Environmental Management Plan for the India-Based Neutrino Observatory Project at Singara and Masinagudi (Nilgiris) Tamil Nadu

Report submitted to

THE INSTITUTE OF MATHEMATICAL SCIENCES
Chennai

CARE EARTH
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Environmental Management Plan for the Proposed India-Based Neutrino Observatory Project at Singara and Masinagudi (Nilgiris) Tamil Nadu

Report Submitted to

The Institute of Mathematical Sciences (IMSc)
Chennai

By

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Preface

A one-day brainstorming workshop was held at the Institute of Mathematical Sciences (Chennai) on August 20, 2007 to discuss the scope of implementing the India-based Neutrino Observatory (INO) Project within the Nilgiri Biosphere Reserve in Tamil Nadu. Ecologists, wildlife biologists and members of the INO Project team participated in the workshop wherein the likely environmental impacts of the Project and the intrinsic and extrinsic hurdles that would hamper the implementation of the project were reviewed.

Basic information about the nature of the Project and the potential environmental impacts was made available to the participants in the form of two documents; *India-Based Neutrino Observatory* (INO Project Report, INO/2006/01) and the *Rapid Environmental Impact Assessment of the India-based Neutrino Observatory Project, Singara, Nilgiris, Tamil Nadu* (Report submitted to the Institute of Mathematical Sciences, Chennai by Salim Ali Centre for Ornithology and Natural History (SACON), Coimbatore, 2007). Subsequently, the Institute of Mathematical Sciences (Chennai) sanctioned a four-month study to Care Earth, Chennai on September 27, 2007 vide their letter No. IMSC/F&A/INO/2006/2140. The scope of the study was to prepare the Environment Management Plan for the first phase of the project adopting the following 4 steps:

1. Reviewing pertinent literature on the environment, socio-ecology and biodiversity of the Singara-Masinagudi landscape
2. Collating and reviewing available information on the impact of the PUSHEP in the Singara-Masinagudi landscape
3. Identifying major gaps in knowledge of the possible impacts of development projects in general and INO in particular on the ecology and wildlife and socio-economics of the Singara-Masinagudi landscape and
4. Analysing the above data/information and developing short-term and long-term management measures for the Singara-Masinagudi landscape with specific focus on the movement of elephants and other wildlife.

Standard Environmental Impact Assessment (EIA) procedures include a practical assessment, an Environmental Impact Statement (EIS) and an Environmental Management Plan (EMP). Whereas the EIA Report that was submitted by SACON was comprehensive in the assessment, the EIS and EMP were rather weak; EMP being the weakest. The present study therefore focused on strengthening the EIS and preparing a more explicit and comprehensive EMP. The study also took into account the perceptions of the different interest groups such as the local residents and their elected institutions, environmental activists,

environmental NGOs, wildlife biologists other than those who were a part of the study team, representatives of the Tamil Nadu Electricity Board (TNEB) Tamil Nadu Forest Department and other government departments. Further, the study assessed the feasibility of relocating the INO Project elsewhere within Tamil Nadu by visiting possible alternate sites in the Western Ghats.

The results of the 4-month study are presented in the current report. For the sake of easy reference and use, the contents have been presented as an Executive Summary followed by seven detailed and inclusive parts:

Part I: Introduction (overview, about the INO Project)
Part II: The Landscape (Biodiversity and its conservation significance in and around the location of the Project)
Part III: Impact of Hydroelectric Projects on the Landscape (The seventy-five year history of habitat alteration and infrastructure development in the landscape)
Part IV: Anticipated Environmental Impacts of the INO Project (Both scientific and people's perceptions)
Part V: Alternate Sites and Landscapes (For the sake of preparedness in the event circumstances forbid the INO Project in the proposed location)
Part VI: Environmental Management Plan (The detailed EMP and recommended actions specifically focussing on the Singara-Masinagudi landscape)
Part VII: Annexure (Photos of alternate sites, modules for monitoring impacts, outcome of meetings, sources of Information)

The INO Project is proposed to be located within one of the most significant conservation areas in the world. Besides being home to not less than 5000 elephants, the flagship of the region, the Nilgiri Biosphere Reserve also harbors 60-75% of the 415 tigers that survive in the states of Karnataka, Tamil Nadu and Kerala; 20% of which occur in Mudumalai WLS. There are numerous other species of endemic and endangered plants and animals in the Reserve.

In the context of the ecological signficance of the Biosphere Reserve, there is little justification as to why the INO Project should choose Singara and Masinagudi as the preferred location. If, however, there are compelling and convincing reasons for pursuing the Project as planned within the Biosphere Reserve, the entire design and operation has to be guided by the very stringent socio-ecological recommendations outlined in the EMP. The Project activities will no doubt be closely monitored by a large segment of the public besides the designated Environment Monitoring Committee and local interest groups. However, the foremost guiding principle needs to be the recognition and respect that the project needs to accord to the ecological sensitivity and vulnerability of the region.

Keeping this in view, the EMP has focused on the following pertinent questions:

1. Does the INO Project fit within the mandate of the Biosphere Reserve?
2. Will the project affect threatened biodiversity directly or by reducing the carrying capacity of the habitats that support it?
3. Will the Project increase the population of the local human residents?
4. Will the Project cause long-term stress to the ecosystem?

An interim draft of the EMP was submitted to the Institute of Mathematical Sciences on November 29, 2007. Comments and inputs provided by the INO Project personnel, where relevant and appropriate, were incorporated while finalizing the final report. There is little doubt that the present report details one of the most comprehensive and inclusive Environmental Management Plan that has been prepared for any project in the Western Ghats.

Critical review of earlier projects and EIA reports and the INO DPR-I presented in the Executive Summary and the Full Report are in the interest of the Project and without prejudice for any person, institution or agency. It is our sincere hope that the contents of the report guide the INO Project team and all others concerned in taking the right decisions in implementing the Project.

We take this opportunity to thank the Director of the Institute of Mathematical Sciences (IMSc), Prof R Balasubramanian for giving us the opportunity to undertake the study and prepare the EMP. We thank Smt Saraswathi Ramaraj (Registrar, IMSc) and Mr V Palani (Accounts Officer, IMSc) for their prompt service and logistic support.

The project team of Care Earth places on record its gratitude to the Thiru C K Sreedharan IFS (Principal Chief Conservator of Forests, TNFD) and Dr Thiru Sukhdev IFS (Prinicpal Chief Conservator of Forests and Chief Wildlife Warden, TN) for their support and inputs. Dr Thiru K S Neelakantan IFS (Chief Conservator of Forests, TNFD) and Thiru J Upadhyay IFS (Conservator of Forests, TN) shared with us their views of the Project and clarified specific aspects of the relevant wildlife and forest conservation laws and policies. Thirumathi Jayanti Murali IFS (Head, Land Use and Planning, TN State Planning Commission) provided useful information on land use and development in the Nilgiri district. Thiru R K Dogra IFS (Wildlife Warden) and Thiru M M Iqbal Basha IFS (DFO, Nilgiris North) spared time to provide inputs and clarifications about the probable impacts of the Project on Mudumalai WLS and the local wildlife. We are grateful to them.

Dr P A Azeez (Director-in-Charge, SACON) kindly provided us with all relevant information relating to EIA studies undertaken by SACON in the Nilgiri Biosphere Reserve. Dr Ajay Desai (Bombay Natural History Society), Mr Mohan Raj (WWF-India and Nilgiri Wildlife and Environment Association), Mr A C Soudararajan (NWLA) shared with us their experiences of wildlife corridors and perceptions of the Project in general. We place on record our gratitude to each one of them.

The District Collector (Nilgiris) Thiru Anand Patil IAS kindly extended his support for our field investigation for which we are most thankful. Field studies would not have been possible without the support of the TNEB and TN Forest Department. We sincerely thank Sr Sasikumar (Executive Director, Projects, TNEB) for providing us the permission to visit the TNEB campus and the INO Project site. We are also grateful to Mr Thirumalai, AD (Civil/TNEB) for accompanying us to the proposed project site. We also wish to thank the officials of the District Survey Office, Udagamandalam led by the Head Draughtsman, Thirumathi S Jagadambal. The Tashildar (Elections) Thiru N Raman provided us the Census Reports, while Thiru T K Rajan (Village Adminstrative Officer) and his assistants provided us the land holding records and also accompanied us to the field.

Thirumathi Sangeetha B, Panchayat President (Masinagudi) and the ward members of Masinagudi Panchayat lent all support that was essential in the field, and also convened a meeting to present their views. We are grateful to them. The wildlife guides and drivers as well as the traders/shop keepers of

Masinagudi provided us their views, concerns and information. We are grateful to them. We are also grateful to the residents and leaders of the indigenous communities for participating in the process.

Finally, we sincerely thank the INO Project team, particularly, Prof Naba K Mondal, Prof M V N Murthy, Prof D Indumathi, Prof G Rajasekaran, Prof H S Mani, Prof Kamales Kar, Prof V M Datar and Mr N S Sreenivasan (Project Leader - WG, INO) for the total involvement with the study and for freely sharing all the relevant information about the INO Project as and when required.

Project Team

Dr R J Ranjit Daniels (Coordinator)

Dr Jayshree Vencatesan (Socio-ecology)
Dr J-P Puyravaud (Landscape Ecology)
Dr C Arivazhagan (Wildlife Biology)
Dr P S Easa (Wildlife Biology)
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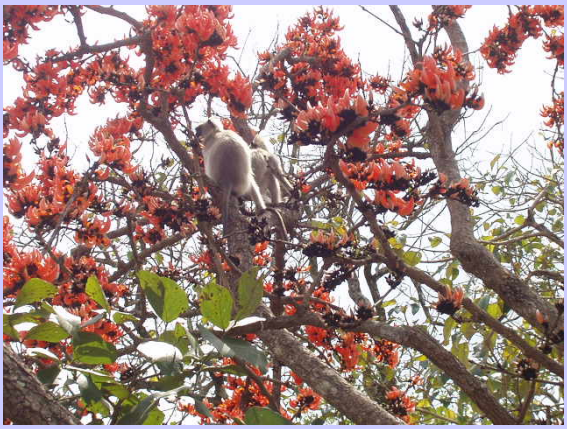
Field Assistants

Mr Maran (Wildlife Tracker)
Mr K Kethan (Wildlife Tracker)
Mr G Das (Community Organizer)
Mr Kumar (Driver)

Executive Summary



Science and development have a multi-dimensional symbiotic relationship. Just as science fosters development, development sustains scientific advancement and growth. However, science and development that are fostered at the expense of the environment is unsustainable. .

India, having stayed as a vanguard of developing countries in its commitment to nature conservation, has a great potential to be a world leader in creating and establishing models grounded on ecological and environmental considerations. Since a majority of India's one billion people continue to be governed by traditions, regional culture and societal norms, there is immense scope for implementing projects that focus equally on scientific development and environmental concerns and protection The advantage of keeping ecological concerns in focus is higher for first time projects, rather than existing initiatives.

The proposed India-based Neutrino Observatory (INO) Project offers immense scope and opportunity for a model (pilot) project of scientific development. The vision of a model project can however be fulfilled only when all the recommendations provided in the EMP are strictly adhered to. Considering the fact that the location that has been identified for the project falls within the Western Ghats, a global Biodiversity Hotspot, it is reiterated that Project INO has to be implemented in such a way that it is fully compatible with the statutory norms that govern the region and the specific landscape.

The INO Project has been conceived on a scale that no other basic sciences project in India has ever attempted. During the first phase of the Project, a magnetized tracking iron calorimeter (48mx16mx12m) will be installed in an underground laboratory, which will be used to detect atmospheric neutrinos. The aim of the study is to make precision measurements of the parameters related to neutrino oscillations.

The installed detector can be used as the far-detector of a long-base-line (6000-7000km long) neutrino experiment using neutrino beams from a neutrino facility in Japan, Europe or USA. While this is envisaged as the second phase of the Project, it is clearly a long-term goal as neutrino beam producing facilities are not yet a reality. Over the years, INO is expected to develop into a full-fledged underground science laboratory hosting experiments that can exploit its special low background environment and infrastructure, including other disciplines such as geology and biology.

Strengths
The INO Project team is sensitive to environmental concerns
The Project opens new avenues for strengthening the pursuit of fundamental science in India
The Project proposes to train young scientific workforce
The proposed infrastructure does not *per se* demand extensive aboveground space and as such will not transform existing habitats in the landscape
Once operational, the resident workforce will be minimal and the overall human impact on the landscape will be negligible
During the construction phase it offers scope for local employment generation, an attribute that the residents are looking forward to
The Project does not involve equipment or experiments that lead to environmental pollution

The Environmental Management Plan (EMP) has been drafted using firsthand information collected by Care Earth during a 4-month study (October 2007-January 2008). It has attempted to fill some of the identified gaps in the EIA report and the Detailed (INO) Project Report through field investigations, reviews of primary and secondary information, brainstorming, and historical analysis of trends. Based on an analysis of trends, the EMP outlines a protocol for monitoring. The EMP does not however present a 'no change scenario' as the Project landscape has had a long history of human interference and development and the numerous changes that biodiversity and its natural habitats have undergone lie quite bare. And as some of the apparent ecological patterns may just be that of a succession, they cannot be taken as the 'ideal'.

Information generated during the last 10-15 years is alone being analyzed and presented in the EMP. For the sake of wider readership and understanding, the present work has adopted rather simple definitions that are subject to the geographical scales at which the analysis and recommendations are being presented. Thus, Western Ghats represents the region of interest and within the Western Ghats

- The Nilgiri Hills comprise the hilly zone that spreads across Tamil Nadu, Kerala and Karnataka north of the Palghat Gap.
- Eastern Ghats are the hills that extend eastwards from Nilgiris, through northern Tamil Nadu and southern Karnataka into southern Andhra Pradesh.
- The Nilgiri Biosphere Reserve is the all-encompassing 'conservation unit'.
- The Nilgiris Plateau refers to the tableland above 1500m ASL.
- The Nilgiris district is in Tamil Nadu with its headquarters in Udhagamandalam (Ootacamund, Ooty).
- The Project landscape includes Mudumalai WLS and adjoining areas such as Masinagudi, Moyar and Singara.

- Singara and Masinagudi are the specific project sites.

Western Ghats is known for its wealth of plants and animals and the high percentage of endemic species (around 40% of the known species are endemic). Western Ghats is also known for its long history of human impacts and has rightly earned a place in the list of 'biodiversity hotspots' that are recognized on Earth. Hotspots are regions where the biological diversity is very significant but at the same time are under imminent threats of habitat degradation, erosion of diversity and extinction of species.

After the Government of India adopted the UNESCO's Man and Biosphere Programme, the Nilgiri Biosphere Reserve (NBR) was the first to be established. Since it came to be in 1986, NBR is also the only Indian Biosphere Reserve that has been formally included in the UNESCO's global network of Biosphere Reserves.

NBR is the most significant mass of land and water that represents the biological diversity of the Western Ghats. NBR covers 3 southern states, Kerala, Tamil Nadu and Karnataka and an area of 5520km^2 (2020km^2 core, 2290 km^2 buffer/forestry and 1330 km^2 manipulation/agriculture zones). It was established vide the Government of India notification number J.22010/6/86.CSC on September 1, 1986. It embraces a complex of Protected Areas and Reserved Forests including Mudumalai WLS.

The Nilgiris plateau is an elevated mass of ancient rocks that are 2 billion years old. These massifs rise to over 2000m ASL locally. Peaks above 2400m are frequent; the highest being Dodabetta at 2637m ASL. Rainfall varies from less than 500mm in the eastern parts to 7000mm per year in the western slopes. Winter frost is common in the plateau that is characterized by relic species and communities that have survived through the Pleistocene (ice ages).

The biological wealth of NBR is fairly well understood. From the available information it is evident that 20% of all species of flowering plants, 15% of butterfly species and 23% of vertebrate animal species (excluding marine) that are found in India occur in NBR. Fifty-five percent of the vertebrates that are endemic to the Western Ghats are also found in NBR. Amongst animals, fish, amphibians and reptiles have contributed the most to the endemic biodiversity. NBR is home to not less than 300 tigers and 5000 or more elephants.

Weaknesses

The Project has chosen one of the most critical wildlife habitats in the country as its preferred site.

The Project plan has not been drawn based on the ecological sensitivity of the landscape

The general paucity of case studies on the impact of tunnelling in the landscape has biased the site selection

The impact of the Project on the aquatic habitats in the landscape has not been critically assessed; very little is known of the aquatic fauna, especially the fish, in the landscape

The environmental impact that the blasting, removal and disposal of muck, the likely noise, air and water pollution and the movement of trucks and other machinery that the landscape might suffer during the construction phase has been underestimated

Considering the prior experience of blasting and tunnelling in the landscape it is apparent that the excavation and construction of the underground facility cannot be completed within the proposed 5 year period without placing undue stress on the landscape its valuable wildlife and resident people

The greatest environmental threat to the landscape is posed by the huge volume of muck that will be generated and the manner in which it is handled; this critical issue has not been sufficiently addressed in the project plan

Judging by the experience gained from PUSHEP, the muck generated by the Project will be an equivalent of 37,500 truckloads; the 2ha land earmarked for disposing the muck is insufficient

The Project plan that envisages splitting the infrastructure between Singara and Masinagudi is flawed, as it will place undue pressure on critical segments of the Moyar-Avarahalla Wildlife Corridor that falls between and around the two sites

The outermost fringe of Masinagudi is the natural pathway for the movement of wild animals from the forests adjoining the Masinagudi checkpost; in fact the habitat that surrounds Masinagudi village is in the form of an 'elliptical' orbit

The Project does not offer any tangible benefits to the society; it will not uplift the marginalized indigenous people; it does not have the scope of offering appreciable socio-economic benefits to the resident human population

The project may serve as the front-runner for proposing and establishing more projects in future – essentially, additional laboratories may piggy-back on Project INO

Agriculture and development are the two major reasons for adverse environmental impacts in NBR; the latter being more severe, especially due to the construction of dams/reservoirs, tunnels and roads to feed

and maintain the powerhouses. The Tamil Nadu Electricity Board (TNEB) has implemented in phases several hydroelectric projects during the past 75 years. There are 12 hydroelectric powerhouses located in the Nilgiris district alone with an installed capacity to generate more than 800 MW of electricity.

Tea industry has exploited the NBR during the past 100 or more years. In the Nilgiris district the present cover of tea estates is 45,974ha (459.74km^2) with an annual production of around 60,000 tons. Besides tea, plantations of eucalyptus, wattle, cinchona, coffee and a variety of hill vegetables have impacted the NBR.

The Mudumalai WLS is situated in the north of the Nilgiri Hills at an altitude of 850-1250m ASL. It spreads over 321km^2. Average annual rainfall varies from east to west; being drier in the east (less than 500mm) and moister in the west (2500mm). Rains are largely confined to the June-November seasons. The east-west gradient in the rainfall and local variations in the topography have together created and sustained a mosaic of vegetation that includes scrub, thorn forests, dry deciduous forests, tree savannas, moist deciduous and semi-evergreen forests.

Grazing, fire and various kinds of human interference have created a variety of secondary and degraded habitats throughout the landscape. To add to these, there are monocultures and agriculture. A large number of species of exotic plants like *Lantana camara, Ageratina adenophora* (*Eupatorium*)*, Parthenium hysterophorus* and *Prosopis glandulosa* have proved to be invasive in and around Mudumalai WLS.

Plant diversity is largely due to species of grasses, herbs and shrubs. The low diversity of trees in the landscape has been inferred from an assessment of the permanent 50ha forest dynamics plot that is being monitored by the Indian Institute of Science since the mid 1980s. Number of species of trees known in the 50ha plot is 71.

Deciduous forests in the southern Western Ghats are however known for the diversity of terrestrial vertebrates including reptiles (lizards in particular), birds and mammals. The Mudumalai WLS is no exception to this general pattern and as such has the greatest conservation value when it concerns non-aquatic vertebrate animals.

The Mudumalai wildlife sanctuary is significant for its large population of elephants. Although estimates tend to vary, it is evident that the largest population of elephants in Tamil Nadu is found here. Together with the adjoining parts of Kerala and Karnataka the landscape may be home to an estimated 1800-2300 elephants. Besides elephants, the Sanctuary is an important habitat for gaur, sambar and chital. The large carnivores found here are tiger, sloth bear, leopard, hyena and wild dog. The 60-80 tigers (around 20% the tigers known in the states of Tamilnadu, Kerala and Karnataka) that inhabit the Sanctuary prompted the Government of India to declare Mududmalai WLS as a Tiger Reserve.

The earliest human inhabitants of the landscape are the Paniyar, Betta Kurumbar, the Jenu or Shola Nayakar and the Irulars. Early migrants include the Moundadan Chetti and Wyanadan Chetti who are land-owning agriculturists. With the onset of development in the form of hydroelectric projects since the early 1930s a large population of laborers and government employees have immigrated and settled around the Sanctuary, especially in Masinagudi. Along with the early immigrants came 28,000-30,000 livestock. The 30 years between 1960 and 1990 witnessed the greatest ecological transformation in and around Masinagudi.

Masinagudi village Panchayat comprises of the following settlements: Masinagudi, Singara, Theppakadu, Moyar, Bhoothakallu, Chemmnatham, Mavinhalla, Vazhaithottam and Dodda Moyar, spread over 134.03km^2. The overall density of human population is 36/km^2; varying locally and exceeding 800 in Masinagudi. The area of the Masinagudi Panchayat was demarcated before the Census of 1960-61. The Panchayat includes only lands that are under the jurisdiction of the Revenue Department, although protected forests may be intermittently present. Masinagudi that evolved from a diminutive settlement into a major village by the early 1960s is the pivot in the landscape.

That indigenous people were sparsely present even in the past in Masinagudi is evident in the fact that in 1971 only 19.84% of the total population in the Panchayat was comprised of Scheduled Tribes. The ST population has continued to decline that current estimates place it at a mere 6% of which many are not native but have migrated from Salem and other adjoining districts. Scheduled castes were 23.21% in 1971 and 38% at present, once again due to inflow of migrant labor. Most residents have survived on occupations/livelihoods that are directly derived from forests (tourism) and hydroelectric projects.

Between 1960 and 1990, human population in the Masinagudi Panchayat had grown by 142%. As per the 1991 census the population was 8416 and by 2001 it was 8577. According to the records at the Panchayat Office and Village administration office the population at present is 12,535. Livelihood provided by tourism and associated infrastructure development has attracted more people that the population has continued to be on the rise. As per information provided by the Revenue Department and the Panchayat President, the reported human population is only of those who are resident and hold ration cards. And as there is a large floating population, the actual number of people is more than 10,000 in Masinagudi. While the human population in Masinagudi is on the rise, it has dropped in Singara. The population of 567 reported in 1991 has since dropped to 302 (as per 2001 census). There are at least 100 registered vehicles in Masinagudi. Sixty-one resorts and 121 shops are also located here

Masinagudi has historically been a favored land for rearing cattle that were managed by tenancy rights. Apart from catering to the meat industry of Kerala, trade of dung was the most significant trade of the region that during the 1970s and 1980s the village had between 28,000 and 30,000 cattle. These cattle were free ranging. Of the 139 residents that were interviewed during the study, 108 had moved to Masinagudi to trade in manure.

Cattle population however dropped subsequently in that during the 1990s there were only 15,000-17,000 animals. Current estimate suggests that there are around 4800 cattle in Masinagudi. Cattle frequent the Kalmalai-Singara-Avarahalla segment of the Moyar-Avarahalla Wildlife Corridor through the Singara-Masinagudi road, often coinciding with the migratory season of elephants (and other herbivorous mammals) leading to competition and outbreak of contagious diseases. The local people recurrently burn the forests along the Corridor to encourage fresh growth of grass for the cattle.

Singara Camp and Masinagudi village are two human settlements that are located about 6km apart, southeast of the Mudumalai WLS. They fall in a rainfall zone that is dry-moist, being drier in Masinagudi. The vegetation varies along the gradient; while it is dry deciduous with scrub and thorn dominating in and around Masinagudi, it tends to be semi-evergreen in Singara (a climate quite suited to the coffee estates).

At least 2 well-established segments of the Moyar-Avarahalla Wildlife Corridor viz., Kalmalai-Singara-Avarahalla and Moyar-Avarahalla are in close vicinity of the Project sites. Of which, the Kalmalai-Singara-

Avarahalla segment (also known as Singara-Mavanalla corridor) is bisected by the Singara-Masinagudi road.

Masinagudi divides the otherwise contiguous Corridor into the northern Moyar-Avarahalla segment and the southern Singara-Mavinhalla segment. The northern limits of Masinagudi (the TNEB settlement) abut the Moyar-Avarahalla segment. As a result, wildlife movement through the Corridor is in the form of an elliptical orbit around Masinagudi village.

The 2 segments of the Moyar-Avarahalla corridor are 'critical' to the elephant. These (wildlife) corridors are naturally in the form of a 'bottleneck' due to the steepness of the Moyar gorge and Kalhatti slopes. The intervening flatter terrain that the elephant had traditionally used for ranging and migration has already suffered due to various kinds of degradation. Here natural habitats have been fragmented by development. Further degradation by way of creating barriers and chokers or 'squeeze-in-zones' is likely to lead to human-wildlife conflicts.

Clans of elephants (in Mudumalai) are known to have a home range that varies between 530 and 800km^2. Adult males apparently have a smaller home range (between 200 and 375km^2). Home ranges of animals vary in size in relation to the quality of available habitats. Smaller home range is an indication of stress and it is the first clue that the elephants will enter human settlements and thus get into conflicts. At least 2 deaths of humans were reported from the corridor during September-October, 2007. While the density of elephants was around 0.48/km^2 during the period of the present study, this is likely to increase during summer.

The Project, as proposed, is spread over two localities; Singara and Masinagudi. The Project site at Singara will house the INO portal, access tunnel, the utility building and area for disposal of the muck. The portal (as per alignment 2 that has been proposed) will lie within a distance of 200m from the south portal of the PUSHEP access tunnel (and 50m away from the main gate of the TNEB Pykara Camp) and closer to a private coffee estate at Singara; however within TNEB land. The 2370m long access tunnel that adopts a gradient of 1 in 13.5 is to pass through the coffee estate (for about 200m) and the underground laboratory will be located 1300m below the peak (2207m ASL) that rises from within the Singara-Bokkapuram reserve forests.

Ecosystem processes that govern the Project sites are as complex and obscure as they are in the rest of the Western Ghats and most other human-impacted tropical landscapes. The fundamental environmental influences that govern the local ecosystem are climate, topography and the resultant vegetation types. Locally, however, around the INO Project site, the landscape is heterogeneous being relatively drier dominated by deciduous, thorn and scrub vegetation around Masinagudi where the key players are large mammals; elephant being the 'flagship' species. Elsewhere, around Singara, the vegetation is moister offering habitat to species of endemic plants, amphibians, reptiles and birds.

The total area of land that is required for the Project, as per the INO DPR-I, is provided below. In principle, the forestland is only 'notional' as the construction required for the Project in the said area is underground. Above ground activity in Singara is on TNEB land and the adjoining coffee estates. The residential facilities (including administration, hostel and quarters) are proposed to be located in Masinagudi; within TNEB land.

