal fractures
Collapsed check dam poor design – needs to be reworked

Afternoon 330 PM by bike to Bokkapuram
Senthil and I went to Bokkapuram to study the geology and watercourse, check dam in the forest. Geology quite similar to the rest of the plateau. Gneisses

On the way from Bokkapuram to the point before Masingudi, there is a seasonal wetland type of area, where wild animals drink water during the rainy season. This and some adjacent areas are devoid of rock outcrops, which could possibly indicate that there was some structural disturbance. This could be a potential area for water sourcing except for the fact that this falls in the reserve forest area. The soils are very clayey and the drying cracks are already 9 inches deep. The clay is quite blackish indicative ferromagnesian origin and higher adsorbed humic matter.

Day 4 - 27 Feb 06, Monday

Visit to Falls of Sigur River near the Moyar Gorge.
Gneisses common
At the junction where the road turns off to the village, there is an outcrop of quartzites, which show promise for ground water. Adjacent there are also pieces of orthoclase and muscovite, which indicate possible pegmatite in the vicinity.

This village is one of the Keystone villages and has irrigation with power form solar panels of 1.8KW with water from the Avanahall stream, which is seepage water from the channel to Moyar. The well in the Obalinga Farms seen, with joints patterns - both horizontal and vertical. Low yield well of 5 HP Air compressor around 2klph. The BW is near the well and water level in the well goes down on BW pumping, indicating the connection.

The next visit was to Singara, which has a hydro electric power station. The water from the upper areas is being brought to Singara and after power generation, taken through a new watercourse passing near Masinagudi. This supplies water to Masingudi. Saw jeep drivers and others washing their vehicles in the watercourse, which should not be allowed. This water is then impounded beyond Masinagudi and then taken for power generation near the Moyar through a lined channel alongside the road to Moyar village.

Keystone' s Future Water Agenda in Sigur

1. Build complete well inventory for Sigur Plateau – with dimensions, etc see checklist of info needs. This database will help in planning water use, conservation, etc
2. Length, width, depth of well, depth to water,
3. Availability of water rainy season, summer, etc, volumes available
4. Drawdown on pumping, replenishment rate
5. Maintenance

Same exercise for bws

Village population and use survey – AK will use information to calculate water needs for domestic and for agri if done

Annex 4: Time Map – Field Study Sigur – Keystone Foundation, February 24 to 28, 2006

Date	Time	Activity – CAK	Remarks
24-2-06 Friday	0630 to 0830 0830 to 1130 1130 to 1330 1430 to 1900	BY bus to Mysore Drive by taxi to Sigur Reference documents, visit to Sigur river Document and map study	1 day 1
25-2-06 Saturday	0700 to 0900 0930 to 1400 1430 to 1800	Preparation and document Meeting Pratim, Senthil, maps, discussions, lunch With Senthil to Manavala, Chemminatham	1 day 2
26-2-06 Sunday	0700 to 1200 1400 to 1700 1800 to 2100	Visit to Anakatti, Siriyur Visit to Bokkapuram Notes	1 day 3
27-2-06 Monday	0700 to 1300	Visit Moyar, Obalinga Farm, Singara	1 day 4
28-2-06 Tuesday	0700 to 0930 1000 to 1600 1600 to 0600	Drive to Kotagiri Discussions, reference documents, Drive to Ooty and bus 1030 PM to Bangalore	1 day 5
		Total	5 days

1-3-06 Wednesday	0900 to 1800	Analysis and contents for report	1 day 1
2-3-06 Thursday	0500 to 1800	Report writing	1 day 2
3-3-06 Friday	0700 to 1900	Report writing, rough maps	1 day 3
7-4-06	0800 to 2200	Report writing	1 day 4
8-4-06	0700 to 1700	Report writing edit final	1 day 5
11-4-06 Tuesday	0700 to 1700	Final drawings, maps	1 day 6

Annex 5: List of Photographs

Roll 1

1	Musical instrument
2	Musical instrument
3	Langurs near Singara
4	Jeeps being washed in the stream supplying drinking water to Masinagudi
5	Obalinga Farm in Moyar – sprinkler irrigation
6	Water storage unit with plastic sheeting – water pumped with solar energy to this
7	The end of Sigur River and the beginning of the Moyar Gorge
8	The Sigur Falls
9	The Sigur falls
10	The scrub forest near Moyar
11	An ancient burial mound in Moyar
12	Quartzites in Moyar near the village
13	The diversion channel going to Moyar
14	Deer enroute to Moyar
15	Wild boar enroute to Moyar
16	Dead civet cat killed by a speeding vehicle
17	Scrub jungle near Moyar
18	Scrub jungle near Moyar
19	Scrub jungle near Moyar
20	Flame of the Forest tree – Palash near Bokkapuram
21	Damaged check dam at Bokkapuram
22	Small diversion channels in Bokkapuram
23	Damaged Check dam at Bokkapuram
24	Flame of the Forest tree – Palash near Bokkapuram
25	View of forests at foothills of Bokkapuram
26	Mud cracks in watering point near Bokkapuram
27	Watering point near Bokkapuram
28	Damaged check dam at Siriyur
29	Fractured rock near check dam at Siriyur
30	Wild flower near Siriyur check dam area fractured rocks
31	Fractured rock in Siriyur
32	Fractured rock in Siriyur
33	Stream at Siriyur with check dam in background
34	Ancient wild mango tree in bloom
35	Riparian vegetation in Siriyur
36	Siriyur ammani temple
37	The jenukuruba homes
38	Part of temple

Roll 2

1	Rock exposure – biotite gneiss in Anakatti
2	Silk cotton tree in Anakatti – most appropriate
3	Artemesia crop with help from the HOPE Foundation
4	Honey box bamboo in Anakatti
5	Water spring out of rock fractures, Anakatti
6	Collection pond for spring water, Anakatti
7	Spring in soil at Anakatti
8	Artemesia in Anakatti
9	Riparian vegetation along stream course before Anakatti
10	Riparian vegetation along stream course before Anakatti
11	Riparian vegetation along stream course before Anakatti
12	Rock exposures in stream
13	Biotite gneiss in Anakatti
14	Biotite gneiss in Anakatti
15	A ficus tree growing on a fractured rock exposure
16	Rock exposure in stream at Chemminatham
17	Damaged check dam at Manavalla
18	Damaged check dam at Manavalla
19	Vazhaithottam setting sun

References:

1. District Gazetteer, Nilgiris, 1981
2. The Keystone Swallows Water Project Proposal
3. The Nilgiri Biosphere Reserve – A review of Conservation Status with recommendations for a Holistic Approach to Management, India – Daniels, Ranjit R.J. Working paper Nº 16, 1996.
4. TWAD Sigur Board Water data (22-3-2005)
5. Ashok's Field Notes
6. Topo sheets