Purpose	TNEB (ha)	Forest* (Ha)	Private (Ha)
Access tunnel, portal and working front/Singara	0.05	-	0.925
Access tunnel and auxiliary tunnel/Singara (underground)	-	3.2375	-
Underground research lab/caverns 1&2/Singara	-	1.48	-
Utility building/Singara	0.2	-	-
Roads, guard room, rest house/Singara	0.25	-	-
Total	0.5	4.7175	0.925
Surface lab, assembly shop and workshop/Masinagudi	0.15	-	-
Office for scientists and administration, stores and lecture halls/Masinagudi	0.7	-	-
Visitors hostel & guest house/Masinagudi	1.08	-	-
Residential quarters/Masinagudi	0.6	-	-
Roads and gardening/Masinagudi	0.5	-	-
Free space/Masinagudi	0.97	-	-
Total	4.0	-	-

* Notional as the facility will be underground

Land prices have increased from Rs 3000/cent in 1990 to Rs 45,000-50,000/cent at present. While this is in tune with the overall inflation of land prices, pertinent to Masinagudi and adjoining areas is the fact that there is a) additional demand due to the scope that is offered for establishing resorts and vacation homes and b) large contiguous pieces of land are available favoring long-term investments as residential colonies or holiday resorts.

Since the proposed INO Project is the first of its kind in India (also South Asia), there is no benchmark to assess its environmental impacts. However, since it is proposed to be located within the Sinagra camp, and involves tunnelling as with the other TNEB initiatives in Nilgiris, the Pykara Hydroelectric Project has been treated as the benchmark.

Available information on the environmental impacts of the various hydroelectric projects in and around the PUSHEP site has failed to pin down the specific problems and provide clues to ecological mitigation. Fortunately, however, unlike hydroelectric projects that have fragmented aboveground habitats extensively, and unlike plantations, agriculture and human settlements that have encroached upon vast portions of the landscape, the INO Project is conservative in terms of land use as most of its activities will lie deep below the surface.

Impacts of the INO Project on ecological processes (and the threatened biodiversity) will take a long time to become visible. Visible symptoms of ecological collapse that a project like INO may usher can never stay clear of complications as they are seen in a compounded form without revealing the catalysts. And whether the Project itself catalyses a faster collapse will also be inconclusive in an already devastated landscape. This is yet another case of 'data deficiency' and therefore a lot of caution needs to be exercised if the Project has to come up in Singara as planned.

Improving the existing road connectivity between the portal and the main road in Singara has been proposed in the project. Large trees border the proposed access road. All these trees are native (including figs and rosewood) and in age between 150 and 200 years. Widening of the road that leads to the muck yard will also involve the removal of large trees. There are at least two large wild silk cotton trees within the muck yard. These trees have a high conservation value as wild figs are known to be keystone species and silk cotton provides nectar and nest-holes to birds and mammals.

The first 200m of the access tunnel will be through softer medium and a technique called 'cut and cover' will have to be resorted to. A part of the 200m cut and cover zone may lie within a private coffee estate. The trees along the first 200m are largely silver oak planted as shade for the coffee. Being exotic species, silver oak has very little conservation value.

Opportunities

The environmental impact of the Project can be grossly reduced if the entire ground plan is appropriately modified such that the INO infrastructure is locally accommodated in Singara and not extended to Masinagudi

Such a change may also involve a slight realignment of the access tunnel such that the creation of the portal does not require the proposed cut and cover technique and felling of mature native trees

The Project may benefit from buying as much of the adjoining coffee estate and locating the aboveground (modified) infrastructure within it

Since the coffee estate as well as the land immediately adjoining the estate have already been identified as an animal corridor and there are proposals to bring it under the existing system of Protected Areas in the landscape, the INO Project can restrict the aboveground infrastructure and dedicate much of the purchased land to wildlife

The proposed change will minimize the movement of trucks for the disposal of muck and help in putting the bulk of it to good use (example leveling and making the undulating topography suitable for aboveground construction in Singara)

Accommodating the aboveground infrastructure within the coffee estate will prevent construction activities in Masinagudi. While this will reduce the pressure caused on the corridor due to vehicle movement, it will also spare the existing habitat at Masinagudi

The proposed Project site of 4ha adjoining the TNEB PUSHEP guesthouse at Masinagudi is a part of the Moyar-Avarahalla corridor. The presence of a large population of black-naped hare and movement of jackals was observed during the recent study. Moreover, there is regular movement of gaur and elephant along the periphery. A herd of 3 elephants had entered the backyard of TNEB PUSHEP guesthouse after knocking down the wall some 8 months ago. The habitat has great potential for ecological restoration

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Ideally, the private lands that are for sale between Singara and Masinagudi should all be bought by the INO Project and through negotiations with TNEB, Forest Department and the Estates; the habitats can be managed exclusively to complement the Corridor. Unauthorized movement of vehicles can be strictly curbed through such a cooperative process

Reworking the Plan based on the recommendations of the EMP can render the Project a model within the scope of Biosphere Reserves and in management of wildlife corridors and Tiger Reserves

The Project can create local state-of-the-art infrastructure for wildlife biological studies and attract competent students and scientists from India and abroad

There is also scope for relocating the Project elsewhere in the Western Ghats of Tamil Nadu

Three and a half years of excavation will create a lot of noise (blasting, drilling, truck movement, stone crushing, etc) and air, soil and water pollution. As there are places of worship (church and temple) within 100m of the proposed portal, noise and dust can be a major nuisance. There are proposals to minimize these problems that suggest the use of new machines, controlled blasting and restricting the excavation to only light hours of the day. Blasting at night must be avoided.

Available information on preparation for blasting and time taken for clearing muck suggests that the process involved might limit the number of blasts to 1-2 per day. For example when the PUSHEP excavation made use of 51kg of gelatine in 57 drill holes 2m deep, each blast resulted in 13.5m^3 of debris. At yet another location within the project site, 73.5kg gelatine placed in 89 drill holes yielded 59m^3 of debris per blast. The latter output that was larger probably limited the blasting to one per day.

At the above rates, it will take a very long time to excavate the estimated 225,000m^3 of muck that INO project envisages. Assuming a rate of 13.5m^3 of muck per blast and two blasts per day it will require 8333 days (22 years!) to excavate the tunnels. If on the other hand the 59m^3 capacity blasts are undertaken at a rate of one per day, it will still require 1906 days (5 years) for the excavation to be completed. Against these odds, how exactly the INO project plans to complete the task within the 3.5 years as proposed has to be rethought.

As per the INO DPR-I, sullage water and sewage from underground and aboveground structures will be suitably treated and dispersed at a suitable locality, well away from the water bodies (although the exact site is not depicted in any of the maps). However, there are other associated problems that are foreseen; runoff carrying suspended particles of soil and rock during the rains. The existing muck yard precariously overhangs a perennial stream (the flume channel that is used by wildlife as the only source of water in summer). There are no attempts to prevent the slide of the muck into the stream, and there have been conflicts over this with the local people.

Great care has to be taken while excavating and disposing the muck. As per TNEB sources, PUSHEP disposed muck at a rate of 6m^3/load (around 16tons/load). It is more likely that the INO Project will also resort to using the same procedure. If that is the case, it will require 37,500 truckloads to dispose the 225,000m^3 of muck that will be excavated during the 3.5-5.0 years.

When translated, this would imply there might be at least 75,000 trips (up and down) between the site of excavation and the muck disposal area and eventually out of Singara through a narrow 6 km stretch between Singara and Masinagudi. This is essentially, 59 trips/day (for 3.5 years) and when only 12 daylight hours are considered, the number of trips doubles to nearly 120 at a rate of 10/hour.

The existing road to the muck yard is too narrow and steep that movement of vehicles of the prescribed capacity will be much slower than expected. There is little scope for widening the road as it runs in close proximity to existing TNEB residential buildings on one side and is bordered by a storm water drain on the other. Water that flows through the drain reaches the flume channel below posing dangers of silting and pollution.

Obviously the huge task of disposing the muck cannot be fulfilled unless a large fleet of trucks is deployed. Then the question arises as to how many number of trucks will comprise the fleet, where will these come through as access is limited starting from Bandipur WLS. Will the highways department embark on road widening and strengthening? Where these trucks will be parked, how many attendant laborers (drivers & cleaners) will be brought in and where will the fuel be procured? What kind of service infrastructure will be installed to deal with breakdowns? While the Project development plan mentions the need for establishing a local fuelling station, it is silent on all other related aspects including from where the fuel would be procured and transported.

Further, the common practice of truck drivers is to take the trucks to the nearest streams and springs for washing from time to time causing pollution. Will this not affect aquatic life and the quality of water that the wildlife drinks? In the absence of water holes in the immediate vicinity, the threat indeed looms large for wildlife. There is no clarity on this aspect in either Project plan or in the EIA report; although the latter does caution against oil spillage from field machinery.

The site that has been earmarked for the disposal lies within TNEB property. It has an extent of 2ha (200m x 100m). The proposed 4m high walls that are to be built to restrain the muck will enhance the holding capacity to 80,000m^3. This volume is about a third that of the estimated quantity of muck that is to be generated. It seems unlikely that the designated space of 2ha will be able to accommodate the huge volume of muck that is likely to be generated at Singara.

It has been has stated that only 20% of the muck will be used for the INO Project. Of the rest, 50% may be used elsewhere in the Nilgiris district as there are no stone quarries and hence a reasonable demand for stone rubble. The remaining 30% will be 'stacked without any void' during the construction phase itself (probably within the space reserved for the purpose) and after the project species of vegetation will be grown in the residual area so that the stacking area merges with the adjoining vegetation. Thirty percent amounts to 67,500m^3; a volume closer to the total capacity of the 2ha storage facility!

Ironically, according to sources at TNEB and the Panchayat, the existing muck yard is 59,000m^2 (5.9ha). PUSHEP had required this space to store/dispose a mere 15,000m^3 of muck. Of this, over the past years 10,000m^3 have been used for various purposes leaving only 5000m^3. The leftover muck is in the form of a huge mound. Despite the moist conditions that Singara enjoys there has not been any natural regeneration of plants even in the undisturbed nooks of the muck hill. What will happen to the 67,500m^3 of muck that the INO Project is likely to leave behind?

The Project Development Plan has listed mobile cranes, tippers, tip trucks, road rollers and lorry as part of the construction equipment without specifying how many of each and their capacities. Elsewhere it has included 3 lorry each of 5 ton capacity, 2 standard van, 2 ambulance van, 5 jeep, 2 mobile trolleys and 2 battery/diesel operated devices (without specifications) as the requirement. These vehicles may be used for transporting small equipment and personnel. There is however a mention of 40 ton trucks that will be engaged in transporting the larger lab equipment. The latter will ply between the nearest railway station and the project sites carrying equipment. This is not going to be possible considering the condition of the roads and the Protected Area rules and regulations.

All roads that lead to the Project sites at Singara and Masinagudi were examined for their feasibility during the present study. Roads assessed include the one from Satyamangalam via Dhimbum ghat and through Chamrajnagar. Movement of vehicles more than 16 tons is not permitted along the Dhimbum ghat. This is mainly due to the steepness (27 hairpin bends) and the habitat being one that is critical to elephant and tiger, amongst others.

Whichever way, road transport involves passing through Bandipur NP and Mudumalai WLS when approached from the north. Moreover, the iron bridge between Theppakadu (elephant camp) and Masinagudi will not be able to accommodate vehicles more than 20 tons. The concrete bridge built by TNEB for PUSHEP providing a byway through the residential area at Theppakadu is presently not in use and is dilapidated and is subject to permission being given by the Tamil Nadu Forest Department.

Threats

Lack of clarity on the scope of the INO Project has left local residents and environmental agencies in an unduly agitated and anxious state

Unless the local interest groups are taken into confidence, the smooth operation of the Project both in the short and long-terms will not be possible

The flagship of the landscape is the elephant and the limiting resource is water. Local people foresee water conflicts in the future

Unauthorized tourism along the Singara-Masinagudi road is likely to attract the installation of check post restricting the free movement of bona fide vehicles and personnel

The Project has been envisaged at a time when there are proposals to enhance the extent and quality of the wildlife habitats and corridors and when the Mudumalai WLS has come under the network of Project Tiger Reserves

The recent announcement of the TN Forest Department of its plans of procuring private land and annexing the same to the Kalmalai-Singara-Avarahalla wildlife corridor may not work in the interest of the Project

The access roads are not meant to take the kind of load that is needed for transporting the building material and laboratory equipment

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The available network of roads and associated transport infrastructure within the landscape and wildlife Protected Area rules and regulations restrict movement of vehicles that exceed 8 ton capacity; the Project requires much larger vehicles at least during the construction phase

Even if the first phase of construction and operation of the Project is successfully accomplished, future expansion will be curtailed as wildlife conservation efforts succeed in fortifying Protected Areas, buffer zones and corridors

The estimated time required for the construction phase is 5 years of which 3.5 years will be spent on dredging/excavation of tunnel and underground facilities. It is not immediately clear whether construction of the aboveground facilities at Singara simultaneously begin. If that is the case it is foreseen that there will be considerable vehicle movement between Singara and Masinagudi even during the first 3.5 years.

Sand for construction is likely to be sourced from Gundlupet. Trucks that carry sand from Gundlupet will also traverse via Bandipur, Theppakadu, Masinagudi before reaching Singara. There is no indication of the number of loads that will be needed for the purpose; number of trips and weight of each load have to be estimated. Besides sand, it has also been proposed that some bricks will be needed for the construction and the same will be sourced from Gundlupet.

Between 5 and 6 vehicles moved per hour of daylight between Singara and Masinagudi during the time that the study was undertaken. Majority of the vehicles belonged to the lighter category (around 4 per hour). The average number of heavy vehicles that traversed the Singara-Masinagudi road was much lower (1 per hour).

Vehicular movement (October 2007-January 2008) had killed at least 42 animals along a 3km stretch of the Singara-Masinagudi road. As expected, 64% of the kills were of amphibians. About 5% of the kills involved mammals. Road kills tend to vary with the seasons; increasing during the rains and when traffic at night becomes heavier.

Singara-Mavinhalla segment of the Corridor is rather heavily used by elephants and chital during the dry season and sambar in the wet season. Information provided by the local elephant tracker has confirmed that there is frequent movement of elephants in the segment being the highest between 4.30pm until about 8.00pm and the early morning beginning around 3.00am.

At least 20 species of mammals were recorded moving across and beside the Singara-Masinagudi road during the present study. Of these chital ranked first followed by elephant. Of 360 mammals (including 8 species) that were the most frequent users of the road-corridor intersection, 224 were chital, 44 elephants, 24 common langur and 22 each of sambar and gaur.

The Project plan states that to the extent possible local laborers will be engaged to avoid migration. The laborers will be educated on the need for environmental protection and they will not be permitted to venture into forest for the collection of firewood and other sundry works. The laborers will be provided LPG or firewood. They will not be permitted to raise cattle for milk at any cost. Instead ‘Aavin’ milk will be arranged.

The indigenous population at the Singara and Masinagudi villages is small (negligible). They are not likely to benefit from the Project unless they are directly employed. It is however possible to foresee gainful employment opportunities for the other residents during the construction phase.

It is proposed that the existing hospital near the INO portal in Singara will be demolished for accommodating the Project activities. How exactly this will be compensated has not been spelt out? Further, the proposed portal and cut and cover access tunnel and utility building at Singara are very close to a church and a temple. There is no suggestion on how these worship centers will cope with the site preparation and construction during the 5 years.

Vehicle and excavation noises will be quite monotonous that can interfere with the normal behavior of animals that rely on sounds for communication. Very little is known of the impacts of reverberating sounds on animals like bats, cave swifts (one species exists in the Western Ghats) and elephants that rely on ultrasonic sounds for communication and orientation.

Dust pollution in the air can interfere with photosynthesis and pollination in plants. When dust gets into water, it enhances the turbidity. Hill streams are unique in that the shallow waters are clear allowing a lot of light to penetrate thereby keeping the water highly oxygenated. Hill stream fishes, amphibians and insects are very sensitive to turbidity.

Oil pollution is a foreseen problem during the construction phase considering the number of trucks and other excavation machines that will be involved. Oil spills on grass, soil and water interferes with wildlife (also people and domestic animals) in different ways. Fuel spills can also trigger forest fire.

Human wastes, especially excreta, attract a number of animals. They tend to be sources of intestinal parasites. Urine attracts herbivores that lick the wet soil for the salt. Elephants are attracted by salt and the smell of jaggery besides toddy, beer and other fermented drinks. Drunken behavior of elephants has emerged as a major reason for human-elephant conflicts in parts of India.

The National Wildlife Action Plan for 2002-2016 has reiterated the need to identify and preserve wildlife corridors. It has been proposed that all wildlife corridors be given the status of ‘ecologically sensitive areas’ under the provisions of the Environmental (Protection) Act, 1986. The land on either sides of the Singara-Masinagudi road is largely privately owned, and is predominantly the property of Singara Estates. Whatever does not belong to the Estates is owned by TNEB. The critical segment of the Corridor that has been identified along the road by wildlife biologists is in fact 124 acres of private land. As there are no common lands on either side, acquisition of land for enhancing the corridors means outright purchase (ideally by INO Project) or by the Forest Department invoking the Forest Conservation Act (1882) or the Wildlife (Protection) Act, 1972.

INO Project envisages developing a workforce of young and trained scientists and engineers. The workforce thus developed will be the ‘end user group’. The human resource will be drawn from amongst the students, post-doctoral fellows and faculty of the INO collaboration. The workforce or the end user group will have at least 30 scientists and 20 technically qualified personnel. At any time, 15 members of the workforce are required for conducting experiments and for the maintenance of the INO installation.

The required human resource will be developed in 4-5 years. One of the proposals that have been made by INO Project for achieving this is the establishment of an INO Training School. As per the proposal, 15

students at the level of MSc, BTech or BE will be selected from throughout the Country each year for a one-year training course. At the end of five years it is anticipated that 75 technically qualified personnel will join the INO workforce. The trained personnel have the option of working in the INO Project or entering other laboratories in India and abroad that conduct experiments in related fields of science (example High Energy Physics and Nuclear Physics).

Besides the above suggestions there are also plans of recruiting students and scientists from various collaborating institutes for the INO Project on a yearly basis. The following are some of the proposals that are already in place for improving HRD in front-line experiments in India:

- Annual recruitment of 12 post-graduates in physics and graduates in engineering who will work in the INO project under the guidance of senior physicists for 5 years

- Offering INO Fellowships for Master's level studies in IITs and other engineering institutions and selected university departments; the fellowships will be available for two-years during which the student may submit a dissertation in neutrino physics

- PhD programs in instrument building; this is unfortunately a neglected science in India and has to be revived and strengthened through long-term programs like the INO; hands-on experience that the Project offers will be the primary motivation

- The Government of India's Department of Atomic Energy (DAE) might consider HRD in universities by inducting young personnel into INO and related research in physics

- Human resource developed by INO Project can cater to the needs of certain upcoming fields of medical science such as 'functional imaging'; functional imaging techniques have a great potential in the detection and treatment of cancers

INO Project will be closely watched by many interest groups due to its close proximity to Mudumalai WLS and its location within NBR. It is important that the Project agency is well informed of the various Government programs, policies and action plans that govern the landscape. For this purpose, the relevant Government of India programs and action plans such as Project Elephant, Man and Biosphere Program, Project Tiger and Wildlife Action Plan are briefly discussed in the EMP.

The Project Elephant of the Government India in its strategy and action plan states 'there can be no hard and fast rule about the design of corridors. The main thing is to ensure that elephant will use them and will not spill over into the adjacent human settlements'.

The Project Elephant plan document has also emphasized that 'preserving the integrity of elephant habitats should not be lost sight of while planning any new development project and appropriate measures to keep the migration corridors of elephant intact must be taken'.

The Government of India launched the Project Tiger programme in 1973 to arrest the loss of the tiger and its natural habitat throughout the country. As of now there are 29 tiger reserves in India of which Bandipur and Mudumalai are within the Nilgiri Biosphere Reserve. The Mysore-Ooty highway passes through the

Bandipur and Mudumalai tiger reserves. Mudumalai was recently brought under the purview of the Government of India's Project Tiger programme. As per the guidelines of Project Tiger

- No intensive form of land use like mining, quarrying and the like should be fostered in the buffer zone, and due care should be exercised while granting no objection certificates (NOC) to such activities in private or revenue areas, if any, included in the multiple use area

- Development projects obligated to have a local orientation so that they become part of local area development without upsetting the resource needs and common property resources; appropriate compensations or alternatives to be built into project cost, preferential employment of local people, if necessary after arranging education and training for them

The National Wildlife Action Plan (2002-2016) is more of a vision for long-term conservation of wildlife in India. And in its preamble it states that 'habitat loss caused by developmental projects such as dams, mines, etc compound the problems of wildlife conservation'. The Action Plan has also reiterated the need to minimize man-animal conflicts. In stating this it has made it explicit that 'while increasing man-animal conflict is an outcome of shrinkage, fragmentation and deterioration of habitats, it has caused destruction of wildlife and generated animosity against wild animals and protected areas. This is a crucial management issue, which needs to be addressed through innovative approaches'.

For the sake of effective conservation of endangered species and their habitats, the Action Plan has recommended that 'all identified areas around Protected Areas and wildlife corridors shall be declared as ecologically fragile under the Environment (Protection) Act, 1986'. Further while discussing strategies for the restoration of degraded habitats outside the protected areas NWAP has proposed that degraded habitats around each Protected Area and potential corridors be identified where protection and restoration will yield best results. In such areas the key factors responsible for degradation are to be identified and recovery plans are to be made for restoration. The proposed INO Project should see a great opportunity in this action point.

The Environmental Management Plan is the most vital contribution of the present study. And judging by the detailed overview and results that have been presented, it is evident that the EMP is the outcome of an objective assessment of the impact caused by the development processes in the past in and around Masinagudi village Panchayat. The following section details the principles and the specific action points that need to be incorporated into the planning and implementation process of Project INO. It is also important that care is taken to ensure that these form an integral part of all implementation mechanisms and contractual agreements of Project INO.

- In principle, Project INO should adopt the 'Elephant' as its nominate species. Following this, a minimum of 10% of the total project cost (under direct and indirect support, as well as support in the form of providing facilities) should be earmarked as the corpus for the conservation of the elephant. This should be further strengthened by annual grants/budgetary allocation to the initiative (Immediate action).

- The corpus thus created should be managed by a working group/unit that will develop the norms, guidelines and implementation procedures for the conservation programme. This group will necessarily have the representation of Project INO, the Tamil Nadu Forest Department, reputed

non-governmental organisations and academic/research institutions. The conservation programme should not be operated on an ad hoc basis, but be subjected to periodic review, including a community-based review (Short, Mid and Long-term actions).

- The vulnerability map developed for the EMP highlights Singara–Mavinhalla segment of the corridor as one of the two critical areas within the landscape. The project as it is being proposed currently will only compound the existing stress on this zone.

- It is recommended, both in the interest of the Project and wildlife, that the entire infrastructure (underground and aboveground) be restricted to Singara. This recommendation has been made, as the 4ha land earmarked within the TNEB campus at Masinagudi is a part of the Moyar-Avarahalla segment of the Corridor where there is immense movement of wildlife (including elephants). The only waterhole that exists here is very close to the Project site and there is a lot of wildlife movement in this habitat during summer (see vulnerability map) (Immediate action)

- Irrespective of the land use in the project site, compensatory mechanisms for re-vegetation need to be evolved and implemented. The project team needs to recognise that trees alone do not make a forest. Appropriate location for re-vegetation will have to be identified in consultation with the Forest Department, TNEB, NGOs and residents; a potential site is the 4ha adjoining the PUSHEP guesthouse at Masinagudi earmarked for the INO Project (Mid and Long-term actions).

- Compensating the loss of vegetation should not however be done by planting trees along the Singara-Masinagudi road. In fact, planting trees along the roads will only aggravate human-wildlife conflicts as avenues of trees tend to attract animals closer to roads. When these animals attempt to cross roads attracted by trees on the other side (example primates; macaques and langur that are abundant in the landscape), they are run over by passing vehicles.

- There are suggestions of creating gardens within the Project site and this should not be done. The project, even in its expansion phase, should strongly deter from any of the routine 'beautification' processes such as lawns or creating ornamental shrubbery. This needs to be incorporated into the DPR (Immediate action).

- The EIA report has categorically stated that there should be no parallel fencing made anywhere along the road between Singara and Masinagudi. Fencing in any form anywhere will prove detrimental to wildlife in the landscape. Temporary walls (if absolutely needed) would be the most ideal option after specifying the area that will be thus cordoned during the 5 years of construction and installation of equipment (Immediate and Short-term actions).

- A volume of 67,500m^3 of muck that may be left unused will create a mound that is much larger than what is presently there at Singara. Leaving this huge volume unused and covering it with earth for growing plants (trees) does not seem a viable proposal. There is need for better management plan when it concerns the disposal of muck. In fact, disposal of muck is certainly the greatest environmental impact the INO Project is likely to cause in the landscape (Immediate action).

- There should be a complete cessation of activities during the months November to February, excluding localised activities of limited or no immecdiate impact to wildlife within Singara. There should also be no movement of vehicles of Project INO/ implementing agency/contractor during the

elephant movement hours (3 Am until 6 Am and between 4.00 pm until 8. PM). The night hours are critical for the other wildlife. Hence the vehicular movement of Project INO should be only between 6 am and 4 pm (Immediate and Short-term actions).

- Based on the existing vehicular movement on the Masinagudi-Singara Road it is being proposed that only 4 trips of heavy vehicles (which entails that the vehicle moves 8 times to and fro) be allowed per day (Short-term actions).

- In accordance with the existing norms of the GOI, the heavy vehicles can be of only 8 tonnes capacity. Adherence to this norm will ensure that the habitat integrity is preserved, and that there is no demand for laying new/additional roads (Immediate action).

- It should be ensured through the EMC and the trackers that the vehicles do not engage in washing, cleaning operations on the Masinagudi-Singara Road. Parking space should be found within Singara (Short-term action).

- Project INO should not in any manner allow the establishment of any additional service provider such as travel and tour operators, catering etc. in Singara (Short-term and Mid-term actions).

- The Project plan must to the extent possible engage, local laborers, who are in a manner are the residual effect of the Pykara project. Strict monitoring of their condition and activities must be ensured by the EMC (Immediate and Short-term actions).

- The indigenous population at the Singara and Masinagudi is small, but comprises of extremely capable trackers/wildlife guides. It is absolutely important that a viable number of indigenous people are employed right from the beginning as trackers. They in turn can be engaged to monitor vehicular movement, movement of wildlife, forest fire mitigation, etc. This once again should be an integral component of the conservation initiative of Project INO (Long-term action)

- Nature's services that the INO Project personnel will enjoy include 'relaxation' (recreation) thanks to the proximity of Mudumalai WLS and the Maravakandy Reservoir. Willingness to pay amongst the small fraction of INO Project staff and visiting scientists/students can be translated into kind appropriately so that the aesthetic and recreation service benefits that they enjoy will also provide economic incentives to a larger spectrum of local residents. A contributory 'nature conservation fund' can be considered (Long-term action).

- The National Wildlife Action Plan for 2002-2016 has reiterated the need to identify and preserve wildlife corridors. It has been proposed that all wildlife corridors be given the status of 'ecologically sensitive areas' under the provisions of the Environmental (Protection) Act, 1986. The INO Project should honor the commitment.

- Herds of elephants may continue to roam in the adjoining habitats despite the construction activities. Variations between individuals of elephants in their sensitivities to noise, vibrations and the smell of explosives have not been understood. INO Project should post a competent team of wildlife biologists (and trackers) to monitor the elephants both during construction and operational phases. The Project should be sensitive to precautionary recommendations that the experts (Environmental Monitoring Committee) provide from time to time.

- A watchtower located at a strategic point within the Project site will greatly aid the monitoring of wildlife movement both in the short and long terms (Immediate action).

- The tie-up with the TIFR/NCBS MSc Wildlife Biology Programme is an achievable target. Creating a permanent wildlife research and monitoring facility within the available space is also an achievable target. Dedicating infrastructure like a vehicle for wildlife studies in the landscape is certainly possible. Many such recommendations that find a place in the EMP with indications of whom the Project agency should partner with while attempting to implement them must be given the due consideration.

- The proposed INO Project can easily take head-on the challenge of contributing to the Goals II and III of the 1995 Seville Strategy of the Man and Biosphere Program. Specific ways of achieving the targets set by the Goal III are the following:

    - Integrate wildlife research with the INO Project by making provisions for a state-of-the-art field research facility within the residential complex and ear-marking staying facilities for students and researchers who are involved in wildlife studies in the landscape
    - Provide a vehicle (four-wheel drive) exclusively for wildlife studies in the landscape
    - Make a formal tie-up (immediately) with the TIFR/NCBS MSc Programme in Wildlife Biology such that the students enrolled for the course can use the INO Project facility for their annual field trip. These field trips that last for as much as twenty days at a stretch can be effectively used for collecting high quality base-line data on wildlife in the landscape and for effective monitoring of the short and long-term impacts of the Project. The proximity to Bangalore will make this initiative a fabulous success and least expensive strategy if carefully fabricated

- While the above pointers have to be given due consideration, there are certain recommendations that might come in as an advantage to the INO Project. These are:

- Eco-development in multiple use areas of tiger reserves and other protected areas permit the use of rope ways in difficult and remote high altitude areas so as to ensure better economic returns to the local people from the transport of goods; *the possibility of reviving the TNEB winch in Singara may be explored if it serves the purpose*

- Eco-development programs should also provide building material to the people who are relocated from the core areas (example the proposed relocation from the Mudumalai WLS); *the possibility of diverting a part of the muck for this purpose has to be carefully explored*

- The project agency should evolve flexible procedures to ensure that the landscape and its inhabitants are insulated and protected from the problems that have been enumerated. Exisiting and routine norms, guidelines, protocols and procedures that typify audit processes should not be used to jusity actions that are contrary to the ecological sensitivity of the landscape.

- In the event that a situation arises wherein the above recommendations are not acceptable to the INO Project or the other interest groups, there are options for relocating the Project outside the

Nilgiris. A number of sites have been assessed during the present study of which the following can be considered:

1. The Palani Hills landscape can be approached from Madurai and Coimbatore, both cities with airport and necessary infrastructure. Six sites including one each in Palar and Pannapatti and two each in Marudhanadi and Manjalar were assessed here. Of these only the sites at Palar and Pannapatti offer the required 1300m of overburden. Such an overburden can be achieved when the tunnel length is around 3700m in Pannapatti. If however, there can be some flexibility in the overburden or the overall slope of the tunnel the sites in Manjalar may be considered for the Project.

2. Munnar, Munthal, Kanagudi, Sakanutu Metti and Bodi are the five sites assessed in the Cumbum-Theni landscape. The landscape is best accessed from Madurai. The maximum distance from the airport is 120km. In both Kanagudi and Munthal the required overburden of 1300m can be obtained when the tunnel is less than 4000m provided the slope can be increased to more than 4 degrees.

3. If 4 degrees slope is mandatory to the tunnel design, only Alyar 1b and Manjalar 6b have the potential.

4. Yet another site is located further south in the Mahendragiri Hills bordering Kanyakumari-Tirunelveli districts. It is accessible by road and rail and the nearest airport is at Trivandrum. An added advantage of Mahendragiri Hills is that ISRO has an exclusive facility here. It may be possible to locate the INO Project within the ISRO facility. The potential can be assessed.

The Union Cabinet formally approved the National Environment Policy (NEP) on May 18, 2006. The key concern of NEP 2006 is one that is directly relevant to the monitoring of compliance (of environmental norms, standards and EMP). Involving the impacted local communities in the monitoring of compliance is mandatory to development projects.

Finally, in compliance with the NEP, the INO Project *must* prepare an Action Plan indicating how it will adopt the recommendations of the EMP. The Action Plan is ‘immediate action’ and the job should be entrusted with the Environmental Monitoring Committee and well before any construction begins at Singara.

Environmental Management Plan for the Proposed India-Based Neutrino Observatory Project in Singara and Masinagudi (Nilgiris) Tamil Nadu

Part I: Introduction

Overview
Scope and Objectives of EMP
About the INO Project

Overview

Science and development have a multi-dimensional symbiotic relationship. Just as science fosters development, development sustains scientific advancement and growth. Science and development that grow at the expense of the environment are however not sustainable. There are many examples to illustrate this contention; the much cited example being the 'grow more food campaign' and Green Revolution. The Green Revolution that appeared to have averted forever the global food crisis has started crumbling in less than 40 years. The Revolution while crumbling had unfortunately catalyzed a number of unanticipated environmental problems such as pollution, water logging, desertification, invasive species, malnourishment, poverty, and farmer suicides.

Whereas the Green Revolution may be an extreme case, there is little doubt that unplanned development is continuing to take a toll of the earth's environment. While it is fashionable to discuss green development and eco-friendly enterprises, the strategy adopted for these innovative designs often fail to yield the anticipated results, as they are not specific to the local environment. Eco-friendly development does not imply that the use of biodegradable material, non-toxic ingredients and zero-waste strategies are the automatic solutions to environmental concerns. Eco-friendly (and sustainable) development is one that is sensitive to the local non-living, biological (living) and social environments. Such development models are yet to be in place in most parts of the world.

India having stayed at the forefront of developing countries in terms of its nature conservation commitments has a great potential in leading the world by way of creating and establishing sound eco-friendly enterprises. Since majority of India's one billion people are still governed by traditions, regional culture and societal norms, there is immense scope for implementing eco-friendly projects that focus on scientific development. It is a lot easier to keep such commitments in focus while implementing projects for the first time than while replicating existing ones.

The proposed INO Project offers immense scope and opportunities for a model (pilot) project of scientific development. The vision of a model project can however be fulfilled only when all the recommendations provided in the environment management plan are strictly adopted. Considering the fact that the location that has been identified for the purpose falls within the Western Ghats Biodiversity Hotspot, and a critical wildlife area it is reiterated that the Project has to be implemented in such a way that it is fully compatible with the statutory norms that govern the region and the specific landscape.

Scope and Objectives of EMP

The environmental impacts of any development project are felt not only at the time of implementation, or when it is operational, but also through and beyond its lifetime. Whereas governments are inclined towards development, worldwide concerns about the rapid degradation of the earth's natural environment have succeeded in sensitizing nations about the need for integrating well-designed safeguards against the loss of nature's integrity that some forms of development are likely to usher in. The most widely adopted means of guaranteeing environmental safeguards against the possible impacts of development is the environmental impact assessment (EIA). And after the Environment (Protection) Act, 1986 came into force in India the Government has made it mandatory that all development projects undertake EIA exercises.

As per EIA mandate, the exercise is carried out prior to site selection and decisions of investment. EIA is meant to provide options for screening alternate sites for locating projects. An EIA is done so that environmental considerations are incorporated right at the time a project is conceived and the cost of environmental protection measures are built into the total cost. As per the Government of India guidelines (MoEF, 1989) EIAs are done not only for new projects but also for those that involve major changes in existing facilities (Daniels, 1992).

According to the Commission for Environmental Assessment (2006) EIA is mandatory for the following development activities:

- Activities in Protected Areas
- Activities in threatened ecosystems outside Protected Areas
- Activities in ecological corridors identified as being important for ecological or evolutionary processes
- Activities in areas known to provide important ecosystem services
- Activities in areas known to be habitat for threatened species
- Extractive activities or activities leading to a change of land-use occupying or directly influencing an area of at minimum a certain threshold size
- Creation of linear infrastructure that leads to fragmentation of habitats over a minimum length
- Activities resulting in emissions, effluents, and/or other means of chemical, radiation, thermal or noise emissions in areas providing key ecosystem services
- Activities leading to changes in ecosystem composition, ecosystem structure or key processes responsible for the maintenance of ecosystems and ecosystem services in areas providing key ecosystem services

What methods an EIA practitioner might adopt depends on the future changes that the project is likely to usher in (Commission for Environmental Assessment, 2006). When considered over 10 or more years into the future EIA turns out to be a tool that helps in visualizing possible, probable and preferable scenarios. Scenario development is focused on alternative visions of the future and is done using one or more of the following methods: scanning (primary and secondary information), trend analysis, trend monitoring, trend projection, creating multiple scenarios, polling, brainstorming, modelling, gaming, historical analysis and visioning (Duinker and Greig, 2006).

EIA has three equally important complementary parts. The first part is the assessment. Assessment involves field studies as well as review of all published and unpublished information about the ecological, social and economic conditions of the project site and the landscape prior to the actual planning and implementation of the project. Based on the preliminary assessment, an environmental impact statement (EIS) is outlined. The EIS includes the following:

1. A brief description of the project
2. Description of the existing environment
3. Likely impact of the proposed project
4. Mitigation, protection and enhancement measures
5. Consideration of alternatives
6. Consideration of 'no change scenario'
7. Summary and conclusions

Based on the EIS, an environmental management plan (EMP) is drawn. An EMP is an implementation plan for mitigation, protection and/or enhancement measures that are recommended in the EIS. To this end an EMP includes

- A work plan
- An implementation schedule
- Man-power requirement
- Protocol for monitoring

The present EMP is based on the EIA report of SACON (Azeez *et al*, 2007). It nevertheless attempts to fill some of the identified gaps in the SACON report by scanning (primary and secondary information), brainstorming and historical analysis. Based on an analysis of trends, the EMP outlines a protocol for monitoring. The EMP does not however present a 'no change scenario' as the landscape has had a long history of human interference and development and the numerous changes that biodiversity and its natural habitats have undergone lie quite bare.

About the INO Project

Wolfgang Pauli first proposed the neutrino in 1930. Neutrinos are tiny, neutral, elementary particles that interact with matter via the weak force. The weakness of the force gives neutrinos the property that matter is almost transparent to them. The Sun, and all other stars, produces neutrinos copiously due to nuclear fusion and decay processes within their core. Since they rarely interact, the neutrinos pass through the Sun, and even Earth, unhindered.

There are many other sources of neutrinos including bursting stars (supernovae), relic neutrinos (from birth of the universe), natural radioactivity, and cosmic ray interactions in the atmosphere of the Earth. For example, the Sun produces over two hundred trillion neutrinos every second and a supernova blast can unleash 1000 times more neutrinos than the Sun will produce in its 10-billion year life time. Billions of neutrinos stream through our body every second, yet only one or two of the higher energy neutrinos will scatter from one's body in his/her lifetime.

Indian scientists were pioneers in neutrino experiments. Neutrinos produced by cosmic ray interactions in the earth's atmosphere were in fact first detected in the deep mines of the Kolar Gold Fields in 1965. The proposed Project is aimed at reviving the underground neutrino experiments in India. To this end a multi-institutional Neutrino Collaboration has been forged with the objective of creating an India-based Neutrino Observatory (INO). The composition and structure of the Neutrino Collaboration is provided below:

The INO Collaboration	
Aligarh Muslim University (AMU)	Aligarh
Banaras Hindu University (BHU)	Varanasi
Bhabha Atomic Research Centre (BARC)	Mumbai
Calcutta University (CU)	Kolkata
Delhi University (DU)	Delhi
Harish Chandra Research Institute (HRI)	Allahabad
University of Hawaii (UHW)	Hawaii
Himachal Pradesh University (HPU)	Shimla
Indian Institute of Technology-Bombay (IIT-B)	Mumbai
Indira Gandhi Centre for Atomic Research (IGCAR)	Kalpakkam
The Institute of Mathematical Sciences (IMSc)	Chennai
Institute of Physics (IOP)	Bhubaneshwar
North Bengal University (NBU)	Siliguri
Punjab University (PU)	Chandigarh
Physical Research Laboratory (PRL)	Ahmedabad
Saha Institute for Nuclear Physics (SINP)	Kolkata
Sikkim Manipal Institute of Technology (SMIT)	Sikkim
Tata Institute of Fundamental Research (TIFR)	Mumbai
Variable Energy Cyclotron Centre (VECC)	Kolkatta
Scientific Steering Committee	
Ramanath Cowsik	Indian Institute of Astrophysics, Bangalore
H S Mani	IMSc, Chennai
V S Narasimhan	TIFR, Mumbai
G Rajasekaran	IMSc, Chennai
Amit Roy	Nuclear Science Centre, New Delhi
Probir Roy	TIFR, Mumbai
Bikash Sinha	SINP & VECC, Kolkata
INO Spokesperson	
Naba K Mondal	TIFR, Mumbai

Source: INO (2006)

The existence of non-zero neutrino masses has profound implications on fields as varied as nuclear physics, geophysics, astrophysics and cosmology apart from being of fundamental interest to particle physics. The Kolar experiments were the harbingers of present day atmospheric neutrino science. Unfortunately, the mines were closed in 1990 and neutrino physics experiments have been since discontinued in India. In view of the importance of neutrino physics and the past experience, it is widely felt that neutrino physics experiments should be revived in India.

INO has been conceived on a scale that no other basic sciences projects in India has attempted. During the first phase of the Project a magnetized tracking iron calorimeter will be installed in an underground laboratory and used to detect atmospheric neutrinos. The aim of the study is to make precision measurements of the parameters related to neutrino oscillations. A foreseen outcome of the science is the determination of ordering of neutrino mass levels.

The installed detector can be used as the far-detector of a long-base-line (6000-7000km long) neutrino experiment using the neutrino beams from a neutrino producing facility in Japan, Europe or USA. While this is envisaged as the second phase of the Project, it is clearly a long-term goal as neutrino factories are not yet a reality. Over the years, INO is expected to develop into a full-fledged underground science laboratory hosting experiments that can exploit its special low background environment and infrastructure, including other disciplines such as geology and biology. Details of the INO Project are provided in INO (2006 & 2007) and Azeez *et al* (2007).

Part II: The Landscape

Information Base and Definitions
The Nilgiri Biosphere Reserve
Mudumalai WLS
Singara and Masinagudi
Project Site

Information Base and Definitions

This Part of the document is a compliance of item 2 of the environmental impact statement (EIS). It aims at providing a description of the existing environment within the Project landscape. While there is more than 200 years of published information about the biodiversity and culture of the Nilgiris Hills and its surrounding landscapes, for the purposes of the EIS, information generated during the last 10-15 years is alone being analysed and presented.

Most normally, EIA reports tend to present detailed lists of plants and animals identified within the Project landscapes. While these are essential for project planning, environmental mitigation and monitoring, the lists are not being included in the EMP, as much of what is available is general to the Nilgiri Biosphere Reserve (example Daniels, 1994; Daniels and Vijayan, 1996). Azeez *et al* (2007) has provided a species list that contains 678 names of flowering plants that includes 189 species of trees, 198 species of shrubs, 223 species of herbs and 68 species of grasses. SACON's list also includes 173 species of vertebrates; 12 amphibians, 46 reptiles, 87 birds and 28 mammals (Azeez *et al*, 2007).

Lists of species are often useful in landscapes where prior information on biodiversity does not exist. Most parts of the Nilgiri Biosphere Reserve are quite well explored biologically and through requests to the institutions such as Botanical and Zoological Surveys of India, BNHS, IISc, Kerala Forest Research Institute (KFRI) and SACON comprehensive lists of a wide spectrum of living organisms including algae, fungi, ferns, bryophytes, insects, spiders, other lesser-known invertebrate animals and all classes of vertebrate animals can be compiled from existing literature and museum collections. Such comprehensive lists are however not critical to the present analysis. Species names/lists are hence limited to important species of plants and animals that are recommended for restoration and monitoring activities. These names/lists are provided in the respective sections.

For the sake of wider readership and understanding the present work has adopted rather simple definitions of geographical terms some of which may deviate from the standard usage. The definitions are also subject to the geographical scales at which the analysis and recommendations are being presented. Thus, Western Ghats represents the region of interest. Within the Western Ghats

- The Nilgiri Hills comprise the hilly zone that spreads across Tamil Nadu, Kerala and Karnataka north of the Palghat Gap.

- Eastern Ghats are the hills that extend eastwards from Nilgiris, through northern Tamil Nadu and southern Karnataka into southern Andhra Pradesh.
- The Nilgiri Biosphere Reserve is the all-encompassing 'conservation unit'.
- The Nilgiris Plateau refers to the tableland above 1500m ASL.
- The Nilgiris district is in Tamil Nadu with its headquarters in Ootacamund (Ooty).
- The Project landscape includes Mudumalai WLS and the adjoining areas such as Masinagudi, Moyar and Singara.
- Singara and Masinagudi are the specific project sites.

The Nilgiri Biosphere Reserve

During the 1970s UNESCO launched the Man and Biosphere Programme (MAB). The goal of the UNESCO-MAB Programme is to integrate conservation and development. It deviates from the early concepts of exclusive 'inviolate' conservation zones, as the Yellowstone National Park, to be more inclusive in that human cultures and livelihoods are seen as integral parts of biodiversity conservation. The UNESCO-MAB Programme offered the Biosphere Reserves concept. In adopting the Concept, nations that have a wealth of biodiversity are obliged to designate vast geographical areas that are representative of their biological diversity. The designated Biosphere Reserves are to be designed and managed such that there are core (inviolate and pristine) zones, buffer (research and sustainable use) zones and manipulation or transitional (agriculture, human settlement and sustainable development) zones that are complementary to each other (Afrinet/MAB, 1995).

After the Government of India adopted the MAB Programme, it set a target of setting aside 14 Biosphere Reserves in the country. The Nilgiri Biosphere Reserve (NBR) was the first to be established in India when it came to be in 1986. NBR is also the only Indian Biosphere Reserve that is formally brought under the UNESCO's global network of Biosphere Reserves. NBR found a place in the global list in the year 2000.

NBR is the most significant chunk of land (and water) that represents the biological diversity of the Western Ghats (Daniels, 1993). Western Ghats is known for its wealth of plants and animals and high percentage of endemic species; around 40% of the known species. Western Ghats is also known for its long history of human impacts (Daniels and Vencatesan, 2008) and has rightly earned a place in the list of 'biodiversity hotspots' that are recognized on Earth. Hotspots are regions where the biological diversity is very significant but at the same time are under imminent threats of habitat degradation, erosion of diversity and extinction of species.

NBR covers 3 southern states, Kerala, Tamil Nadu and Karnataka and an area of 5520km^2 (2020km^2 core, 2290 km^2 buffer/forestry and 1330 km^2 manipulation/agriculture zones). It was established vide the Government of India notification number J.22010/6/86.CSC on September 1, 1986. It embraces a complex of Protected Areas and reserve forests including the Rajiv Gandhi National Park (Nagarhole), Bandipur Tiger Reserve, Wyanad Wildlife Sanctuary and the slopes of Nilambur, Silent Valley National Park, Siruvani

Hills, J Jayalalithaa Wildlife Sanctuary (Mudumalai), Mukurti National Park and the adjoining Nilgiris Plateau (Daniels and Vijayan, 1996).

NBR is an elevated mass of ancient rocks that are 2 billion years old. These massifs rise to over 2000m ASL locally. Peaks above 2400m are frequent; the highest being Dodabetta at 2637m ASL. Rainfall varies from less than 500mm in the eastern parts to 7000mm per year in the western slopes. Winter frost is common in the Plateau that is characterized by relic species and communities that thrived during the Pleistocene (ice ages).

The biological wealth of NBR is fairly well understood. From the available information it is evident that 20% of all species of flowering plants, 15% of butterfly species and 23% of vertebrate animal species (excluding marine) that are found in India occur in NBR. Fifty-five percent of the vertebrates that are endemic to the Western Ghats are also found in NBR; 39 species of fish, 31 species of amphibians, 60 species of reptiles, 14 species of birds and 12 species of mammals. Amongst animals, fish, amphibians and reptiles have contributed the most to the endemic biodiversity. Between 25 and 30 species including fish, amphibians and reptiles that are found in NBR are not known to exist anywhere else in the world. 82 species of flowering plants are also endemic to NBR (Daniels, 1993). The list of endemic species has grown longer over the years as more and more plants and animals have been discovered and identified.

The greatest conservation value of the NBR lies in the fact that it supports substantial numbers of some of the world's most endangered mammals. Not less than 5000 elephants (recent estimates suggest there can be more than 6000) are found here. Between 60 and 75% of the 415 tigers presently known from Kerala, Tamil Nadu and Karnataka are found here. Amongst others, the Nilgiri Tahr, Nilgiri Langur and the Lion-tailed Macaque have large populations within the Biosphere Reserve.

Agriculture and development are the two major reasons for adverse environmental impacts in NBR; the latter being more severe, especially due to the construction of dams/reservoirs, tunnels and roads to feed and maintain the powerhouses. The Tamil Nadu Electricity Board has implemented several hydroelectric projects during the past 75 years. There are 12 hydroelectric powerhouses located in the Nilgiris district alone with an installed capacity to generate more than 800 MW of electricity (Table 1).

Table 1: The 12 hydroelectric Powerhouses located in the Nilgiris District (INO, 2007)

Serial No	Name of Powerhouse	Capacity (MW)
1	Pykara PH	59
2	Pykara Micro PH	2
3	Moyar PH	36
4	Kundah PH I	60
5	Kundah PH II	175
6	Kundah PH III	180
7	Kundah PH IV	100
8	Kundah PH V	40
9	Kundah PH VI	30
10	Mukurti Mini PH	0.7
11	Maravakandy Dam PH	0.75
12	PUSHEP PH	150
Total		833.45

Tea industry has exploited the NBR during the past 100 or more years. In the Nilgiris district alone the present cover of tea estates is 45,974ha (459.74km^2) with an annual production of around 60,000 tons (INO, 2007). Besides tea, plantations of eucalyptus, wattle, cinchona, coffee and a variety of hill vegetables have impacted the NBR (Daniels and Vijayan, 1996).

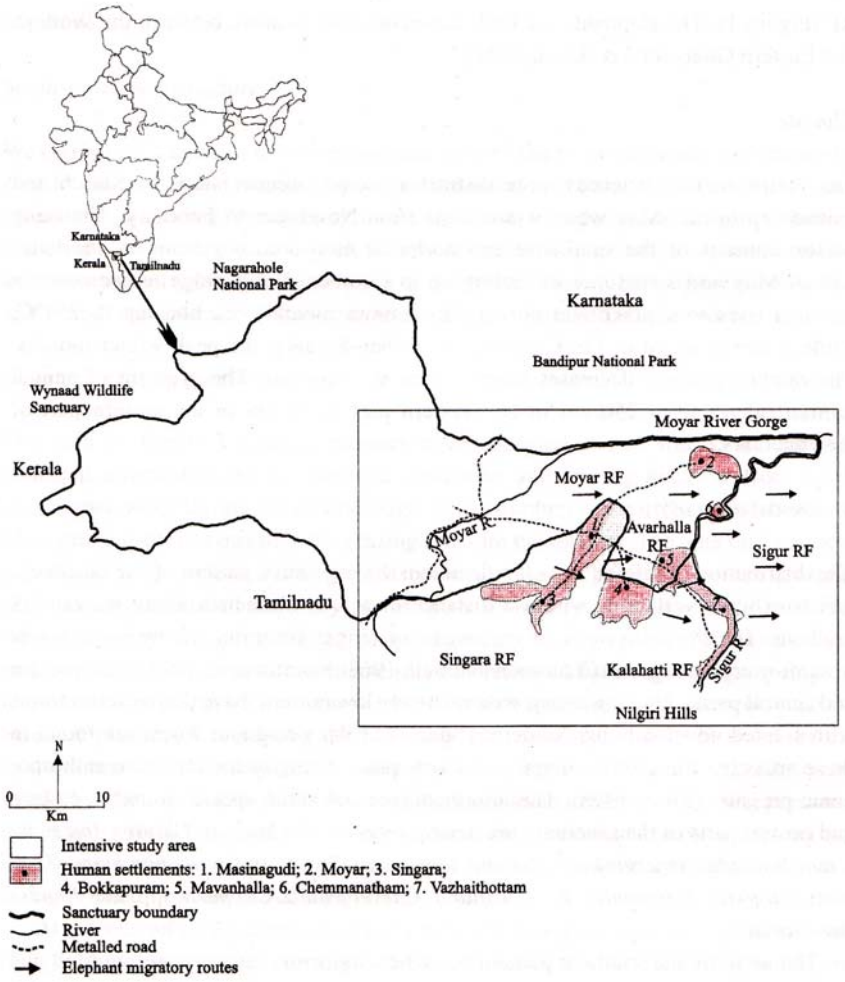
Mudumalai WLS

The Mudumalai WLS (renamed as J Jayalalithaa WLS during the early 1990s) is situated in the north of the Nilgiri Hills at an altitude of 850-1250m ASL. It spreads over 321km^2. Average annual rainfall varies from east to west; being drier in the east (less than 500mm) and moister in the west (2500mm). Rains are largely confined to the June-November seasons. The east-west gradient in the rainfall and local variations in the topography have together created and sustained a mosaic of vegetation that includes scrub, thorn forests, dry deciduous forests, tree savannas, moist deciduous and semi-evergreen forests (Prabhakar and Pascal, 1996). And within the moister zones, the low-lying areas are swampy, locally called 'vayal' (Vencatesan, 2003). Grazing, fire and various kinds of human interference have created a variety of secondary and degraded habitats throughout the landscape. To add to these, there are monocultures and agriculture. A large number of species of exotic plants like *Lantana camara, Ageratina adenophora* (*Eupatorium glandulosum*), *Parthenium hysterophorus* and *Prosopis glandulosa* have proved to be invasive in and around Mudumalai WLS (Azeez *et al*, 2007; Sivaganesan *et al*, undated).

Deciduous forests in the southern Western Ghats are generally richer in terrestrial vertebrates including reptiles (lizards in particular), birds and mammals (Daniels and Vencatesan, 2008). The Mudumalai WLS is no exception to this general pattern and as such has the greatest conservation value when it concerns non-aquatic vertebrate animals. Plant diversity is generally contributed by the many species of grasses, herbs and shrubs in the landscape although the diversity of trees *per se* is low. The low diversity of trees in the landscape has been inferred from an assessment of the permanent 50ha forest dynamics plot that is being monitored by the Indian Institute of Science since the mid 1980s. Number of species of trees known in the 50ha plot is 71 (Sukumar *et al*, 1992; Vencatesan, 2003).

The Mudumalai WLS is amongst the first protected areas established in Tamil Nadu. As early as 1940 an area equal to 23 square miles (about 60km^2) was earmarked for the sanctuary. The sanctuary was expanded to its present extent of 321km^2 in 1958. The earliest human inhabitants of the landscape are the Paniyar, Betta Kurumbar, Jenu or Shola Nayakar followed by early migrants such as the Moundadan Chetti and Wyanadan Chetti. Of these, the Chettis are land-owning agriculturists (Vencatesan, 2003). With the onset of development in the form of hydroelectric projects since the early 1930s a large population of labourers and government employees have immigrated and settled in the landscape. Along with the immigrants came livestock. The 30 years between 1960 and 1990 witnessed the greatest ecological transformation in the landscape.

The sanctuary is significant for its large population of elephants. Although estimates tend to vary, it is evident that the largest population of elephants in Tamil Nadu is found here. Together with the adjoining parts of Kerala and Karnataka the landscape may be home to an estimated 1800-2300 elephants (Baskaran *et al*, 1995). Besides elephants, the sanctuary is an important habitat for gaur, sambar and chital. The large carnivores found here are tiger, sloth bear, leopard, hyena and wild dog. The 60-80 tigers (around 20% of the tigers found in the three states of Tamilnadu, Kerala and Karnataka) in the landscape prompted the Government of India to declare the sanctuary as a Tiger Reserve.



Singara and Masinagudi

Masinagudi village Panchayat comprises of the following settlements: Masinagudi, Singara, Theppakadu, Moyar, Bhoothakallu, Chemmnatham, Mavinhalla, Vazhaithottam and Dodda Moyar, spread over 134.03km^2. The density of human population is 36/km^2. The area of the Panchayat was demarcated before the Census of 1960-61. The Panchayat includes only lands that are under the jurisdiction of the Revenue Department, although protected forests may be intermittently present. Rather interestingly, the demarcation of the revenue village has been done using geo-ecological features such as the Moyar gorge and the river as boundaries and hence it is no surprise that the entire area coincides with the elephant corridor that is being proposed as a conservation area.

That indigenous people (the Kurumbas and Irulars) were sparsely present even in the past in Masinagudi is evident in the fact that in 1971 only 19.84% of the total population in the Panchayat was comprised of scheduled tribes. The ST population has continued to decline that current estimates place it at a mere 6%

of which may are not native but have migrated from Salem and other adjoining districts. Scheduled castes were 23.21% in 1971 and 38% at present, once again due to inflow of migrant labor. Most residents have survived on occupations/livelihoods that are directly derived from forests (tourism) and hydroelectric projects. This is evident from data that suggests that until 1990 there were only 168 cultivators and 264 seasonal agricultural workers in Masinagudi village.

Masinagudi is smaller than Singara in extent but has a much larger human population. The population size that was recorded during the early 1990s was 3924 in 768 households; a population density of 785/km^2 that is 10 times higher than Singara. Of the resident families, 55% were laborers and 17.5% were government employees. Unlike Singara, Masinagudi had much larger livestock population in the early 1990s. At least 300 families owned livestock that included cattle, buffaloes, sheep and goats numbering 3257; 79% of which was cattle (Silori and Mishra, 2001).

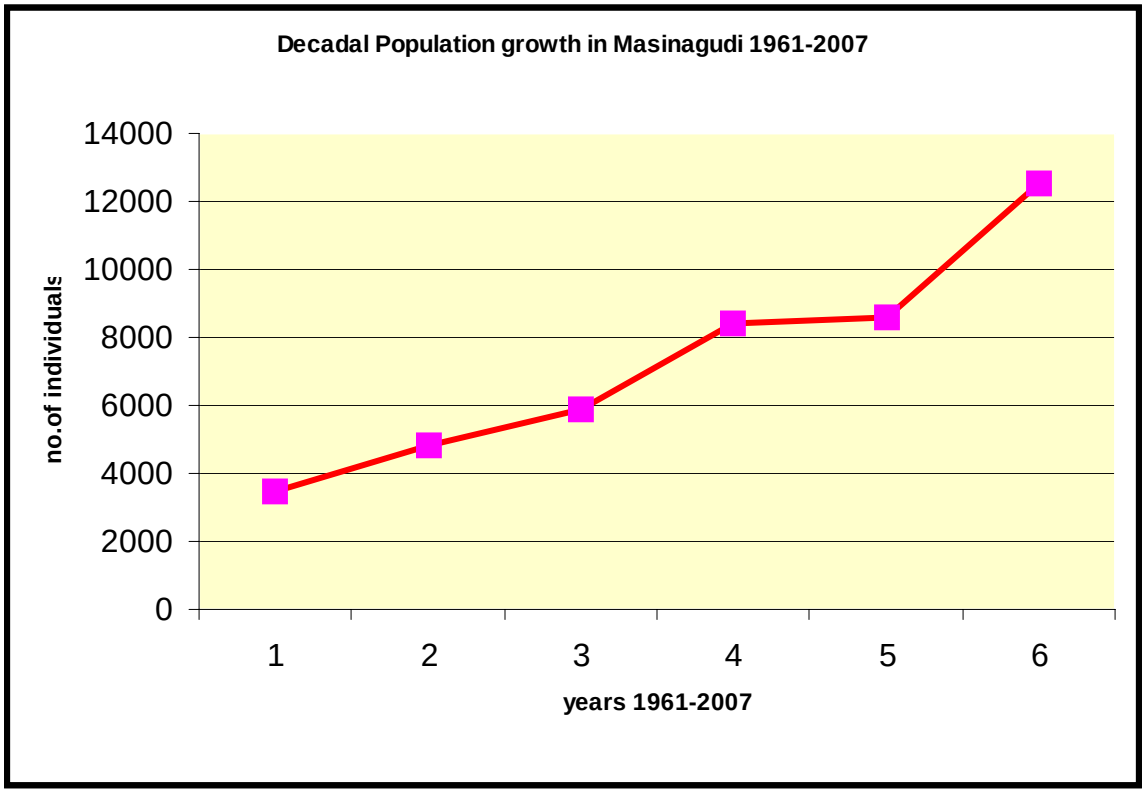
Singara village (essentially TNEB Camp) had a human population size of 567 representing 115 families (population density of 74/km^2) in the early 1990s. Of these a mere 38 families owned livestock. The total livestock population (largely cattle and some goats) was 221 (Silori and Mishra, 2001).

Masinagudi has historically been a favored land for rearing cattle that were managed by tenancy rights. Apart from catering to the meat industry of Kerala, trade of dug was the most significant trade of the region that during the 1970s and 1980s the village had between 28,000 and 30,000 cattle. These cattle were free ranging. Of the 139 residents that were interviewed during the study, 108 had moved to Masinagudi to trade dung.

Cattle population however dropped subsequently in that during the 1990s there were about 15,000-17,000. Current estimate suggests that there are around 4800 cattle in Masinagudi. Cattle frequent the corridor through the Singara-Masinagudi road, often coinciding with the migratory season of elephants leading to competition and outbreak of contagious diseases. There are also instances of leopards preying on cattle along the corridor. The local people recurrently burn the forests along the corridor to encourage fresh growth of grass for the cattle.

Between 1960 and 1990, the human population in the Masinagudi Panchayat (includes Singara and other adjoining hamlets/settlements) had grown by 142%. As per the 1991 census the population was 8416 and by 2001 it was 8577. According to the records at the Panchayat Office and Village administration office the population at present is 12,535. Livelihood provided by tourism and associated infrastructure development has attracted more people that the population has continued to be on the rise. According to data provided by the Revenue Department and the Panchayat President, the reported human population is only of those

who are resident and hold ration cards. And as there is a large floating population, the actual number of people is more than 10,000 in Masinagudi alone that is a notable rise from the 3900 in 1991.



There are at least 100 registered vehicles in Masinagudi. Sixty-one resorts and 121 shops are also in place here. While the human population in Masinagudi is on the rise, it has dropped in Singara. The population of 567 reported in 1991 has since dropped to 302.

The Singara-Masinagudi part of the landscape is encompassed by Bokkapuram RF, Singara RF, Avarahalla RF, Moyar RF, Kalmalai RF and Northern Hay RF. Both Singara and Masinagudi are outside the limits of the Mudumalai WLS; the northern limit of the TNEB campus at Masinagudi is practically abutting the nearest boundary of the Sanctuary. Singara is farther away (7-15km) on any side. Singara (Project site) is 1039m ASL (about 100m higher than Masinagudi) and is moister than Masinagudi. The vegetation type is more of the semi-evergreen type as is evident from the available maps and the local biodiversity. It is located 6km southwest of Masinagudi.

At least 2 intensively used segments of the Moyar-Avarahalla Wildlife Corridor viz., Kalmalai-Singara-Avarahalla (also known as Singara-Mavinhalla corridor) and Moyar-Avarahalla are in close vicinity of the Project sites. Of which, the Singara-Mavinhalla Corridor is bisected by the 6km long Singara-Masinagudi road.

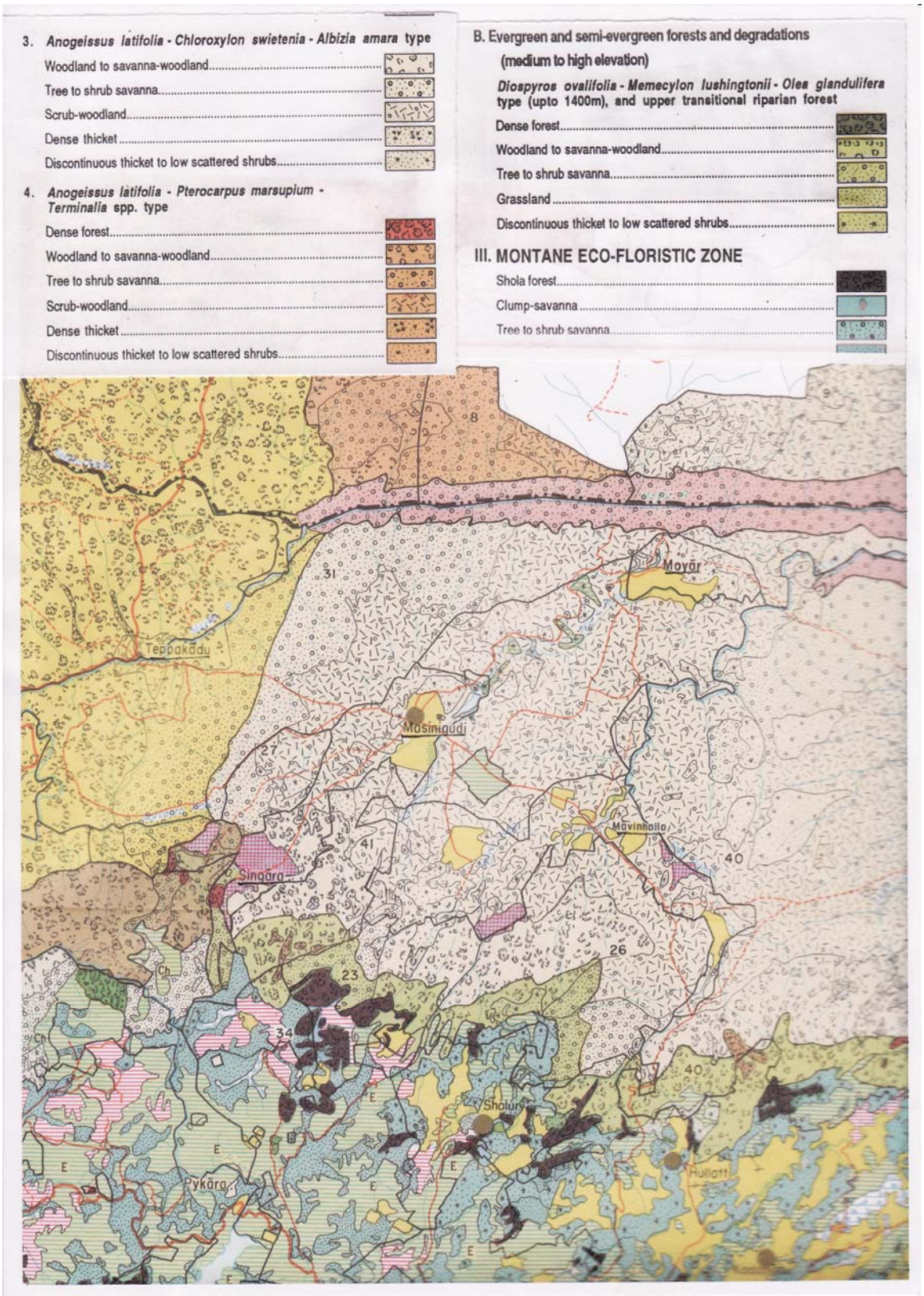
Masinagudi (around 950m ASL) that evolved from a diminutive settlement into a major village by the early 1960s is the pivot in the 134.03km^2 landscape. It divides the otherwise contiguous forests into the northern Moyar-Avarahalla segment and the southern Singara-Mavinhalla segment. It falls in a rainfall zone shared by Maravakandy and Moyar. The rainfall recorded for Maravakandy and Moyar during 1992-1996 averages at 532mm and 652mm respectively. Masinagudi, by road, is 6km northeast of Singara.

The impact of changing land use is evident throughout the Singara-Mavinhalla corridor. The information on land use was obtained from the records of the village administrative officer (VAO), the office of the Assistant Director of Survey and Land Records (District Survey Unit/revenue map in the scale 1:1600), on-site assessment and verification and interviews with the local people.

In view of the fact that the habitat is open and not manned, collection of wood for fuel and construction, and making implements by the inhabitants of Masinagudi, Singara, Chemmanatham and Moyar is extensive. Woodcutting is intensive along the flume channel. Much of the wood is sold at the local market and to the resorts (for camp fire).

As in other parts of the State, land in the landscape is held by the Revenue and Forest Departments. Land governed by the Revenue Department exists as revenue-patta land, revenue-wastelands and revenue-forest lands. Using the Singara-Masinagudi road as the benchmark, land holding on either side was determined.

The landscape has extensive revenue forests that have not been properly demarcated on the ground, though they serve as important components of the Singara-Mavinhalla corridor. Since the lands have not been accorded their rightful importance, they have been made available to projects as that of TNEB since the 1940s. What is now being referred as Singara village is essentially a camp that was developed by modifying the habitat to accommodate the TNEB staff.


3. Anogeissus latifolia - Chloroxylon swietenia - Albizia amara type
Woodland to savanna-woodland
Tree to shrub savanna
Scrub-woodland
Dense thicket
Discontinuous thicket to low scattered shrubs
4. Anogeissus latifolia - Pterocarpus marsupium - Terminalia spp. type
Dense forest
Woodland to savanna-woodland
Tree to shrub savanna
Scrub-woodland
Dense thicket
Discontinuous thicket to low scattered shrubs
B. Evergreen and semi-evergreen forests and degradations
(medium to high elevation)
Diospyros ovalifolia - Memecylon lushingtonii - Olea glandulifera type (upto 1400m), and upper transitional riparian forest
Dense forest
Woodland to savanna-woodland
Tree to shrub savanna
Grassland
Discontinuous thicket to low scattered shrubs
III. MONTANE ECO-FLORISTIC ZONE
Shola forest
Clump-savanna
Tree to shrub savanna
Moyar
Teppakadu
Masinagudi
Mavinhalla
Singara
Sholur
Pykara
Hullatti
Ch
E
8
31
27
41
40
26
23
34

Project Site

The Project, as proposed, is spread over two localities; Singara and Masinagudi. The Project site at Singara will house the INO portal, access tunnel, the utility building and area for disposal of muck. The portal (as per alignment 2 that has been proposed) will lie within a distance of 200m from the south portal of the PUSHEP access tunnel (and 50m away from the main gate of the TNEB Pykara Camp) and close to a private coffee estate at Singara; however within TNEB land. The 2370m long access tunnel that adopts a gradient of 1 in 13.5 will pass through the coffee estate (for about 200m) and the underground laboratory will be located 1300m below the peak (2207m ASL) that rises from within the Singara-Bokkapuram reserve forests (Azeez *et al*, 2007; INO, 2007) (see Map).

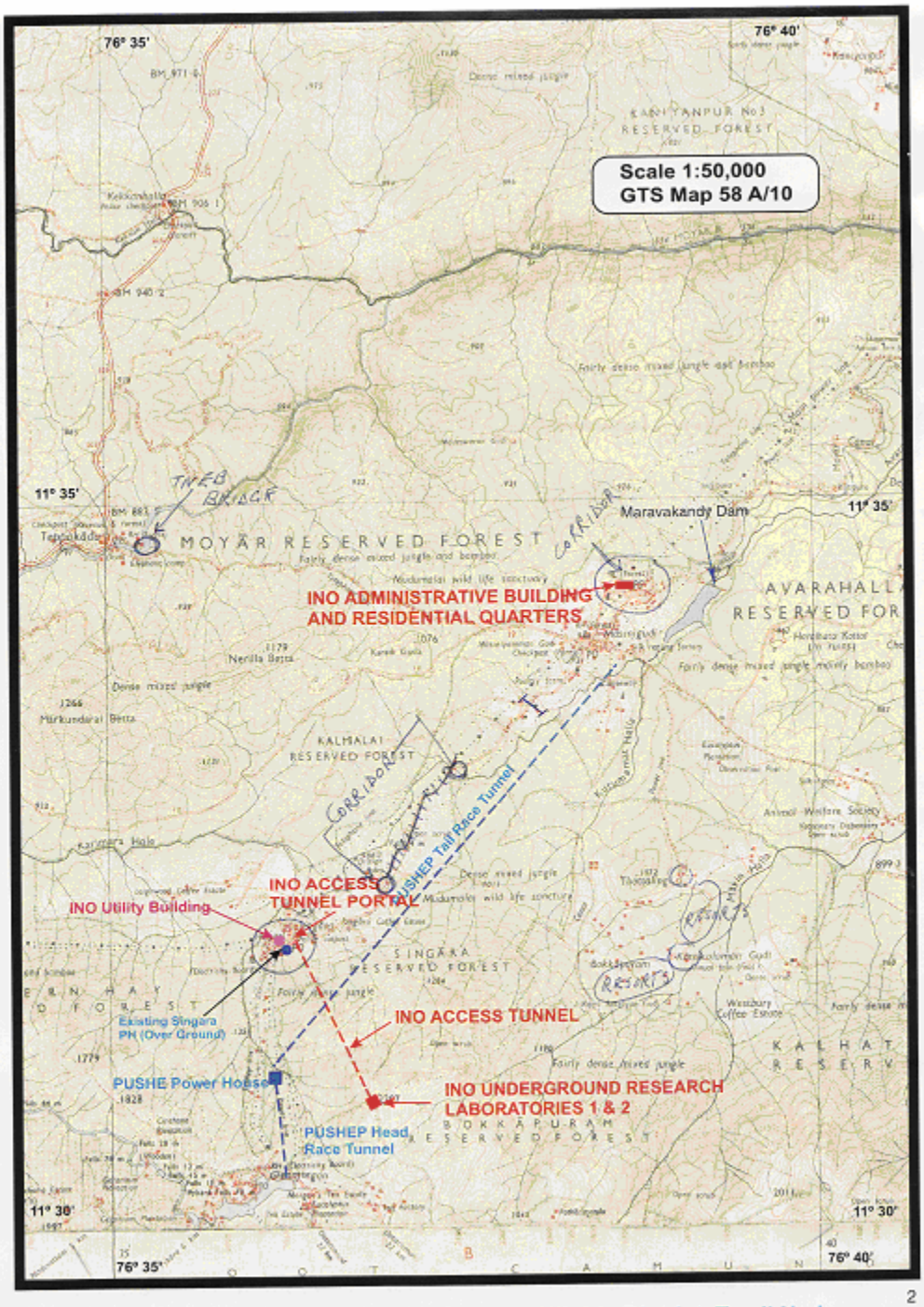


Fig. 2. Layout of INO Project at Singara, Nilgiris District, Tamil Nadu

The total area of land that is required for the Project at Singara is provided in Table 2. In principle, the forestland is only 'notional' as the construction required for the Project in the said area is underground (INO, 2007). Above ground activity in Singara is on TNEB land and the adjoining coffee estates.

SACON has listed some of the plants found here and they include grasses, herbs, shrubs and trees. The trees known from the site are *Artocarpus* spp (Jack and relatives), *Ficus* (4 species), *Syzygium cumini* (Jamun), *Anogeissus latifolia, Butea monosperma* (Flame of the Forest), *Cassia fistula* (Indian Laburnum), *Dalbergia* sp (allied to Rosewood) and *Kydia calcina* (Azeez *et al*, 2007). Most of the isolated trees that have survived within the TNEB campus earmarked as the Project Site are between 150 and 200 years old.

Kydia calcina is a food plant of elephant and it tends to attract elephants. Forest-dwellers inside Mudmumalai WLS do not allow this tree to grow in their gardens and backyards as they attract elephants (Vencatesan, 2003). The non-preference of this species by people locally and the excessive pressure due to elephants (they feed on the bark of the tree), *Kydia calcina* is one species of forest trees in Mudumalai that is slowly disappearing (Vencatesan, 2003). Data on population trends of trees available from the 50ha forest dynamic plot has also suggested a drastic decline in the population of *Kydia calcina* during the past 2 decades (Sukumar *et al*, 1998), although there are indications that in recent years, a process of recovery is visible (personal communication: Bharanayya).

Table 2: Details of land required and sources in Singara (INO, 2007)

Utility	Land requirement and Source		
	TNEB (ha)	Forest* (Ha)	Private (Ha)
Access tunnel (underground), portal and working front	0.05	-	0.925
Access tunnel and auxiliary tunnel (underground)	-	3.2375	-
Underground research lab/caverns 1&2	-	1.48	-
Utility building	0.2	-	-
Roads, guard room, rest house	0.25	-	-
Total	0.5	4.7175	0.925

*Notional as the facility is underground

The dry climate that governs Masinagudi has favoured thorn and deciduous forests dominated by trees such as *Acacia leucophloea, Cassia fistula, Zizyphus mauritiana* and others like *Anogeissus latifolia* and *Terminalia* spp. *Lantana camara* is a common invasive and the plantations are dominated by *Eucalyptus globulusos* (Azeez *et al*, 2007).

The residential facilities (including administration, hostel and quarters) will be located in Masinagudi; within TNEB land. The extent of land required for the construction of residential facilities in Masinagudi is provided in Table 3. The 4ha land earmarked for the purpose lies in the northwest extreme of the TNEB land. It is presently degraded with dense growth of the invasive *Lantana,* as with many of the peripheral portions of the Mudumalai WLS. There are however, scattered trees, especially the magnificent Flame of the Forest (*Butea monosperma*). Elephants use the habitat as they move through the Moyar-Avarahalla corridor, especially in summer as the only source of water available here is located close by (near the Log House of

the Forest Department within the adjacent RF). Gaur (small herds) has also been observed in the habitat. Other common mammals observed during the study include the black-naped hare (abundant) and jackal.

Table 3: Details of land required and sources in Masinagudi (INO, 2007)

Utility	Land requirement and Source		
	TNEB (ha)	Forest (Ha)	Private (Ha)
Surface lab, assembly shop and workshop	0.15	-	-
Office for scientists and administration, stores and lecture halls	0.7	-	-
Visitors hostel & guest house	1.08	-	-
Residential quarters	0.6	-	-
Roads and gardening	0.5	-	-
Free space	0.97	-	-
Total	4.0	-	-

Not less than forty-five species of birds were observed in just one morning in the 4ha plot during the study. The habitat is used as a thoroughfare by the local residents (especially women as they walk back with water) and for herding cattle. Children were also using the bushes as a public toilet. Interestingly, as informed by the keeper of the PUSHEP guesthouse, a small herd of elephants (3 individuals) had sneaked on to the portico of the guesthouse after knocking down the wall some 8 months ago. The elephants were then driven out and back into the Corridor.

Part III: Impact of Hydroelectric Projects on the Landscape

Justification
Origin and Background of Hydroelectric Projects
Temporal and Spatial spread
Review of EIA
Identified Gaps, Issues and Concerns
Effectiveness of Environmental Monitoring and Mitigation
Environmental Costs and Social Benefits
Effectiveness of Damage Containment and Compensations
Lessons Learnt

Justification

The proposed INO Project is the first of its kind in India (also South Asia) and as such there is not any benchmark to assess its environmental impacts. However, as it is envisaged that the location of the Project will be in the Singara-Masinagudi parts of the Mudumalai landscape in the Nilgiri Hills, and the Project involves extensive tunnelling, the Pykara Hydroelectric Project can be treated as a benchmark. Unfortunately due to the long and staggered history of the Pykara Hydroelectric Project and the fact that there were not any clear environmental guidelines till about twenty years ago, direct comparisons are not possible. What has therefore been attempted in the sections that follow is an analysis of the Pykara Project, its merits and shortcomings and how they might have impacted the environment both in history and the recent past. Needless to state that most scientists and engineers who were involved during the initial phase of the Project have ceased to exist; their diaries and writings, if any may well be lost or buried deep in one or more archives. Nevertheless, since INO is not a hydroelectric project, it may suffice if some common impacts such as that caused by blasting and tunnelling, habitat fragmentation due to construction of roads, increased traffic and human occupation in the landscape, are understood from an analysis of the available information and through direct field assessment.

Origin and Background of Hydroelectric Projects

Pykara is one of the highest of south Indian streams originating in the Mukurti peak at an altitude of around 2400m ASL. It is the biggest stream in the Nilgiris Plateau. The stream flows over a number of cascades and waterfalls that it provides a drop of about 1000m before it reaches the Pykara Dam at Glenmorgan. Downstream Pykara joins the River Moyar and eventually River Cauvery through its tributary, the River Bhavani.

The Pykara Hydroelectric Project Scheme was the first hydroelectric project that the state of Tamil Nadu (erstwhile Madras) launched and successfully implemented. The Project that was formally sanctioned during the British rule in 1929 was meant to generate and supply electricity for the industries in Coimbatore.

Situated in the Nilgiris Plateau, the Pykara HP stands out as the highest in Asia and continues to be amongst the highest of hydroelectric projects in the world (source: Pell Frischmann Group and TNEB).

The Pykara Ultimate Stage Hydroelectric Project (PUSHEP) that was completed during the beginning of the 21st century was formally inaugurated in September 2005 by the then Chief Minister of Tamil Nadu, Selvi J Jayalalithaa. PUSHEP cost the Government of Tamil Nadu a sum of Rs 3.83 billion (source: The Hindu, September 7, 2005). The power generation capacity of PUSHEP is 150 MW.

Temporal and Spatial spread

The Pykara HP has been implemented in stages over a period of 75 years; PUSHEP being the final one. The spadework for the Project started in 1932. The first power-generating units were small with a capacity of 6.5 MW. Three such units were installed in the powerhouse located at Glenmorgan taking advantage of the run-of-river water alone. In order to enhance the available flow, two regulating storages were added. These storages were located at Mukurti (upstream) and Pykara (downstream). The additional flow thus achieved enabled the installation of more power generation units. Subsequently, another storage dam was built across the Sandynallah stream. This reservoir was built to regulate and divert flows from a catchment of 44.03km^2 into the Pykara Dam. The network of reservoirs thus built helped achieve the set target of generating 70 MW of electricity (Tyagi, 1995).

In 1955, the Nilgiris Plateau experienced yet another major transformation due to the Kundah Hydroelectric Scheme. The Kundah HS led to the creation of Avalanche Dam (372m long; 57.66m high) and Emerald Dam (328.6m long; 65.72m high) around Portimund within the Kundah basin. A 733.77m long horseshoe-shaped tunnel that had the capacity to discharge 900 cusecs of water connected the two dams. The Avalanche and Emerald streams were tributaries that directly fed Pykara before the dams were constructed.

Two other dams were constructed across the tributaries of Pykara in 1965; Parson's Valley Dam (14.5km^2) and Portimund Dam (10.6km^2). These dams enhanced the volume of water that got diverted into the Kundah basin. The Naduvattam Diversion Project completed in 1976 harnessed water from the 12.82km^2 Naduvattam basin that lies to the west of Pykara basin. In order to augment further the power generation capacity of the Pykara HP, water was diverted from the 12.95km^2 Lone Valley and Melkodmund stream in the Nilgiris Plateau; both streams flowed between Pykara and Sandynallah. The huge volume of water thus diverted into the Pykara Dam necessitated the enlargement of the fore bay. The enlargement of the Pykara fore bay was completed in 1978-79. During the 1990s when the Pykara HP was in its final stage of implementation (PUSHEP) it had a well-established network of reservoirs that harnessed water from a catchment fed by Pykara, Sandynallah, Naduvattam, Melkodmund and Lone Valley streams (all tributaries of River Moyar). The catchment has provided the gross storage necessary for making PUSHEP operational and generating the additional 150MW of electricity that was envisaged (Tyagi, 1995).

During 1946-52, the Moyar Hydroelectric Scheme was implemented. The Scheme was implemented using the tail water of the Pykara HP. The project is located at a distance of 16km downhill of the Pykara

(Glenmorgan) power station. The Moyar HS also benefits by the water that is diverted from the Maravakandy Dam (located north-east of Masinagudi) through a flume channel. At Maravakandy there is a mini-hydroelectric scheme capable of producing 2.6 MW of power (Tyagi, 1995).

The Maravakandy-Moyar flume channel is 6.81km long and 10.86m wide. The Moyar Ultimate Stage Hydroelectric Project (MUSHEP) that was proposed in 1995-1996 had envisaged the widening of the flume channel by another 2m. The channel that is around 2m deep had 19 bridges across it; 3 wide (5-11m), 16 narrow (1-5m) and 3 underground passages (Azeez *et al*, 1996).

The various hydroelectric projects that were implemented since 1932 in the Nilgiris Plateau together established a 53km network of tunnels (INO, 2007). Of these, MUSHEP and PUSHEP (being the closest in proximity and time) are most relevant to the INO Project. PUSHEP involved the construction of a headrace tunnel 21.2m long and with a diameter of 2.1m between the Glenmorgan fore-bay and the underground powerhouse located in the north. It also has an underground control-cum-surge shaft having a diameter of 5m with gates and a 1381m long pressure shaft (2.4m diameter) opening into three individual penstocks near the powerhouse end. Three power-generating units each with a capacity of 50 MW have been installed within the underground powerhouse (20m wide, 39m high and 70m long; 6.5m x 6.5m access tunnel with 3m vertical sections and D-shaped top; Mondal, 2004). The tailrace waters of the powerhouse are led to the Maravakandy Dam by a 6680m (6805m as per Azeez *et al*, 1996) long tunnel that has a diameter of 3.16-3.5m. In addition, there are two tunnels; a 1990m long access tunnel and a 1038m long ventilation-cum-cable tunnel (Tyagi, 1995).

Review of EIA

Hydroelectric projects have directly impacted not less than 150km^2 of the watershed in the Nilgiris Plateau. The major aboveground impacts include loss of wildlife habitats by inundation, fragmentation of wildlife habitats by dams, channels and the wide network of roads and immigration of people in the form of labourers, petty traders and government employees. Vast tracts of forests were also cleared to create safe corridors for overhead power transmission lines (example the 90km long 110kv transmission line between Moyar and Gobichettipalayam; Azeez *et al*, 1996) and surface pipes laid to divert water locally (example Western Catchment within the Mukurti NP). Below ground, the nearly 53km network of tunnels required the excavation of hard rock (Tyagi, 1995; INO, 2007). The muck thus generated and partly left unused has usurped natural habitats locally (Azeez, *et al*, 2007).

The 75 years that spanned the initial and final stages of the Pykara HP fall into 3 distinct periods in the history of environmental conservation in India. The first period (1932-1972) being the longest, was one wherein there was no law that could effectively regulate projects that are likely to have adverse impacts on the environment and forests. As such, it is unlikely that any government or non-government agency had felt the need to carry out an Environmental Impact Assessment (EIA) of projects. Development projects (especially those focused on generating power) had a freehand and their insensitivity towards the environment and ecology of the Nilgiris Plateau is still evident throughout the landscape. In fact, the Asian

Elephant Research and Conservation Centre identified hydroelectric projects as a 'major cause for wildlife habitat fragmentation in the Nilgiris' (source: AERCC, unpublished).

That hydroelectric projects have been the greatest cause of habitat loss and fragmentation in the Nilgiri Biosphere Reserve has been repeatedly emphasized (Gadgil and Sukumar, 1986; Sivaganesan *et al*, undated; Tyagi, 1995). However, a review of published information suggests that there was no environmental impact assessment or environmental management plan for the first 40 years of Project activity. It was only after the Wildlife (Protection) Act, 1972 came into force that many parts of the Nilgiris Plateau and adjoining landscapes that were earlier notified as Game Reserves and Wildlife Sanctuaries were brought under a regime of strict protection.

Despite the Protected Area status that some parts of the Nilgiris enjoyed after 1972, including the status of Biosphere Reserve in 1986, areas impacted by the hydroelectric projects were not ecologically restored. This was for two reasons; one, many sites continue to be owned and/or managed by TNEB and two, the strategic location of the hydroelectric projects and the related infrastructure guaranteed free access to all project sites for TNEB because of the existing State or Panchayat roads that passed through key wildlife habitats and conservation areas. As a result, despite the realization of the impacts and the coming into force of the Wildlife (Protection) Act, the period 1972-1986 was also a 'dark' period with little or no focus on regulating the environmental impacts of development projects such as hydroelectric projects. The only, remarkable exception to the general rule is Silent Valley a 90km^2 rainforest habitat that enjoys the status of a National Park within the Nilgiri Biosphere Reserve in Kerala.

The Government of India enacted the Environment (Protection) Act in 1986. It was only after this that there has been any focus on environmental impacts of development projects. The Environment (Protection) Act, 1986 established Central and State Pollution Control Boards. It also notified the EIA Rules and made it mandatory for development projects to do impact assessments and develop detailed guidelines for mitigation of adverse impacts. In anticipation of the enactment of the Environment (Protection) Act, 1986, the Ministry of Environment and Forest (GOI) published EIA guidelines from time to time for the different kinds of development projects (example: Anonymous, 1985).

As per the MoEF (1989) guidelines, an EIA is undertaken in such a way that it helps in evolving an environmental management plan (EMP). It is mandatory that environmental considerations are incorporated in the initial stages of project planning and cost of environmental protection measures should be treated as an integral component of the total cost of the project. The guidelines are applicable not only to all new projects, but also to projects involving significant changes in existing facilities (Daniels, 1992).

Hydroelectric projects in the Nilgiris including PUSHEP were reviewed through an EIA during the third period only (1986 till present). Premier Government of India institutions such as Salim Ali Centre for Ornithology and Natural History (SACON) carried out the EIA exercises. Examples of EIA undertaken in the Nilgiris by SACON include Azeez *et al* (1996, 1997a, 1998 & 2007).

The EIA of PUSHEP, in particular, is definitely a *post facto* exercise. The Government of India EIA guidelines (MoEF, 1989) have made it explicit that EIA for development projects are carried out prior to site selection and investment decisions. MoEF (1989) also insists that EIA is meant for inter-comparison of the development options and screening of alternative sites for locating the projects (Daniels, 1992). For instance, when SACON started the EIA in January 1996, the 6800m long tailrace tunnel had already been excavated to a distance of 1057m (Azeez *et al*, 1996).

Azeez *et al* (1996) have categorically stated that no EIA was done before the commencement of the work and that an independent agency should be entrusted with the task of ensuring that the recommendations made in the EMP are carried out.

Identified Gaps, Issues and Concerns

There are very few critical reviews available of EIA standards and procedures enforced in India (example: Daniels, 1992). The most common drawback in the EIA process is that it is undertaken *post facto*; in majority, if not all, of the projects that involved an EIA, the project site and ground plan were first decided (and approved in principle) considering all factors other than environmental impacts. In such situations, EIA is normally adopted as 'essential ritual'. The second major concern is the time allowed for carrying out an EIA. Once again, even for mega-projects, the duration of the EIA is pitiably short. 'Rapid' EIA has become the norm (example, see Azeez *et al*, 1997a & 2007). Short duration invariably limits the scope of the EIA restricting field studies to selected attributes like the presence or absence and distribution of some obvious plants and animals and the routine assessment of a handful of adverse impacts like pollution, removal of trees and displacement of human settlements (if relevant). Analysis of costs and benefits of the proposed projects against the predetermined set of attributes more frequently lead to faulty and biased environmental management plans and mitigation.

Several gaps have been identified in the EIA while reviewing the ecological impacts of PUSHEP and also in the way the recommendations have been adopted by the implementing agency. For example the impact of blasting and tunnelling on den animals continues to be unclear. Den animals are those that live within underground or aboveground caves and large burrows. And there are many species including leopard, sloth bear, hyena, porcupine, bats and the rock python in the landscape. Azeez *et al* (1996) have stated that leopard and hyena that are nocturnal animals were not impacted by the construction activity. What has not been stated however is whether there are chances of these animals using the tunnels as a daytime shelter during pauses in construction activity.

An environmental impact may either be for the worse or better. What tends to appear 'harmless' initially can be for the worse later. That den animals seemingly were unaffected by the tunnelling can also be a reason for concern as these animals can eventually be seen as a nuisance by the project agency when they adapt and invade. While grill gates may keep away larger birds and mammals, they are not impervious to insects, spiders, scorpions, reptiles, smaller birds and mammals. For example, a colony of rock bees (*Apis dorsata*) that might choose to build a hive at the entrance of the tunnel may seem environmentally sound yet may prove to be a threat to daily commuters. Or even cave-dwelling animals like swifts and bats that choose to colonize the tunnels or the cavern can prove to be a practical nuisance.

A study that was conducted by the Bombay Natural History Society (BNHS) in 1994-95 of elephant movements in relation to human activities in the Moyar-Avarahalla elephant corridor has not once mentioned the hydroelectric project (Desai and Baskaran, 1996). The fact that during the period of peak project activity, its impact on elephants has been totally ignored (whether due to oversight or design) is indeed a concern. Yet another study by SACON has made the statement 'development activities such as hydel projects, reservoirs and network of roads have also hampered the forest contiguity within the (Nilgiri Biosphere) reserve' qualifying the statement with just one photograph of a hydroelectric project development activity along the Moyar-Avarahalla wildlife corridor (Sivaganesan *et al*, undated).

Azeez *et al* (1996) have stated that when SACON began the EIA of the PUSHEP tailrace tunnel in 1996 the blasting was being done underground at a distance of 1057m from the portal. At this distance, apparently, the blasting was only as loud as 'gunshots' and did not cause any discernable vibrations. Herds of elephant were observed moving through the adjoining corridors despite the construction activity in Singara. Unfortunately, however, there is practically no information available on the loudness of the blasting at the start of the tunnel.

Regarding the sensitivity of elephants to sound and vibrations, it is not easy to conclude anything based on a few observations. There is little doubt that elephants vary individually in their sensitivities. This assumption has been fortified by more than 10 years of observations on domestic dogs and their response to fireworks during Divali and other festivities (RJR Daniels, personal observation). The sensitivity of dogs varies to such an extent that while some are totally unmindful of the noise, others show signs of anxiety, depression and fright made evident through continuous panting, attempts to run and hide, not eat or drink and worse not urinate and defecate. Feral pigeons that normally come for food do not show up during Divali. While such behavioural changes in wild animals have not been documented, there are instances when directors of zoos have attempted to educate the villages in the landscape to restrain from blasting loud crackers. Zoo directors have also sought a ban on blasting rocks in quarries that lie close by. It is not the noise and vibrations *per se*, but the smell of fire may also affect animal behaviour around the site of blasting.

There is paucity of published information on the impact of blasting and tunnelling on wildlife in the Nilgiris in general. Published studies had failed to focus on the impact of Pykara HP and PUSHEP specifically on wildlife other than elephants and den animals. From Azeez *et al* (1996) it is apparent that except the gaur that avoided the Singara-Mavinhalla corridor during the PUSHEP construction, there is little information on whether or not other wildlife was affected. More than 25 species of medium-sized and large mammals have been reported from the landscape (Azeez *et al*, 1997a). At least 20 were sighted during the present study. How each one of these mammals respond to the construction activity remains to be understood.

The only publication that has really highlighted the anticipated ecological impacts of the hydroelectric projects around the Mudumalai WLS is that by the then Wildlife Warden (Tyagi, 1995). Analysing the impacts of the Maravakandy HP at Masinagudi and PUSHEP Tyagi (1995) has made the following remarks:

'The Project work involves tunnelling and excavation of large quantity of earth and rubble. The rubble and muck will be dumped in certain specified areas. The labour force and machine working in the project will disturb the wildlife and conservation effort in the area will receive a setback. The demands of the labour force for their basic needs like fuel-wood and fodder will further aggravate the pressure on forests. The proposed projects viz., the Mukurchihalla Project and the Moyar hydroelectric project in the vicinity of the sanctuary will further degrade the habitat. The projects are necessary for generating electricity but a balance has to be drawn between development and conservation. The safeguards and guidelines incorporated in the orders granting permission for the projects are more often not followed and the forest and wildlife suffer'. The specific objections that the Wildlife Warden of Mudumalai WLS had raised about the two projects are the following (Tyagi, 1995):

- Concerns about the impact on the ecology of Mudumalai on account of the excavation and dumping of large quantity of rubble and the noise pollution caused by the activity

- The Forest Department feared that the transportation of rubble from different locations which are far apart and one of them located at a different elevation of 800m ASL at the top near Glenmorgan, will be through forest areas only and this will affect the ecology

- TNEB had not given the Forest Department any plans for ecological restoration of the disturbed areas; condition pertaining to this aspect had not been incorporated in the Government Order

- Migration path of elephant lies close to Singara and any obstruction will affect elephant movement. This will lead to man-elephant conflict

- Pressure may increase on forest resources from the following activities: fuel wood removal, cattle rearing, etc

- The floating population working in the project would require civic amenities which will further disturb the wildlife population

- The enhanced flow of water in the flume channel from Maravakandy to Moyar Powerhouse will prevent elephants from crossing the channel and will be an obstruction in their migration path.

Despite the concerns raised by the Forest Department, the Government of India and TN Pollution Control Board (TNPCB) had given clearance for the execution of the projects and the work was in progress (Tyagi, 1995). Well after the blasting operations had started for PUSHEP, SACON was invited to carry out 'impact' study (Azeez *et al*, 1996).

Available information on the environmental impacts of the various hydroelectric projects in and around the PUSHEP site has failed to pin down the specific problems. They have also provided little or no clue on whether the project agency was sensitive to any of the concerns raised by the Forest Department or other scientific recommendation. It is quite evident that even the independent studies by the various research agencies that have worked in the landscape have not been comprehensive enough to provide a set of authentic benchmark information about the environmental impacts of PUSHEP and other hydroelectric projects. Finally, it is rather evident that none of the hydroelectric projects have made any attempt to evolve comprehensive environmental management plans (EMPs). Even if there were such plans, these have not been made available for subsequent environmental mitigation.

Major gaps in available information about the Pykara Hydel Projects have left the following questions either partially or totally unanswered:

1. How does tunnelling affect animals that live in dens/caves, burrows and cavities below the ground?
2. How do animals respond to blasting and the noise of machines when the portal and near end of the tunnel is being excavated?
3. How do people locally cope with the noise and dust pollution?
4. How does dust in the air affect pollination and photosynthesis, especially in seasonal forests where leaf flushing and flowering are quite synchronized?
5. How does the runoff carrying muck as silt affect aquatic habitat, especially streams?
6. How is soil erosion prevented within the project site, especially in sites like Singara where the terrain is steep, after forests are cleared?
7. What impact does the project have on biodiversity other than large mammals?

8. How does a project justify in stating that it was not responsible for long-term ecological changes in the landscape?

Effectiveness of Environmental Monitoring and Mitigation

In lieu of a comprehensive EMP and authentic benchmark information about PUSHEP (and associated hydroelectric projects in the landscape) effective environmental monitoring and mitigation are virtually impossible. As a result, anyone concerned about the long-term environmental impacts of the Project will have to ingeniously identify indirect clues or browse through a large and scattered set of information available of ecological, social and economic changes that the landscape has undergone since the implementation of the Project. A few sporadic observations and studies reported during more recent times have reflected the adverse impacts and how they were mitigated.

TNEB officials had given assurance that the rubble obtained from the excavation will be dumped in a specific area near Singara Powerhouse in their own land which is large and will take the entire volume of rubble (Tyagi, 1995). It was also assured that the muck excavated during PUSHEP would be used for the construction work (Azeez *et al*, 2007). Nevertheless, SACON has reported the presence of unused muck around the project site (Azeez *et al*, 2007) a fact also evident during the current exercise. This is clearly a result of the lack of monitoring and mitigation.

Sources at the TNEB claimed that the mound caused by the remnant muck contained only 5000m^3 as the rest (c. 10,000m^3) had been put to various uses over the years. The mound is quite huge and precariously overhangs the stream (flume channel) below. Despite the moist conditions that Singara enjoys there has not been any natural regeneration of plants even in the undisturbed nooks of the muck hill. There are people breaking the boulders into different size categories (3 sizes) and being transported through trucks. Worse still, the stone-workers simply push the finer muck into the flume channel.

Elsewhere in the landscape, TNEB had assured that more bridges will be constructed across the flume channel at several places to facilitate crossing over by elephants and other wild animals but this has not been done (Tyagi, 1995). Apparently wild mammals cannot cross sixty percent of the flume channel and where crossable, only the bridges that are more than 5m wide are used by large mammals like the elephant (Azeez *et al*, 1997a). Although during the early 1990s the situation was ‘not grim’ because of the lower volume and velocity of the flow of water (Tyagi, 1995), the real impact of the flume channels on the movement of wildlife remains to be assessed.

Unfortunately however, and during the past few years, many parts of the flume channel have been fortified using steep concrete embankment. This development has made it more difficult for wildlife to crossover that access to drinking water is from only one side, depending on where the animals are. As such, in most parts along its length the flume channel is a permanent barrier to the movement of elephants and other wildlife.

Frequency of vehicles plying the roads between Masinagudi and other villages in the landscape had increased not only due to market demand for cattle dung but also when labour had to be transported to the different project sites. While precise estimates of the number of trips made by trucks (and other vehicles) and the number of labourers involved in the movement are not available, one observation has reported that PUSHEP had transported 7000 labourers daily from Masinagudi to the project site, through elephant

corridors (Krishna, 2007). This figure however seems a gross overestimate, as the total human population of the Mudumalai landscape was 7400 (Silori and Mishra, 2001).

Monitoring the impacts of the Pykara HP beyond the boundaries of the immediate landscape has not been given due importance in general. The one probable exception is the following case:

The power generated at Singara Powerhouse is transmitted to Arasur in Coimbatore through overhead transmission lines. For purposes of laying the overhead power lines the NEB required a corridor of which 49.78ha was within reserve forests. Creating the transmission corridor required the clearing of all tall vegetation that included an estimated 19,200 trees. When this was proposed in 1998, there were objections that led to the stalling of the work. Finally, in 2004 when the corridor was made available to TNEB after obtaining necessary clearance from the Government of India under Section 2 of the Forest (Conservation) Act of 1980, the total area that fell within reserve forest was only 29.94ha. The reduction in size of the reserve forestland used for the corridor also spared a large number of trees; 4177 trees were felled (source: The Hindu, September 7, 2005; Forest Case Update, February 2005).

Environmental Costs and Social Benefits

The total expenditure that the Government of (Madras) Tamilnadu incurred during the 75 years in implementing the Pykara HP is not readily available. The various stages of the Project were completed with budgets that varied between Rs 3 million (in the 1930s) to Rs 3.83 billion (PUSHEP). Apart from the direct project costs, a number of indirect costs continue to plague the Project. Around 4000 trees were planted by TNEB between 1932 and 1935 at a cost of Rs 290,000 to compensate the loss of forests (Azeez *et al*, 1996).

There is however government expenditure that is not under the purview of the TNEB. In such a case, the liability largely rests with the Forest Department as part of its mandate on protecting the Wildlife Sanctuary. The Forest Department has from time to time monetarily compensated farmers and livestock grazers. Cattle killed by predators like tiger and leopard attract compensation. Elephants raiding crops have also been a reason for expenditure to the Forest Department as farmers are compensated. Finally, whenever human beings come into conflict with wildlife and get injured or die, they or their families have to be compensated. Forest Department also incurs annual expenditure fighting fire and eradicating invasive plants that spread through the protected areas taking advantage of the network of roads.

Right from its inception in 1932, the Pykara HP has been a boon mainly to industries in Coimbatore. More specifically, the greatest beneficiaries of the hydroelectric schemes are the cotton mills of Coimbatore and not the local residents. Economic benefits to the local residents have come in the form of daily wages for labour in the hydroelectric projects and as government employment. Forty-four percent of the 1475 families settled in and around Mudumalai in 1991 were landless labourers working in the hydroelectric projects at Singara, Masinagudi and Moyar. Another 23% of families belonged to (government) employees of TNEB. Thus 67% of the immediate beneficiaries of PUSHEP and associated hydroelectric projects were actually immigrants (Silori and Mishra, 2001).

Other economic benefits came through the sale of milk and dung. While the milk was sold locally (including to TNEB projects; Tyagi (1995)), the dung was sent out. The study by Silori and Mishra (2001) has estimated the average annual income per family from the sale of cow dung as Rs 1757. Dung from the milk cattle maintained in sheds during the years 1992-93 substantially contributed to this income.

Effectiveness of Damage Containment and Compensations

A review of the available literature on the Pykara HP has clearly highlighted the overall lack of mechanisms that were built into the Project for environmental damage containment and compensations. What is however evident is that despite the apprehensions of the Forest Department about the ecological damage that was anticipated as a result of tunnelling and disposal of muck, immigrant labour and the obstruction of wildlife corridors, TNEB had not offered any explicit plans for ecological restoration of the disturbed area. It has also been stated that a clause pertaining to this aspect had not been incorporated in the Government Order (Tyagi, 1995).

The 5000m^3 of muck that has been left unused as yet is being salvaged for building material at present. While there is enough evidence that suggest that the muck runs into the flume channel below, the study also witnessed the workers pushing unwanted material straight down the slope into the water. The stone crushing work that is currently on (using manual labour) is unsupervised.

Elsewhere, as inferred from Forest Case Update (February 2005), the continued impacts of the Project have had to be minimized by means of litigations; example the partly successful aversion of the felling of the trees along the power transmission corridor that passed through reserve forests. The litigation apparently saved at least 15,000 trees along the transmission corridor.

Around 4000 trees were planted by TNEB between 1932 and 1935 at a cost of Rs 290,000 to compensate the loss of forests (Azeez *et al*, 1996). Trees have also been planted more recently within the vacant spaces around the PUSHEP guesthouse in Masinagudi. The latter is largely of exotic species.

Probably the most positive step that the TNEB has taken in containing and compensating the damages caused is in the form of support ecological research in the landscape. Beginning in 1986, TNEB has extended support to ecological and wildlife research in Mudumalai. It has provided some of its unused residential buildings for accommodating the IISc/CES field station and staff quarters.

Lessons Learnt

The first of lessons learnt from the analysis of the impacts of the Pykara and other hydroelectric projects in the landscape is that environmental concerns continue to be secondary to development. This is however not entirely the fault of the Government or the implementing agency. Field biologists and naturalists have also contributed to the secondary status of environmental concerns. A Project that was implemented over a 75-year period offers a lot of scope for impact assessments at various spatial and temporal scales. Researchers and nature enthusiasts (including those from credible institutions who had access to project sites) have unfortunately failed to utilize the opportunities to specifically assess and highlight the ecological impacts of the Project. This is evident in most published sources of information that have discussed the

possible interference of the Project with movement of wildlife through designated corridors without providing even a single example of what exactly the interference is.

In the absence of specific examples highlighting ecological impacts, it is not possible to spell out guidelines for monitoring and mitigation of already completed projects and those that are to come up in the landscape. Hence the second important lesson learnt, which is an automatic outcome of the first, is that future projects in the landscape should start by reassessing the impacts of the earlier projects. They should ask the following questions:

1. Whether the project fits within the objectives of the Biosphere Reserve and Wildlife Protected Areas?
2. Will the project affect the survival of threatened species?
3. Will the project contribute to declines in the carrying capacity of the habitat when it concerns rare, endemic and endangered species?
4. Will the project increase the population of local human residents?
5. Will the project bring about long-term stress to the ecosystem?

The third important lesson is drawn from the World Conservation Union's (IUCN) cautious approach to evaluating the conservation status of species of plants and animals. IUCN adopts a category called 'data deficient'. It is important that projects like Pykara HP are treated as data deficient whenever their environmental impacts become a matter of concern.

Finally, judging by the EIA guidelines of the Government of India (MoEF, 1989), the Pykara and other hydroelectric projects in the Nilgiris have paid little regard to the mandatory environmental safe guards, especially those that concern wildlife and protected areas. The Pykara HP is one of the mega-development projects that have been implemented over a vast area and long duration of time in India; spread over more than 150km^2 and 75 years. Lessons learnt from the Project, though seemingly general, have a much wider scope and application value than what is immediately apparent.

Part IV: Anticipated Environmental Impacts of the INO Project

Background

Part III of this report has made it evident that there is not much for the INO project to gain from the lessons learnt in the Pykara HP. The analysis presented here is hence entirely based on facts and figures provided in two reports; the Detailed Project Report (INO, 2007) and Environmental Impact Assessment of SACON (Azeez *et al*, 2007). Additional inputs have come from the four-month study undertaken by Care Earth (September 2007-January, 2008). These inputs were derived from direct field observations and interactive discussions with local residents and relevant environmental agencies including the Forest Department.

Site preparation

The reference benchmark of the INO Project site has been established near TNEB's hospital at Singara residential area at an elevation of 918.53m ASL. Reference pillars have been erected at 12 locations for guiding the construction. Five boreholes (out of 7 planned) have been made along a distance of 200m to explore the thickness of rock cover at the proposed INO portal. From the boreholes, it is inferred that the first 200m of the access tunnel will be through softer medium and a technique called 'cut and cover' will have to be resorted to. The 200m cut and cover zone lies within a private coffee estate (INO, 2007).

Improving road connectivity in Singara and Masinagudi is required. Two new roads, one connecting the access tunnel with the existing roads in Singara and the other for approaching the quarters in Masinagudi, have been proposed. The roads that will together cover 1500m (1.5km) will be black topped and require the clearing of 11,250m^2 (1.125ha) of vegetation. Further there is a proposal of widening existing roads over a length of 1500m (although not specified where) that involves clearing 1000m^2 (0.1ha) of vegetation. Of the

total 1.225ha of vegetation that is likely to be removed in the process, about 4% is described as 'heavy jungle' that probably means there are trees here. The development plan has also built-in a cost for 'uprooting and removal of small trees' as part of the operation (INO, 2007).

The SACON study (Azeez *et al*, 2007) has recommended that large tress around the portal can be spared if the alignment if shifted. During the recent study, it was noted that the trees that are earmarked for felling are mature native trees in the age of 150-200 years. There are suggestions of creating gardens in Masinagudi within the Project site (INO, 2007). Fencing the project site even before the construction activity is foreseen.

INO (2007) has proposed that the existing hospital near the INO Portal in Singara will be demolished for accommodating the Project activities. How exactly this will be compensated has not been detailed. Consensus of the residents (both at Singara and Masinagudi) including the local inhabitants has to be sought before any action. Further, the detailed map of the access tunnel and utility building at Singara prepared for the Project has shown the existence of a church within 50m and a temple at around 100m from the portal. There is no statement of how these worship centres will cope with the site preparation and construction during the 5 years.

It is proposed that water will be transported through pipes from the Maravakandy dam to the residential facilities at Masinagudi. It is not clear how the demands of water during construction in Singara are going to be met.

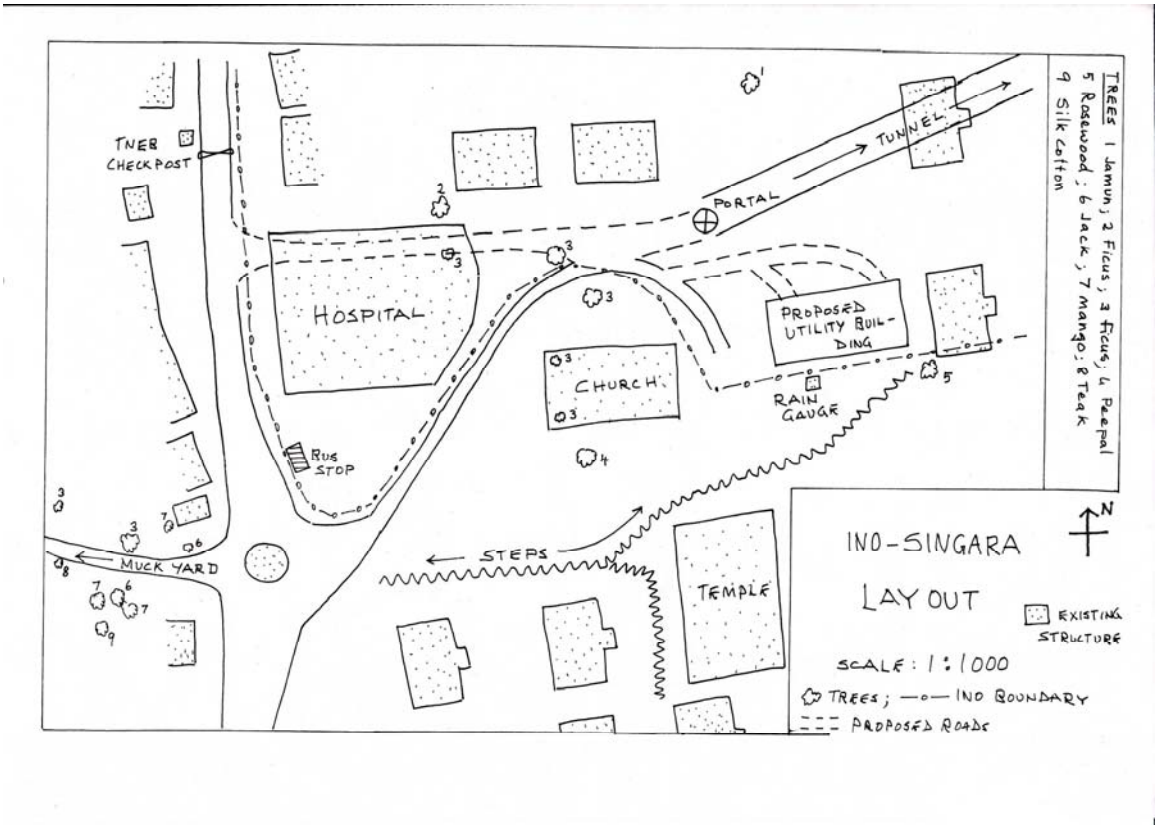
The INO (2007) project development plan has shown 4 alignments. It however has *a priori* decided on alignment 2 (which is about 260m longer than alignment 1) for the simple reason that the alignment 1 'is now difficult to execute especially since the powerhouse has started functioning'. It also states 'although the geological set up and structural fabrics are similar for all the four alignments, the alignment 2 is considered to be the best independent access considering all other aspects'. Prior to this statement the TNEB report has said 'alignment 1 is the easiest to execute since the tunnel portal will be in the hard rock medium. There is no need for any portal formation. It also has the shortest distance to the INO cavern. The saving in time will be quite considerable'.

The proposed alignments do require some rethinking. Alignment 1 is 1867 long. Alignment 2 is 2129m, alignment 3 is 2380m and alignment 4 is 3194m long. By choosing alignment 1 there are the following savings:

- The 262m reduction in total length of the tunnel reduces the volume of muck excavated by 11,568m^3 (30,000-33,500 tons; 1500-1675 truck loads when 20 ton trucks are considered; not less than 6000 trips when smaller trucks are used); it also saves cost

- The 200m cut and cover that is needed for alignment 2 can be avoided; hence cost of purchasing land exclusively for this purpose from the coffee grower is saved
- The need for removal of large trees that fringe the portal of alignment 2 can also be avoided

Against these visible advantages the statement that it 'is now difficult to execute especially since the power house has started functioning' stands quite unjustified. Further under Section 11 the INO (2007) plan has categorically stated that 'the following aspects are to be taken into account in the finalization of alignment'. The first of these aspects is 'it should be the shortest possible'. The alignment of the access tunnel therefore needs re-examination.



Excavation

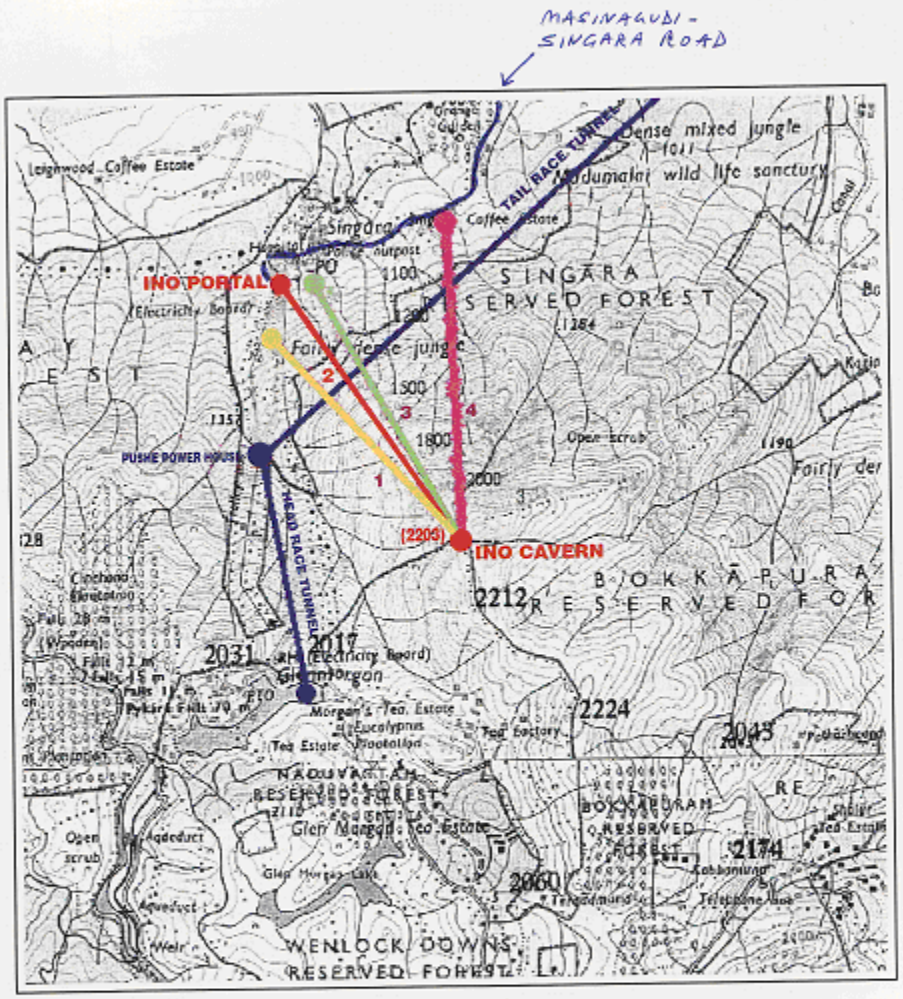
Three and a half years of excavation will create substantial noise (blasting, drilling, truck movement, stone crushing, etc) and air, soil and water pollution. As there are places of worship (church and temple) within 100m of the proposed portal, noise and dust can be a major nuisance. There are proposals to minimize these problems that suggest the use of new machines, controlled blasting (whatever that means) and restricting the excavation to only light hours of the day (INO, 2007). The report states that there will be no blasting at night. Azeez *et al* (2007) however states that night blasting will be avoided only where the earth cover is less than 300m.

Information provided by Azeez *et al* (1996) on preparation for blasting and time taken for clearing the muck may limit the number of blasts to 1-2 per day. For example when PUSHEP excavation involved the use of 51kg of gelatine in 57 drill holes 2m deep each blast resulted in 13.5m^3 of debris. At yet another location

within the project site, 73.5kg gelatine placed in 89 drill holes yielded 59m^3 of debris per blast. The latter output that was larger probably limited the blasting to one per day.

At the above rates, it will take a very long time to excavate the estimated 225,000m^3 of muck that INO project envisages. Assuming a rate of 13.5m^3 of muck per blast and two blasts per day it will require 8333 days (22 years!) to excavate the tunnels. If on the other hand the 59m^3 capacity blasts are undertaken at a rate of one per day, it will still require 1906 days (5 years) for the excavation to be completed. Against these odds, how exactly the INO project plans to complete the task within the 3.5 years as proposed has to be rethought.

As per the detailed Project Report sullage water and sewage from underground and aboveground structures will be suitably treated and dispersed at a suitable locality, well away from the water bodies (there is no site shown on any of the maps; INO, 2007). However, there are other associated problems that are foreseen; runoff carrying suspended particles of soil and rock during the rains (Azeez *et al*, 1996 & 2007).



Source : **Survey of India Maps**

INDIA-BASED NEUTRINO OBSERVATORY PROJECT AT SINGARA, NILGIRIS DISTRICT, TAMIL NADU

29

Fig : 9 Topography of INO Area at Singara

Disposal of Muck

An estimated 225,000m^3 of muck will be excavated over a period of 3.5 years (INO, 2007). Considering the specific gravity of the underlying rock as 2.62-2.9 the weight of the muck generated will be anywhere between 589,500 and 652,500 tons; an equivalent of 29,475-32,625 truck loads if 20 ton trucks are despatched. However, if as mentioned in the INO (2007) plan document only 5 ton trucks are deployed, the number of truckloads will increase four times.

As per TNEB sources, PUSHEP disposed muck at a rate of 6m^3/load (around 16tons). It is more likely that the INO Project will also resort to using the same procedure. If that be the case, it will require 37,500 truckloads to dispose the 225,000m^3 of muck that will be excavated during the 3.5 years.

When translated, this would imply there might be at least 75,000 trips (up and down) between the site of excavation and the muck disposal area. This is essentially, 59 trips/day (for 3.5 years) and when only 12 daylight hours are considered, the number of trips doubles to nearly 120 at a rate of 10/hour.

The existing road to the muck yard is too narrow and steep that movement of vehicles of the prescribed capacity will be much slower than expected. There is little scope for widening the road as it runs in close proximity to existing TNEB residential buildings on one side and is bordered by a storm water drain on the other. Water that flows through the drain reaches the flume channel below posing dangers of silting and pollution.

Obviously the huge task of disposing the muck cannot be fulfilled unless a large fleet of trucks is deployed. Then the question arises as to where these trucks will be parked? How many attendant labourers (drivers & cleaners) will be brought in? Where will the fuel come from? What kind of service infrastructure will be installed to deal with breakdowns? While the Project development plan mentions the need for establishing a local fuelling station, it is silent on all other related aspects including from where the fuel would come in and how?

Such huge truck traffic even if it is restricted within a small area (this is unlikely as some will have to ply across to Masinagudi from time to time carrying muck in the event that building activities are started simultaneously) will place an undue burden on roads calling for frequent relaying and widening of roads. The noise, dust and smoke pollution in Singara due to truck movement (although the Project development plan states that muck will be transported in a covered manner) are definitely matter of concern, as it will affect the local residents. Further, the common tendency of truck drivers is to take the trucks to the nearest streams and springs for washing from time to time. What kind of pollution does this cause? Will this not affect aquatic life and the quality of water that the wildlife drinks? There is no clarity on this aspect in either Project plan or in the EIA report of SACON (Azeez *et al*, 2007); the latter does caution against oil spillage from field machinery.

The site that has been earmarked for the disposal lies within TNEB property. It has an extent of 2ha (200m x 100m). The proposed 4m high walls that are to be built to restrain the muck will enhance the holding capacity to 80,000m^3. This volume is about a third that of the estimated quantity of muck that is to be generated. While it can be argued that the daily excavation will be much smaller volume and that the excavated muck when broken for reuse will prevent the filling up of the designated space, this is unlikely to happen for the following reasons:

- Disposal of muck can happen only after trucks enter the site. Trucks need adequate space for manoeuvring within the site; it depends on how many trucks may enter simultaneously

- The muck delivered by trucks needs to be cleared and piled up continuously and that requires at least one bulldozer operating daily

- The proposal to reuse the muck for construction requires on-site breaking (suggesting the use of stone crushers) and labour; this also requires exclusive storage space for the broken stones and dust

- Reuse of muck for reinforcing the tunnel and access roads may not begin till the excavation is complete till a workable distance

- More than all, the short time within which the entire operation has to be completed does imply more intensive use of the available space

Considering the above logistic and infrastructural requirements it seems unlikely that the designated space of 2ha will be able to accommodate the huge volume of muck that is likely to be generated at Singara.

INO (2007) has stated that only 20% of the muck will be used for the INO Project. Of the rest, 50% may be used elsewhere in the Nilgiris district as there are no stone quarries and hence a reasonable demand for stone rubble. The remaining 30% will be 'stacked without any void' during the construction phase itself (probably within the space reserved for the purpose) and after the project species of vegetation will be grown in the residual area so that the stacking area merges with the adjoining vegetation. Thirty percent amounts to 67,500m^3; a volume closer to the total capacity of the 2ha storage facility!

A volume of 67,500m^3 of muck will weigh between 175,000 and 200,000 tons and demand 8000-10,000 truckloads when 20-ton trucks are used. Creating a mound that accommodates this huge volume and covering it with earth for growing plants (trees) does not seem a viable proposal. There is need for better management plan when it concerns the disposal of muck. In fact, disposal of muck is certainly the greatest environmental impact the INO Project is likely to cause in the Singara-Masinagudi landscape.

According to sources at TNEB and the Panchayat, the existing muck yard is 59,000m^2 (5.9ha). PUSHEP had required this space to store/dispose a mere 15,000m^3 of muck. Of this, over the past years 10,000m^3 have been used for various purposes leaving only 5000m^3.

More than 3 years after the PUSHEP was completed and made operational huge mounds of muck lies unused. Despite the moist conditions that Singara enjoys there has not been any natural regeneration of plants even in the undisturbed nooks of the muck hill. What will happen to the 67,500m^3 of muck that the INO Project is likely to leave behind. Grading and manually breaking the boulders, as observed, is a very slow process.

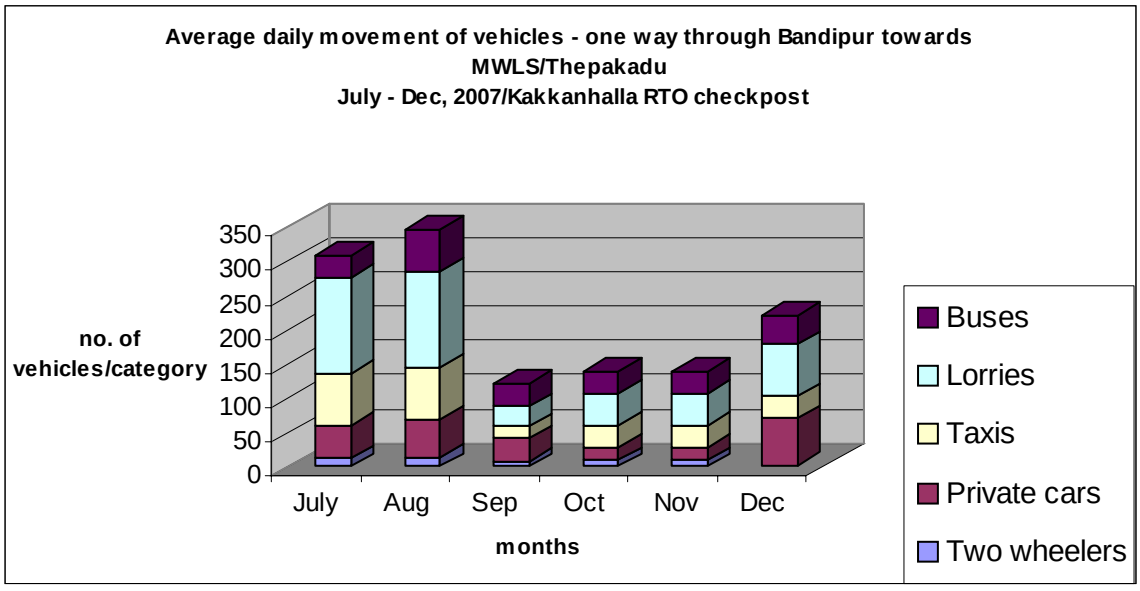
Transport and Traffic

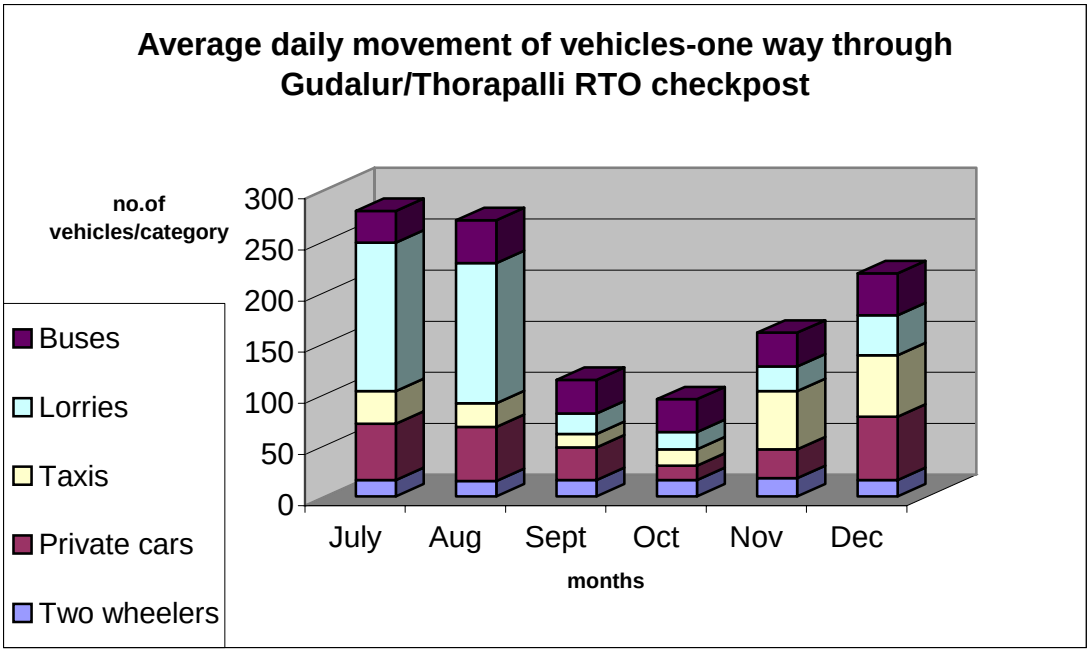
The estimated time required for the construction phase is 5 years of which 3.5 years will be spent on dredging/excavation of tunnel and underground facilities. It is not immediately clear whether construction of the aboveground facilities viz., the utility building at Singara and the residential facilities at Masinagudi will simultaneously begin. If that is the case it is foreseen that there will be considerable vehicle movement

between Singara and Masinagudi even during the first 3.5 years. As the Singara-Masinagudi road cuts through at least one major elephant corridor (Silori and Mishra, 2001) and falls within the home range of 2 clans (female herds) of elephants (Desai and Baskaran, 1996), greater caution has to be exercised to avoid interference with elephant movement (especially since clans often include new-born and young; see Photo) and the resultant human-elephant conflicts.

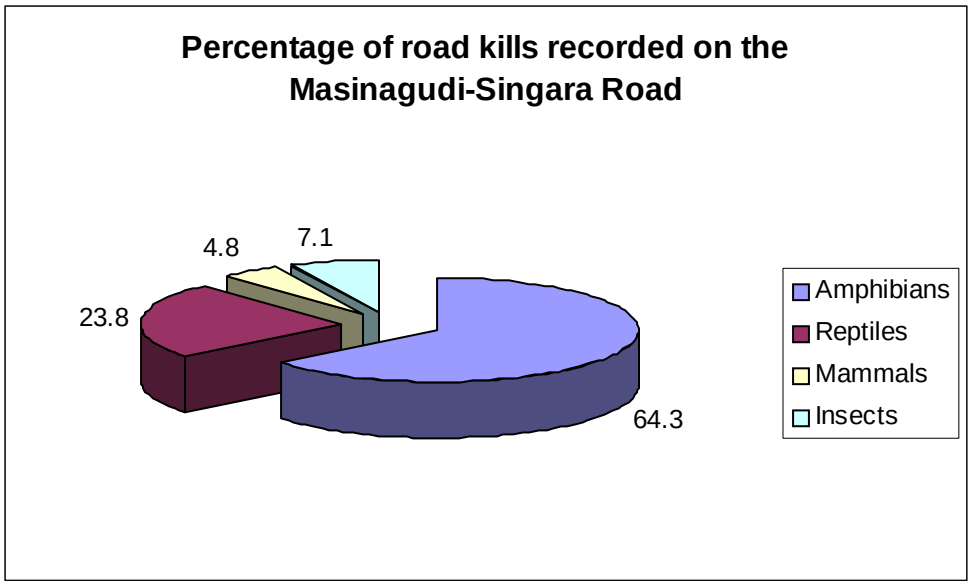
Between 5 and 6 vehicles moved per hour of daylight between Singara and Masinagudi during the time that the study was undertaken (October 2007 and January 2008). Majority of the vehicles belonged to the lighter category (around 4 per hour). The average number of heavy vehicles that traversed the Singara-Masinagudi corridor was much lower (1 per hour).

The light motor vehicles are those used by the tourist resorts to drive through the Singara-Masinagudi road in the guise of eco-tourism. Since these parties are not inclined to discipline, and as most of the tourists are brought in without the consent of the Singara estates, the estate management has dug trenches here and there to curtail the vehicles from getting off the road and wandering through the private property. These trenches are likely to further interfere with the movement of wild animals, as there are fences along the road closer to the estate.





Vehicular movement (October 2007-January 2008) had killed at least 42 animals along a 3km stretch of the Singara-Masinagudi road. As expected, 64% of the kills were of amphibians. About 5% of the kills involved mammals. Road kills tend to vary with the seasons; increasing during the rains and when traffic at night becomes heavier.



The Project involves movement of heavy vehicles for transport of material other than muck. Widening existing roads and creating newer roads at Masinagudi (INO, 2007) is a concern. The existing local Singara road will be rerouted so as to link the INO portal. More importantly, it is the number of vehicles that are likely to ply between Singara and Masinagudi and in and out of the landscape during and after the construction phase of the Project. The Project Development Plan has listed mobile cranes, tippers, tip trucks, road rollers and lorry as part of the construction equipment without specifying how many of each and their capacities.

Elsewhere while presenting the Project costs it has included 3 lorry each of 5 ton capacity, 2 standard van, 2 ambulance van, 5 jeep, 2 mobile trolleys and 2 battery/diesel operated devices (without specifications). These vehicles may be used for transporting small equipment and personnel. There is however a mention 40 ton trucks that will be engaged in transporting the larger lab equipment. The latter will ply between the nearest railway station and the project sites carrying equipment. However this may happen only after the tunnelling and lab excavation works are completed; that is after 3.5 years of initiation of the Project's construction phase.

Sand for construction will be sourced from Gundulpet (INO, 2007). Trucks that carry sand from Gundlupet will traverse via Bandipur, Theppakadu, Masinagudi before reaching Singara. There is no indication of the number of loads that will be needed for the purpose; number of trips and weight of each load have to be estimated. Besides sand, it has also been proposed that some bricks will be needed for the construction and the same will be sourced from Gundlupet.

All roads that lead to the Project sites at Singara and Masinagudi were examined for their feasibility during the present study. Roads assessed include the one from Satyamangalam via Dhimbum ghat and through

Chamrajnagar. Movement of vehicles more than 16 tons is not permitted along the Dhimbum ghat. This is mainly due to the steepness (27 hairpin bends) and the habitat being one that is critical to elephant and tiger, amongst others.

Whichever way, road transport involves passing through Bandipur NP and Mudumalai WLS when approached from the north. The iron bridge between Theppakadu (elephant camp) and Masinagudi will not be able to accommodate vehicles more than 20 tons. The concrete bridge built by TNEB for PUSHEP providing a byway through the residential area at Theppakadu is presently not in use and is dilapidated. It is unlikely that the Forest Department will allow restoration of the bridge for reuse.

It is more likely that trucks less than 10-ton capacity will only be used as GOI/MoEF Guidelines for Eco-development in Protected Areas (especially tiger reserves) has explicitly stated that trucks that exceed a capacity of 8 tons should not be allowed through the protected areas (source: Compendium of Guidelines and Circulars issued by Director (Project Tiger) New Delhi, November 2004).

Heavy vehicle traffic necessitated by the Project, even if it is restricted within a small area (this is unlikely as some will have to ply across to Masinagudi from time to time carrying muck in the event that building activities are started simultaneously) will place an undue burden on roads calling for frequent relaying and widening of roads. The noise, dust and smoke pollution in Singara due to truck movement (although TNEB development plan states that muck will be transported in a covered manner) are definitely matter of concern, as it will affect the local residents. Further, the common tendency of truck drivers is to take the trucks to the nearest streams and springs for washing from time to time. What kind of pollution does this cause? Will this not affect aquatic life and the quality of water that the wildlife drinks? There is no clarity on this aspect in either INO (2007) plan or in the EIA report of SACON (Azeez *et al*, 2007); the latter does caution against oil spillage from field machinery.

Sourcing and Impact of Labour

INO (2007) states that to the extent possible local labourers will be engaged to avoid migration. The labourers will be educated on the need for environmental protection and they will not be permitted to venture into forest for the collection of firewood and other sundry works. The labourers will be provided LPG or firewood. They will not be permitted to raise cattle for milk at any cost. Instead 'Aavin' milk will be arranged. Tyagi (1993) has however observed that there are no simple means of regulating the movement of labourers in and out of forests.

After the completion of the PUSHEP a number of people who came in as labourers have left Masinagudi. It is feared that the INO Project will be reason for immigration of labourers from adjoining districts, towns and villages. Indigenous people were sparsely present even in the past in Masinagudi. In 1971 only 19.84% of the total population in the Panchayat was comprised of scheduled tribes. The ST population has continued to decline that current estimates place it at a mere 6% of which many are not native but have migrated from Salem and other adjoining districts. Scheduled castes were 23.21% in 1971 and 38% at present, once again due to inflow of migrant labor.

Between 1960 and 1990, the human population in the Masinagudi Panchayat had grown by 142%. As per the 1991 census the population was 8416 and by 2001 it was 8577. Although the immigration was triggered by the hydroelectric projects, livelihood provided by tourism and associated infrastructure development has attracted more people that the population has continued to be on the rise. As per information provided by the Revenue Department and the Panchayat President, the reported human population is only of those who are resident and hold ration cards. And as there is a large floating population, the actual number of people is more than 10,000 in Masinagudi Panchayat. Rise in human population has been more in Masinagudi.

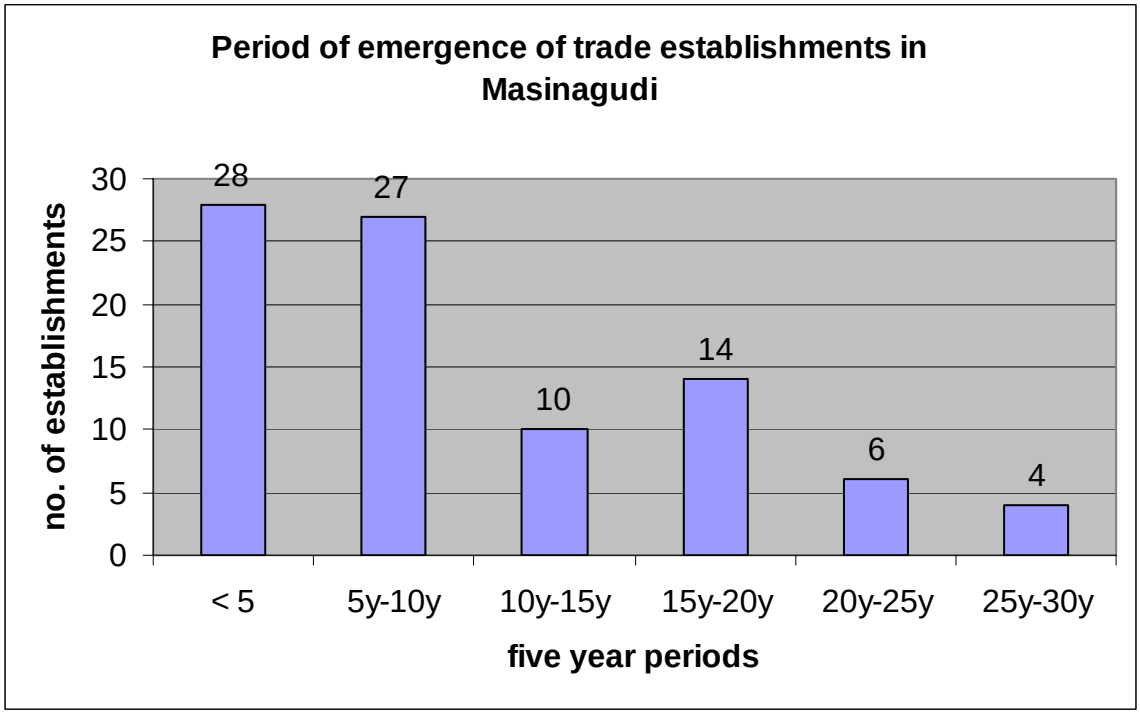
Social Costs and Benefits to Residents

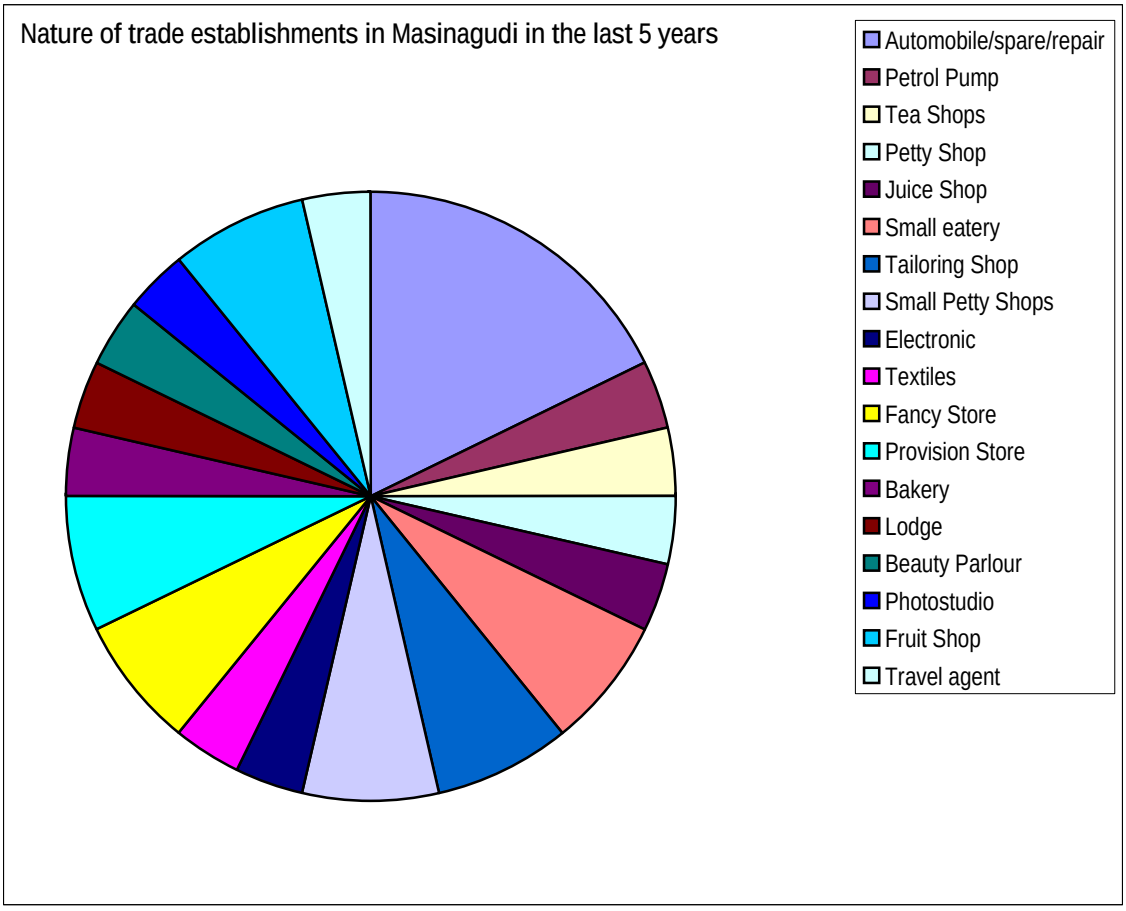
Nature's services that the INO Project personnel will enjoy include 'relaxation' (recreation) thanks to the proximity of Mudumalai WLS and the Maravakandy Reservoir (INO, 2007). While there are standard economic tools available for placing monetary values on such service benefits, the residents who are likely to enjoy are only a small fraction of the local population. Willingness to pay amongst the small fraction of INO Project staff and visiting scientists/students can be translated into kind appropriately so that the aesthetic and recreation service benefits that they enjoy will also provide economic incentives to a larger spectrum of local residents. Ways of achieving this are discussed in the later sections (see Part VI).

The indigenous population at the Singara and Masinagudi villages is small (negligible). They are not likely to benefit from the Project. It is however possible to foresee gainful employment opportunities for the other residents during the construction phase. After the laboratory comes into operation with minimal activity, that too underground, it will not be a major employment source.

The issue of local versus the non-native is rather volatile in and around Masinagudi. The indigenous communities are unanimous in that they were pushed out of their landscapes either because they were viewed as being problematic during the early years of forest protection or because the subsequent years witnessed a good Samaritan approach where they had to be rehabilitated. This has not only deprived them of their traditional and custodial rights over their own landscape, but has reduced them to being landless labour. They also feel that their role in conserving the Mudumalai WLS is also being undermined since a) very few of them are employed by the Forest Department and b) the scope of wildlife tourism itself has changed necessitating resorts and plush vehicles. They neither hold assets nor have the required skill to seek alternate livelihoods and are not overtly enthusiastic about the scope that Project INO could potentially offer. The indigenous communities would rather appreciate being allotted land within the landscape, a legacy to which their rights have to be restored.

On the other hand, settlers have flourished. Early settlers to the village were the Muslims who came to trade the cattle, dung and timber. This was followed by other migrants; notably from Kerala, Karnataka and the hilly districts of Tamil Nadu. Recent years have seen a spurt of growth in migration due to wildlife-based tourism. The trade in Masinagudi is dominated by tourism based service sector – shops, small eateries, jeeps, etc.


Period of emergence of trade establishments in Masinagudi
no. of establishments
30
25
20
15
10
5
0
28
27
10
14
6
4
< 5
5y-10y
10y-15y
15y-20y
20y-25y
25y-30y
five year periods


Nature of trade establishments in Masinagudi in the last 5 years
Automobile/spare/repair
Petrol Pump
Tea Shops
Petty Shop
Juice Shop
Small eatery
Tailoring Shop
Small Petty Shops
Electronic
Textiles
Fancy Store
Provision Store
Bakery
Lodge
Beauty Parlour
Photostudio
Fruit Shop
Travel agent

Impacts on Land Ownership and Floor Pricing

The area of the Masinagudi Panchayat was demarcated before the Census of 1960-61. The Panchayat includes only lands that are under the jurisdiction of the Revenue Department, although protected forests may be intermittently present. Masinagudi that evolved from a diminutive settlement into a major village by the early 1960s is the pivot in the landscape.

The information on land use was obtained from the records of the village administrative officer (VAO), the office of the Assistant Director of Survey and Land Records (District Survey Unit/revenue map in the scale 1:1600), on-site assessment and verification and interviews with the local people.

The impact of changing land use is evident throughout the Singara-Mavinhalla corridor. In view of the fact that the habitat is open and not manned, collection of wood for fuel and construction, and making implements by the inhabitants of Masinagudi, Singara, Chemmanatham and Moyar is extensive. Woodcutting is intensive along the flume channel. Much of the wood is sold at the local market and to the resorts (for camp fire).

As in other parts of the State, land in the landscape is held by the Revenue and Forest Departments. Land governed by the Revenue Department exists as revenue-patta land, revenue-wastelands and revenue-forest lands. Using the Singara-Masinagudi road as the benchmark, land holding on either side was determined.

The landscape has extensive revenue forests that have not been properly demarcated on the ground, though they serve as important components of the Singara-Mavinhalla corridor. Since the lands have not been accorded their rightful importance, they have been made available to projects as that of TNEB since the 1940s. What is now being referred as Singara village is essentially a camp that was developed by modifying the habitat to accommodate the TNEB staff.

TNEB has reserved 0.5ha of its land at Singara for the INO Project (tunnel portal and utility service building) and 4ha of land at Masinagudi on the western side of TNEB Guest House for locating the INO residential facilities including office buildings, hostels and staff quarters (INO, 2007). Besides the TNEB land, it has been proposed that 4.7ha of reserve (notional) forestland has to be availed to accommodate the underground facilities and tunnels in Singara (INO, 2007).

The proposed cost of forestland is Rs 5,856,000 (2.577ha as against the actual requirement of 4.7175ha; see Table 2) and TNEB land is Rs 10,226,000 (4.5ha). The estimated cost translates to around Rs 900,000/acre. While these prices may be at the rates fixed by government, whether the same rates will

apply for the coffee estate land to be purchased needs to be assessed. How do these prices compare against floor prices of land in the landscape and whether such pricing will lead to cost escalation of land in Singara and Masinagudi also is a matter of concern.

Land prices have increased from Rs 3000/cent in 1990 to Rs 45,000-50,000/cent at present. While this is in tune with the overall inflation of land prices, pertinent to Masinagudi and adjoining areas is the fact that there is a) additional demand due to the scope that is offered for establishing resorts and vacation homes and b) large contiguous pieces of land are available favoring long-term investments as residential colonies.

Impacts on Ecosystem Processes

Ecosystem processes that govern the Nilgiris (and Mudumalai) landscape are as complex and obscure as they are in the rest of the Western Ghats and most other human-impacted tropical landscapes. The fundamental environmental influences that govern the local ecosystem are climate and the resultant vegetation types. Locally, however, around the INO Project site, the landscape is relatively drier dominated by deciduous, thorn and scrub vegetation where the key players are large mammals; elephant being the most important species. The generally low density of large predators, especially the tiger, has elevated the large herbivores including the gaur, sambar and chital closer to the elephant as far as their position in the ecological web is concerned. That ecosystem is dominated by large herbivorous mammals is not unique to Mudumalai, but elsewhere also especially where deciduous forests characterize the landscape (example Karanth and Sunquist, 1992).

Statistics regarding the population of elephants in and around Mudumalai vary considerably between the available sources. The generally accepted numbers range between 1800 and 2300; including the adjoining forests of Kerala and Karnataka (Baskaran *et al*, 1995). With few natural predators, the elephant has dominated the landscape much more than any other mammal. The only other mammal that has dominated the landscape is the human being. The Nilgiri Hills are known for the more than 2000-year history of human occupation (Prabhakar, 1994; Vencatesan, 2003). Although the early impact of man on the landscapes was presumably much less (due to malaria, rain and chill and the resultant small population sizes), the British colonists opened the Nilgiris for quick and devastating development. The ecosystem collapse that was triggered by the colonists some 250 years ago soon placed human beings on the top of the ecological pyramid. And till the Wildlife (Protection) Act 1972 enforced strict regulations on hunting, human beings were the single most prolific predators in Nilgiris.

Needless to say that the excessive hunting and transformation of habitats that went on during the past 250 years have made just two species govern the ecosystem processes in most landscapes of the Nigiris Hills; man and elephant. The frequent man-elephant conflict that the landscape (Mudumalai) continues to witness is largely due to the shifts in the ecological importance of mammal species; a scenario where elephant and man are the two primary ecosystem engineers and each trying to assert itself over the other in the absence of guns. Just as we cannot imagine the landscape without human beings, there cannot be an ecosystem in Mudumalai in the absence of elephants. Elephant is the 'flagship' of the landscape and any further development in and around Mudumalai should be fully sensitive to its ecological needs.

Impacts of the INO Project on ecological processes will take a long time to become visible. Mainly because the landscape has already been subjected to immense pressures of development; particularly the 75 years of pressures placed by the Pykara HP. Many species have adapted to the impacts during the 75 years in

various ways. With the exception of the tiger and gaur, most large mammals in Mudumalai freely roam within human habitation. This is not however a good sign as greater proximity to human habitation unduly exposes the wild animals to pollutants, parasites and diseases.

Visible symptoms of ecological collapse that a project like INO may usher in can never be free of complications as they are seen in a compounded form without revealing the catalysts. And whether the Project itself catalyses a faster collapse will also be inconclusive in an already devastated landscape. This is yet another case of 'data deficiency'.

Impacts on Wildlife

The Mudumalai landscape is one of the best wilderness areas in south India. A number of species of mammals including elephant, gaur, sambar, chital, barking deer, blackbuck, four-horned antelope, sloth bear, jackal, dhole (wild dog), hyena, tiger, leopard, common langur, bonnet macaque, giant squirrel, flying squirrel and scores of birds are quite abundant in the landscape. Mudumalai is an important habitat for our National bird, the Indian Peafowl. The peafowl, blackbuck, tiger and elephant are listed in Schedule I of the Wildlife (Protection) Act, 1972 and rated as the most endangered species of wildlife in India. Besides, there are numerous species of large reptiles like the monitor lizard, rock python and mugger (marsh crocodile).

Unlike hydroelectric projects that have fragmented habitats extensively, and unlike plantations, agriculture and human settlements that have encroached upon vast portions of the landscape, the INO Project is conservative in terms of land use as most of its activities will lie deep below the surface. The most serious threat however comes from the movement of vehicles, especially during the 5 years of construction and installation.

Vehicular movement (October 2007-January 2008) had killed at least 42 animals along a 3km stretch of the Singara-Masinagudi road. As expected, 64% of the kills were of amphibians. About 5% of the kills involved mammals. Road kills tend to vary with the seasons; increasing during the rains and when traffic at night becomes heavier. Considering that the kills resulted largely from the movement of lighter vehicles, it is feared that as the movement of heavy vehicles increase during the construction phase, a lot more accidents will involve wildlife.

Vehicular traffic will interfere with wildlife movements and this will be more explicitly treated in the section that follows. The impacts of roads and traffic on wildlife have been studied extensively throughout the world. The situations that drive animals to cross roads arise most commonly when:

- Roads dissect prime habitats and fall within established territories and home ranges of resident wildlife
- Roads come in the way of established wildlife pathways such as migratory routes and corridors
- Herds or groups are temporarily split by a road and a passing vehicle triggers panic inducing one or more animals to rush across. In instances like this, the victim is most often a young animal
- Arboreal animals (example primates, squirrels, lizards) attempt to cross from one patch of forest to another; or they simply get down from one avenue tree to another on the other side of the road
- Reptiles, being cold blooded, come out to bask on the road after a cold or wet night; a night shower followed by a sunny morning invariably leads to such behaviour in reptiles
- Amphibians migrate at night (sometimes daytime as well) in large numbers in and out of their breeding pools during certain seasons (example monsoon and post-monsoon)

- Animals come close to the roads seeking food; roads create ecotones that are generally more productive and offer more food for grazing animals, roads also provide food for birds, rodents and primates when vehicles transporting grains spill some as they move on or, there is food when people who travel (tourists and outsiders) throw them off vehicles carelessly or purposely when they see animals close by

Roads in Mudumalai have taken a toll of all kinds of animals including leopards and pythons. Besides roads, human presence tends to attract some animals like primates, squirrels, mongooses, civets, jackal, jungle cat, peafowl and number of reptiles including snakes that seek food in and around human habitation. Of late, there have been many instances of leopards straying into human habitation primarily seeking dogs as their prey. Elephants are attracted by toddy and other fermented drinks (Anonymous, 1993).

Alternately, domestic animals like livestock, place a lot of grazing pressure on forests and grasslands and spread parasites and diseases amongst wildlife. Domesticated dogs and cats are a great threat to small animals, especially those that live on ground and closer to human habitation. Domestic dogs when free-ranging can be a potential source of rabies that even wild carnivores are not immune to.

Apart from these forms of human interferences, the greatest threat (although subtle) will emerge in the form of noise and pollution. Vehicle and excavation noises will be quite monotonous that can interfere with the normal behaviour of animals that rely on sounds for communication. In the Western Ghats, it has been observed that when cicadas become abundant and very loud locally, birds abandon the habitats temporarily (Daniels and Vencatesan, 2008). Only a few species of birds and some frogs tolerate loud noise of torrential water. Very little is known of the impacts of reverberating sounds on animals like bats, cave swifts (one species exists in the Western Ghats) and elephants that rely on ultrasonic sounds for communication and orientation. How snakes respond to continuous vibrations as caused by drilling and blasting has not been studied in India. But we do know that snakes are more sensitive to vibrations on the ground than signals that they pick up from the air. When some of these animals eventually adapt to the noises and vibrations they may well have become insensitive to dangers.

Dust pollution in the air can interfere with photosynthesis and pollination in plants. When dust gets into water, it enhances the turbidity. Hill streams are unique in that the shallow waters are clear allowing a lot of light to penetrate thereby keeping the water highly oxygenated. Hill stream fishes, amphibians and insects are very sensitive to turbidity (Daniels, 2002 & 2005; K A Subramanian, personal communication).

Oil pollution is a foreseen problem during the construction phase considering the number of trucks and other excavation machines that will be involved. Oil spills on grass, soil and water interferes with wildlife (also people and domestic animals) in different ways. Fuel spills can also trigger forest fire.

Human wastes, especially excreta, attract a number of animals. They tend to be sources of intestinal parasites. Urine attracts herbivores that lick the wet soil for the salt. Elephants are attracted by salt and the smell of jaggery besides toddy, beer and other fermented drinks. Drunken behaviour of elephants has emerged as a major reason for human-elephant conflicts in parts of India.

Interference with Wildlife Corridors

Wildlife corridors are narrow strips of vegetation that connect two otherwise isolated habitat fragments facilitating the exchange of genes, dispersal of individuals or groups, access to seasonal resources and thereby meta-population dynamics (Sivaganesan *et al*, undated; adapted). The most exhaustive assessment of the wildlife corridors available for the Nilgiri Biosphere Reserve is that provided by Sivaganesan *et al*, undated). The study was a part of SACON's initiative supported by MoEF/GOI during the period October 1995 to June 1998. The study apparently covered a distance of 1254km on foot and in vehicles, assessed habitat quality using 1496 vegetation plots (50m x 20m; 10m x 10m) and undertook extensive questionnaire surveys and interviewed numerous local inhabitants. It specifically assessed the proportion of elephant food plants and the overall regeneration potential within the study landscapes. Based on the study, the following wildlife corridors (Table 5) have been delineated.

Table 5: Wildlife Corridors in the Nilgiri Biosphere Reserve (Sivaganesan *et al*, undated); those that are within INO Project landscape are highlighted

Name	Characteristics	Remarks
Moyar Valley-Eastern Ghats	Located at the junction of Eastern Ghats and Western Ghats; extends between Thengumarada and Kallampalayam; 350-400m ASL; 12km long with an average width of 3.5km; scrub and deciduous forests	Links Bannari RF of Satyamangalam Forest Division and Kallar of Coimbatore Forest Division; elephants use the corridor; other important wildlife includes the Blackbuck
Sujalkuttai-Bannari	Located in the northern part of Periyar district bounded in the north by Karnataka; extends between Moyar tail end and Bannari beat of Kallar; 9km in long with a width of 0.5-3.0km; scrub and deciduous forests	Links Moyar Valley and other protected areas within the Biosphere Reserve; elephants use the corridor; good population of Blackbuck present; elephants/other wild mammals 128/165
Kallampalayam-Uppupallam	Located in the foothills of the eastern slopes of Nilgiris; extends between Moyar Valley and the banks of Bhavanisagar Reservoir; 9km long with a width of 0.2-4km; thorn and deciduous forests	Links the Eastern Ghats with the Coimbatore Forest Division; dominated by the invasive *Prosopis juliflora*; elephants migrate frequently; elephants/other wild mammals 22/165
Kallar-Vedar Colony	Located south of the Jaccanari escarpment within the Coimbatore Central Forest Division; 5km long with a width of 0.5-1.5km; dry forests with bamboo and scrub	Links Pillur RF and Attapady Valley; borders the Forest College at Mettupalayam
Kallar-Jaccanari	Located in Coimbatore Central	Borders the private educational

	Forest Division; 5km long with a width of 0.5-1.5km; dry forests and scrub	institute of Swami Sachidananda Jothi Niketan; elephants use the corridor; elephants/other wild mammals 17/66
Kallar-Nellithurai	Located in Coimbatore Central Forest Division surrounded by hills viz., Kovalkombai (1055m ASL), Chengalkombai (1200m ASL) and Melur slope RF, Kallar, Nellithurai, Sattaiyur and Kil Chengal; 9km long with a width of 0.15-3.0km; deciduous and thorn forests; > 60% of the trees were preferred food plants of elephants	Links Pillur RF and Attapady Valley and Silent Valley NP; elephants have a strong preference for the corridor during seasonal migration; elephants/other wild mammals 11/165
Moyar-Avarahalla	Located in the north-eastern part of Mudumalai WLS; bounded by Moyar road and Sigur RF; 9km long with a width of 25-100m; thorn and deciduous forests	Also known as the 'Moyar-Avarahalla roadside corridor' runs parallel to the Singara flume channel; links Sigur Plateau and Mudumalai through Jayadev Avenue; important for elephants; elephants/other wild mammals 95/363
Singara-Mavinhalla*	Located at the southern part of Mudumalai WLS; 8km long with an average width of 2km; deciduous and thorn forests; 63% of the trees were food plants of the elephant	Encompasses Singara private estates and reserve forests of Nilgiri North Forest Division; crucial for elephants; elephants/other wild mammals 96/330

* Also known as Kalmalai-Singara-Avarahalla Corridor

Over the years, there have been a lot of interest in wildlife corridors that there is more information on those that lie within the Project landscape. Careful assessment of the corridors during the present study has clearly suggested what were traditionally treated as two corridors are basically two segments of the same corridor; the Moyar-Avarahalla Corridor. The northern segment has come to be known as Moyar-Avarahalla and the southern, Singara-Mavinhalla corridor.

The Moyar-Avarahalla segment is used mainly during the dry season when elephants, chital, sambar and wild boar are frequently encountered. During the wet season there is a greater abundance of porcupine and black-naped hare in the Corridor. Other mammals that frequently use the Corridor are sloth bear, gaur, wild-dog, civets and jungle cat. Elephants frequent the Corridor in the dry season due to the availability of water in the Moyar flume channel (Sivaganesan *et al*, undated).

Singara-Mavinhalla segment is rather heavily used by elephants and chital during the dry season and sambar in the wet season. Other mammals using the corridor was not directly inferred but there were signs of wild dog, sloth bear, hyena, mongoose, civets, sambar and black-naped hare during the 1995-98 study of SACON. That 63% of the trees that are found here belong to species that are preferred as food by the elephant is a reason for herds using the Corridor more frequently (Sivaganesan *et al*, undated). Baskaran *et al* (1995) have recommended that the private estates of Singara are purchased and used to enhance the quality of the Singara-Mavinhalla Corridor.

The Moyar-Avarahalla Wildlife Corridor

Landscape ecology has designated corridors as one of three elements of a landscape: *a matrix, a patch* and *one that connects*. Corridors are narrow strips of land that differ from the matrix on either side. Corridors can also be isolated strips that connect two patches of similar habitat. They serve as 'conduits' that have a transport function (Forman and Gordon, 1986).

By the above definition corridors are clearly narrow (relative to the matrix and patches of habitats) and serve as passageways or galleries. The commonly assumed distinguishing character of a corridor is that it is a linear landscape element and it facilitates a movement function (Menon *et al*, 2005).

E R C Davidar first described the Moyar-Avarahalla wildlife corridor as critical elephant habitat during the late 1960s. Since then, the Corridor has attracted considerable attention from wildlife biologists and the Forest Department (Menon *et al*, 2005). The Corridor enables the movement of elephants and other wild mammals between the west (Bandipur, Wyanad and Mudumalai) and the east (Thalamalai RF in Satyamangalam) within the Nilgiris-Eastern Ghats Elephant Reserve. The two important centers of human activity that impact the Corridor are Masinagudi and Singara.

Geographically the Corridor lies within a valley that is topographically flat and bounded in the north by the Moyar gorge and in the south by the steep slopes of Kalhatti Ghat. The valley (matrix) varies in width between 6 and 8km. Human settlements that flourished due to the hydroelectric projects and the associated infrastructure development (roads, etc) in the valley first fragmented the contiguous wildlife habitats rendering it more patchy and heterogeneous. The spurt of project activities between 1960 and 1990 has further degraded the Corridor that connectivity between the widely separated habitat patches has been reduced to bottlenecks.

The flume channel linking the Glenmorgan, Maravakandy and Moyar dams that has created major barriers, and the unrestricted proliferation of human activities in Masinagudi and Singara have come in the way of the Corridor that at present the available segments are in the form of two widely separated chokers or 'squeeze-zones' within the bottleneck. The first of the squeeze zones lies immediately north of Masinagudi (Moyar-Avarahalla segment) and the second between Masinagudi and Singara (Kalmalai-Singara-Avarahalla segment). The latter is also known as Singara-Mavinhalla corridor (Sivaganesan *et al*, undated). The two segments of the Corridor have together provided an elliptical orbit around for wildlife around the Masinagudi town.

Grazing cattle and lopping of trees for fodder and collection of wood for fuel are placing sustained pressures on the Corridor. More recently, the mushrooming of holiday resorts in and around the habitat has

unduly increased the pressure on roads due to vehicular traffic under the guise of eco-tourism. The Kalmalai-Singara-Avarahalla segment of the Corridor is bisected between Masinagudi and Singara by a 6km road and a segment of the flume channel. As a result the squeeze zone is a mere 1.5km stretch of forest that spreads between the intersection of the flume channel on the road and the entrance to the Singara estates. Further down (southeast) there is interference due to rampant human activities (resorts in particular) at Bokkapuram.

The land on either side of the Singara-Masinagudi road is largely private and owned by the Singara estates. The boundaries of the RF are located between 0.5 and 1.5km from the road on both sides. Closer to Masinagudi the habitat is drier, degraded and highly human impacted and in Singara where it is moister, there are coffee estates and the TNEB PUSHEP campus. The remnant vegetation in Singara is of the moist deciduous and semi-evergreen types. The habitat within the squeeze zone is dominated by mature bamboo and a variety of trees on the eastern side. The western side is however quite open with shrubs and a predominance of the invasive *Parthenium hysterophorus*. Despite the degraded condition of the habitat closer to the roads, at least 20 species of mammals continue to use the passage as observed during the present study.

Elephant, chital, sambar, gaur, wild boar, black-naped hare, Indian porcupine, common langur, bonnet macaque, Indian giant squirrel, three-striped palm squirrel, common mongoose, stripe-necked mongoose, sloth bear, tiger, leopard, jungle cat, striped hyena, wild-dog and jackal. Of the mammals, tiger, elephant, leopard, gaur, giant squirrel, hyena and sloth bear are endangered species. Three hundred and sixty wild mammals were observed passing through the squeeze-zone in the Singara-Masinagudi road during October 2007 and January 2008. Chital was the most common species (62.2%) followed by elephant (12.2%). Other common mammals included sambar (6%), gaur (6%) and common langur (6%). Leopards frequently use the squeeze-zone too. This was confirmed by direct sighting and by the presence of fresh pugmarks and the remains of domestic cattle killed recently.

Using 4 one-kilometer transects in and around the squeeze-zone we counted the piles of elephant dung. The estimated density of dung in the habitat is 807/km^2 and that translates into 0.48 elephant/km^2. Information provided by the elephant trackers who have worked in the habitat for many years has suggested that the elephant density increases markedly during summer season, as the flume channel is the only source of water within the squeeze-zone.

Forty-four elephants were directly sighted on 18 occasions of which about half were adult females. Only 3 were adult males. The rest were all sub-adult, juvenile and young. The observed sex ratio (male:female) was 1:2 amongst juveniles, 1:3.5 amongst sub-adults and 1:5 amongst the adults.

Movement of vehicles across the squeeze-zone was monitored between 0700hrs and 1800hrs every alternate day. 1270 vehicles were counted during the study (two-wheeler 150, light motor vehicle 877; heavy vehicle 243) moving at an average of 5.5/hour. On a daily basis, around 40 light motor vehicles, 7 two-wheelers and 11 heavy vehicles ply along the Singara-Masinagudi road. Two-wheelers and light motor vehicles were largely those transporting tourists.

Road kills involved 42 animals on just 3km stretch of the Singara-Masinagudi road during October 2007 and January 2008. As expected, 27 were amphibians. Only 2 were mammals. Road kills tend to vary with the seasons and daily pattern of vehicle movement.

Desai and Baskaran (1996) have treated the Moyar-Avarahalla wildlife corridor as 'critical' to the movement of elephant. The two segments of the Corridor have already suffered due to various kinds of degradation and as such are major 'chokers' of wildlife (and elephant) movement where natural habitats have been fragmented by development. Further degradation is likely to lead to human-wildlife conflicts. Whereas steep terrain tends to naturally force wildlife, elephants in particular, through bottlenecks, agriculture, human settlements and development activities like hydroelectric projects are the greatest chokers of wildlife corridors (Baskaran *et al*, 1995). The National Wildlife Action Plan for 2002-2016 (MoEF, 2002) has reiterated the need to identify and preserve wildlife corridors. It has been proposed that all wildlife corridors be given the status of 'ecologically sensitive areas' under the provisions of the Environmental (Protection) Act, 1986.

Impacts on Behaviour of Elephants and other Large Mammals

The total area over which an individual or group of mammals moves to feed and breed is called 'home range'. Radio-collared elephants (3 females and 2 males) that were tracked by the Bombay Natural History Society (BNHS) for 2-3 years between 1991 and 1993 in the Nilgiris have provided some very useful data on home ranges of large mammals. Clans (all female herds) around Mudumalai that BNHS studied had a home range that varied between 530 and 800km^2. Adult males apparently had a smaller home range in that the two radio-collared bulls were found to have moved over between 200 and 375km^2 (Baskaran *et al*, 1995).

Home ranges of animals vary in size in relation to the quality of available habitats. It has been observed that in deciduous forests as that in the Mudumalai WLS the home range of an average clan of elephants is around 600km^2. Mudumalai WLS being only half the size of an average clan's home range will obviously be reason for elephants roaming into the adjoining parts of the landscape. Smaller home range is an indication of stress and it is the first clue that the elephants will enter human settlements and thus get into conflicts (Baskaran *et al*, 1995).

In Mudumalai female elephants stay in herds (clans) and adults males (bulls) tend to be solitary. Since the two sexes have different home ranges and strategies for habitat utilization it is presumed that human impacts affect the clans and bulls differently. While bulls are more prone to 'adventure' and raiding within human settlements, both bulls and clans are apparently equally attracted by the presence of water (Desai and Baskaran, 1996). As human habitation also borders on easy access to water, 'water-conflicts' between man and elephant is a consequence. Elephants are attracted to water much more during summer than the other parts of the year.

At least 28 species of wild mammals are known from the Mudumalai landscape that lies around the Project site. Azeez *et al* (1997a) has reported that Gaur avoided the construction site of MUSHEP although herds of elephants continued to roam in the adjoining habitats despite the construction activities. Variations between individuals of elephants in their sensitivities to noise, vibrations and the smell of explosives have not been understood. Available information on domestic dogs does indicate that the response to noise of explosives and the smell of fire vary considerably amongst individuals in a local population. Birds including feral blue rock pigeons also tend to avoid the sound of crackers and explosives. While birds can more easily avoid foraging in the noisy zones as they are more mobile, continuous noise and vibrations may interfere with their nesting behaviour. The interference is likely to be more in birds that nest on the ground (example lapwings, larks, thrushes), within burrows in embankments (example kingfishers, bee-eaters) and inside tree-holes (example hornbills, owls, nuthatches, woodpeckers, titmice, parakeets, barbets). These birds are typically found in the habitat mosaic of the Project landscape.

Perceptions of Residents and Other Interest Groups

Habitat transformation and interference with wildlife that the Project may cause is seen as a major threat to human livelihoods locally. The loss caused to wildlife-related livelihoods cannot be compensated by the Project as it at best may offer only short-term alternatives. An estimated 100 jeeps ply in and out of the village during the peak wildlife season that coincides with the elephant movement period. Supporting the drivers are the wildlife guides (and animal trackers) of which there are specialists, such as the elephant trackers, bird guides, etc. The wildlife guides were unequivocal in their displeasure over establishing Project INO. The reasons include the following:

1. The Singara-Mavinhalla segment of the Corridor that has received immense attention from researchers, managers and tourists is currently in the process of ecological recovery after a period of hectic activity by TNEB, and Project INO will be detrimental to their livelihoods since the construction phase would involve movement of large vehicles to transport muck and construction material, movement and settlement of labour and most importantly, curtailing of unrestricted access both to humans and the wildlife. They also feel that vehicles would run over smaller organisms, notably amphibians.
2. The general focus unfortunately has been on elephants and their movement and hence strategies to mitigate damages are directed only on the elephant. What about the vast number of amphibians, reptiles, birds (notably hornbills close to the flume channel), chital and other smaller mammals that are found all through the season. Many guides derive their livelihood by specializing the sighting of these organisms.
3. The livelihood opportunities that Project INO offers are of little relevance to the natives/indigenous population. Even if they are hired, as they were in the past by the contractors of the TNEB, their tenure can only be short, coincident with the time taken for the construction of the

tunnel/construction. At the end of the tenure, they are again in a state of insecurity being older with little chances of re-establishing their livelihoods.

4. Restriction of access by project INO, the residents perceive as an eventuality. Erecting check posts will not be effective in deterring vehicle movement but will only facilitate corruption.
5. The guides, while seemingly freelancing are fully supported by the wildlife resorts (61 in all of which only 48 have proper infrastructure) in the landscape. The owners/promoters of these resorts are largely outsiders, with no knowledge of the local terrain or the wildlife. They are hence left with no option but to engage these guides. With major corporate entities now in fray, the wages of the guides have also increased.
6. Discussions with the drivers presented a contrasting picture. A majority of them view Project INO as a livelihood generating entity, as in the case of the other institutions that have a presence in the region.
7. The elected Panchayat, as represented by the President Thirumathi Sangeetha does not resent Project INO, and view it as an initiative that will bring employment and business opportunities. They are however displeased by the fact that as with other major initiatives that are planned for the landscape, they have not been informed about the Project. They also feel that their concerns can be effectively addressed only if a) the team of scientists, represented by a senior person explains to the Panchyat, in Tamil the scope and purpose of the project, b) a formal consensus will be reached when all members of the Panchayat are present and c) the local population be made aware of the project through the use of audio-visual material.

8. The local Panchayat also resents the claim of non-governmental organisations and environmentalists that wildlife is not a priority in Masinagudi Panchayat. Contesting this strongly, they state that mere common sense would help in inferring the following: wildlife and environment would be more important for those people whose lives and livelihoods are dependent on protecting the landscape rather than those proclaiming passion. Further, if indeed local interests have been detrimental to wildlife, what rationale was used to declare the area a Project Tiger Reserve. Representative of the Kurumba tribes categorically stated that they are the rightful custodians of the forest, and have contributed to not only protecting the landscape but also building the career of many wildlife and nature enthusiasts and researchers.

Major fears of the resident population are based on the fact that Project INO has been erroneously seen as a secretive, military project in which weapons of mass destruction would be stored in a tunnel. Apart from visualizing this as a venture that would cause irreparable damage to their health, the fear that access through Singara will be restricted is a major apprehension. There are also fears that a low frequency noise

that the equipment emits would lead to erratic behaviour of elephants. That the Project INO is a basic research project is not very convincing either, since there is a perceptible negative attitude towards basic research that is viewed as an esoteric indulgence of the affluent.

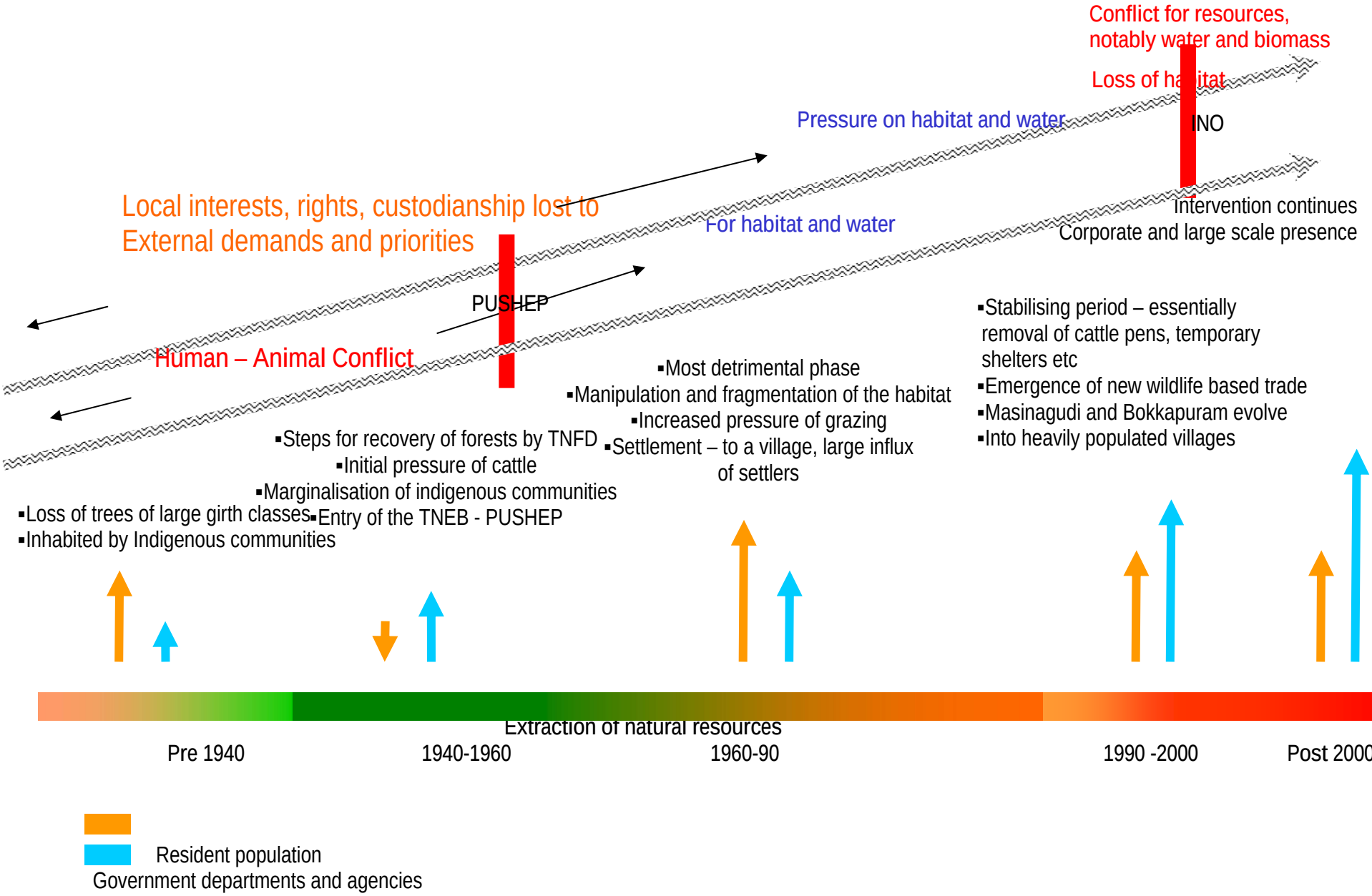
It is also felt rather strongly that while many institutions find Masinagudi to be conducive for their work, none of them have had a programme or initiative to improve the conditions of the resident population. The institutions are perceived as being overtly friendly to the State machinery, notably the Tamil Nadu Forest Department. This is the same grievance that the residents (both native and settlers) have towards the non-governmental organizations that are trying to conserve the landscape. The residents feel that these organizations are alien, highly subjective and volatile in their approach and non-participatory.

Perspectives of the NGOs is limited to those working on wildlife and ecological issues. This in itself is reflective of the fact that there are no notable NGOs in the region which accord equal importance to social and ecological issues and approach the same with a balanced perspective. NGOs interviewed are strongly negative in their attitude towards project INO and state that this will a) aggravate the existing pressure on the landscape b) be detrimental to wildlife and c) no via media solutions can be reached. They also fear that project INO may serve as the catalyst for enabling many of the development projects that they have hitherto opposed.

A consolidated table of the perceptions of the various communities about the Project INO is provided below:

Community	Indigenous tribal communities	Traders	Wildlife guides	Drivers	Panchayat	NGOs	Naturalists/Wildlife biologists/ecologists	Tamil Nadu Forest Department - representatives
Mode of interaction/data collection	Group discussion/ 45 in Masinagudi and Theppakadu	Individual interviews 121 in Masinagudi	Focus group discussion 35 in Masinagudi/ Theppakadu	Focus group discussion – Association representatives	Meeting convened by the President – ward members	Individual interviews – WWF, NWLA, TNGM, BNHS	Individual interviews Dr. Ajay Desai Mr. Armugam	Individual interviews
Area or place of residence	Masinagudi/Theppakadu	Masinagudi – nearby villages	Masinagudi/ Bokkapuram/ Ooty	Masinagudi and adjoining villages	Masinagudi panchyat	Ooty, Kargudi	Kargudi/Coimbatore	Chennai/Ooty
Primary livelihood	Trackers/labourers	Trade	Guides	Also providing services to adjoining villages / settlements and towns	Multi-trade			
Awareness about project INO	No	No	No	No	No	Yes	Yes	Yes
Overall understanding about project INO	A project of the Indian Army involve ng weapons of mass destruction					A basic sciences project which is of no immediate relevance	A basic sciences project	
Anticipated outputs of project INO				More trips	Jobs / opportunities for the service sector	Destruction of the Singara Mavanalla corridor and accelerated growth of Masinagudi		Destruction of forests and wildlife
Potential scope in future		Local trade will be taken over by corporate entities			Other projects such as the Sathyamangalam road/train services will also be sanctioned	Will be used as a platform to bring in other major projects		

Community	Indigenous tribal communities	Traders	Wildlife guides	Drivers	Panchayat	NGOs	Naturalists/Wildlife biologists/ecologists	Tamil Nadu Forest Department - representatives
Major apprehensions/fears	Will further marginalize the community and destroy wildlife, lead to increased human-animal conflict	Restricted access, experiments as portrayed by science fiction	Destruction of wildlife	Restricted access	Restricted access and secondary access to natural resources, especially water	Undermine the fifty odd years of conservation efforts, detrimental to forests and wildlife		
Secondary apprehensions/fears	Will be responsible for other major State supported projects to be located in Masinagudi							
Points for inclusion in the implementation of the project	None	NOne	NOne	None	Should be discussed and arrived at – although local interests should be protected by a local committee constituted for the purpose	NOne	None	None
Reasons for not wanting the project in Masinagudi/Singara	As above							
Overall attitude	Neutral	Neutral	Negative	Positive	Neutral to positive	Negative	Negative	Negative


Conflict for resources, notably water and biomass
Loss of habitat
Pressure on habitat and water
INO
Local interests, rights, custodianship lost to External demands and priorities
For habitat and water
Intervention continues
Corporate and large scale presence
PUSHEP
Human – Animal Conflict
▪Most detrimental phase
▪Manipulation and fragmentation of the habitat
▪Increased pressure of grazing
▪Settlement – to a village, large influx of settlers
▪Stabilising period – essentially removal of cattle pens, temporary shelters etc
▪Emergence of new wildlife based trade
▪Masinagudi and Bokkapuram evolve
▪Into heavily populated villages
▪Steps for recovery of forests by TNFD
▪Initial pressure of cattle
▪Marginalisation of indigenous communities
▪Loss of trees of large girth classes
▪Inhabited by Indigenous communities
▪Entry of the TNEB - PUSHEP
Extraction of natural resources
Pre 1940
1940-1960
1960-90
1990 -2000
Post 2000
Resident population
Government departments and agencies

Contribution to Human Resource Development

INO Project envisages developing a workforce of young and trained scientists and engineers. The workforce thus developed will be the 'end user group'. The human resource will be drawn from amongst the students, post-doctoral fellows and faculty of the INO collaboration. The workforce or the end user group will have at least 30 scientists and 20 technically qualified personnel. At any time, 15 members of the workforce are required for conducting experiments and for the maintenance of the INO installation (INO, 2006).

The required human resource will be developed in 4-5 years. One of the proposals that have been made by INO (2006) for achieving this is the establishment of an INO Training School. As per the proposal, 15 students at the level of MSc, BTech or BE will be selected from throughout the Country each year for a one-year training course. At the end of five years it is anticipated that 75 technically qualified personnel will join the INO workforce. The trained personnel have the option of working in the INO Project or entering other laboratories in India and abroad that conduct experiments in related fields of science (example High Energy Physics and Nuclear Physics; INO 2006).

Besides the above suggestions there are also plans of recruiting students and scientists from various collaborating institutes for the INO Project on a yearly basis. The following are some of the proposals that are already in place for improving HRD in front-line experiments (INO, 2006) in India:

- Annual recruitment of 12 post-graduates in physics and graduates in engineering who will work in the INO project under the guidance of senior physicists for 5 years

- Offering INO Fellowships for Master's level studies in IITs and other engineering institutions and selected university departments; the fellowships will be available for two-years during which the student may submit a dissertation in neutrino physics

- PhD programmes in instrument building; this is unfortunately a neglected science in India and has to be revived and strengthened through long-term programmes like the INO; hands-on experience that the Project offers will be the primary motivation

- The Government of India's Department of Atomic Energy (DAE) might consider HRD in universities by inducting young personnel into INO and related research in physics

- Human resource developed by INO Project can cater to the needs of certain upcoming fields of medical science such as 'functional imaging'; functional imaging techniques have a great potential in the detection and treatment of cancers

Part V: Alternate Sites and Landscapes

EIA Guidelines
Preferred Environmental Conditions
Nilgiris Landscape
Anaimalai Hills Landscape
Palani Hills Landscape
Cumbum-Theni Landscape
Matrix of Feasibility Analysis
Mahendragiri: a viable option?

EIA Guidelines

The Government of India EIA guidelines (MoEF, 1989) have made it explicit that EIA for development projects are carried out prior to site selection and investment decisions. MoEF (1989) also insists that EIA is meant for inter-comparison of the development options and screening of alternative sites for locating the projects (Daniels, 1992).

The environmental impact statement (EIS) is meant to provide inputs of alternate sites and landscapes where the Project might be located. For this purpose, there is a need to first understand the prescribed environmental standards and requirements of the Project. The Project Agency has assessed two distant locations; one the eastern Himalayas and the other in the Western Ghats.

The eastern Himalayan site that has been assessed lies in Darjeeling district of West Bengal. The specific location is within the Ramman Hydroelectric Project (RHP). RHP is situated at an altitude of 1500m ASL. It is 140km from Bagdogra airport. There is an existing tunnel of 3-5km long with a slope of 1:20 and an additional 2km alternate access route. The estimated overburden is 1400-1850m. The site lies within seismic zone 4 and calls for extra precautions during construction. However, as there many existing tunnels and underground caverns already built in the site, seismic vulnerability does not seem an insurmountable problem here (Mondal, 2004).

A detailed comparison of the prescribed environmental standards required for locating underground research facilities between the eastern Himalayan and Western Ghats sites are presented in the background document (INO, 2006). While most of the requirement is more or less equally met in the two sites, the latter has been finalized for the Project. The reasons for the

preference of the Western Ghats site are discussed in the following sections. Options for relocating the Project in other landscapes in the Western Ghats are also being considered in the sections that follow.

Preferred Environmental Conditions

Every project requires some ideal environmental conditions if it has to be successful in the long run. Preferred environmental conditions (PEC) therefore imply those that are specifically sought by the Project. The first consideration while choosing the site in a project that involves underground construction is its vulnerability to earthquakes. Although it has been stated that underground structures are less vulnerable than aboveground structures (INO, 2007), sites that fall within low seismic zones are always safer. As such, that RHP (the Darjeeling site) falls in zone 4 has been a fundamental reason for considering the Western Ghats of Tamil Nadu where the landscapes fall within seismic zone 2 that is less vulnerable (INO, 2007).

Hills are chosen such that an overburden of 1000m (required by the Project) is easily achieved. The Nilgiri Hills have the potential of offering the required overburden in many sites. The site at Singara that has been identified for the Project apparently offers 1300-1400m vertical burden and an all round cover in excess of 1000m (Mondal, 2004). Further, it offers scope for creating a 'not-so-long' and near-horizontal access tunnel.

Besides these qualities, the selection of the Project site has had to take into consideration the rock quality (in this case the required density of rocks is around 2.7gm/cc), existing infrastructure (example projects that have already established underground facilities), accessibility and awareness and support of the local people (Mondal, 2004).

Having fulfilled the first three requirements that are geological in nature, the choice of the Project site has further been influenced by economical and social considerations. The economic consideration includes the accessibility and available infrastructure.

Singara (and Masinagudi) are located close to the Cosmic Ray Laboratory and Radio Astronomy Centre at Ooty. They are close to the existing TNEB residential facilities established during the 75-year pursuit of generating power through hydroelectricity schemes. The sites are also easily accessible from major cities like Coimbatore, Mysore and Bangalore where some of the collaborating institutions are located (Mondal, 2004). Both Coimbatore and Bangalore have international airports (an added advantage).

Social atmosphere has however, been only partly conducive. While the Government of Tamil Nadu and the TNEB have welcomed the Project, local NGOs, environmental activists, wildlife biologists and Forest Department personnel have raised objections to the Project being located in Singara and Masinagudi. Some of the NGOs and activists consulted by the INO agency have recommended that Nellithurai will be better suited to the Project. Also during a brainstorming meeting that was organized at the Institute of Mathematical Sciences on August 20, 2007, it was suggested that alternate sites be assessed further south in the Western Ghats of Tamil Nadu. Such a recommendation was made purely on the grounds that Singara-Masinagudi sites lie close to well-established wildlife corridors in the Mudumalai landscape.

As a part of the present study, Care Earth carried out an exclusive survey of alternate sites in the Western Ghats south of the Nilgiri Hills. During the survey (undertaken in December 2007) 14 locations covering the hilly landscapes of Anaimalais, Palnis and Cumbum-Theni were visited. These locations were first identified using Google Earth Images. The field survey permitted the evaluation and rejection of a few locations at the same time offered scope to visit and assess newer sites. Thus within the 14 locations first demarcated from the Google Earth Images, the survey has identified 20 specific sites (see Annexure for photographs/images). In the sections that follow, the results of the survey are briefly summarized. During early discussions with the INO Project personnel we were given to understand that the environmental/wildlife activists of the Nilgiris district had suggested Nellithurai as an alternate site within the Nilgiris landscape. We have therefore examined the feasibility of the site as well.

Nilgiris Landscape

Nellithurai was proposed by environmental & wildlife activists of the Nilgiris district as an alternative site within the Nilgiris landscape. Sivaganesan *et al* (undated) have identified a very important elephant corridor between Nellithurai and Kallar. Hills here are lower rising between 1000 and 1200m ASL (see Table; Part IV). This site falls on the southern limit of the Nilgiri Biosphere Reserve and close to the Metupalayam ghats that form a part of the already heavily impacted elephant corridor. The corridor is a vital link between the elephant habitats in Kerala and Tamilnadu and as such cannot be considered as an alternate site for the INO Project.

The present study also examined the possibility of moving the INO Project slightly away from the protected area and the already impacted TNEB property/facility into the adjoining Singara Coffee Estates. While this seemed a viable proposal at first, detailed field assessment has highlighted the formidable costs of land that need to be procured and the rather undulating terrain that might not suit the establishment of the proposed aboveground infrastructure. More than all these considerations, it has emerged from the field visits that the estate is used by large mammals (including the elephant) as a corridor and there are proposals from the TN Forest Department to buy it up and annexe it to the existing critical wildlife habitats in the landscape.

Anaimalai Hills Landscape

The landscape is accessed easily from Coimbatore (an industrialized city with an international airport). Two sites in Alyar and two in Thirumurti tend to qualify as potential locations for the Project (see Feasibility Matrix). However, if obtaining 1300m of overburden is considered to be very critical, one of the two sites in Alyar may not be the best. The other 3 sites have the potential of providing the required overburden when the tunnel length exceeds 4500m (see Annexure for photographs/images).

Palani Hills Landscape

The northern sides of the landscape can be accessed from Coimbatore. Much of the Palani Hills landscape is best approached from Madurai another city with an airport and necessary infrastructure. Six sites including one each in Palar and Pannapatti and two each in Marudhanadi and Manjalar were assessed here (see Feasibility Matrix). Of these only the sites at Palar and Pannapatti offer the required 1300m of overburden. Such an overburden can be achieved when

the tunnel length is around 3700m in Pannapatti. If however, there can be some flexibility in the overburden or the overall slope of the tunnel the sites in Manjalar would be the most appropriate for the Project (see Annexure for photographs/images).

Cumbum-Theni Landscape

Munnar, Munthal, Kanagudi, Sakanutu Metti and Bodi are the five sites assessed in the landscape. The landscape is best accessed from Madurai. The maximum distance from the airport is 120km (see Feasibility Matrix). In both Kanagudi and Munthal the required overburden of 1300m can be obtained when the tunnel is less than 4000m; Kanagudi being the best requiring only 3160m. Considering all other conditions, Kanagudi (located near Bodinayakanur) seems to be the best alternative site for the INO Project (see Annexure for photographs/images).

Matrix of Feasibility Analysis

Table 6 summarizes the feasibility assessment of the 15 sites covering 3 landscapes outside the Nilgiris. The feasibility assessment was based on accessibility, distance from protected areas, reserve forests and wildlife corridors, the altitude, the length of the tunnel that is required, distance to the nearest airport and other infrastructure needs such as electricity, residential facilities and presence of TNEB (mainly for purposes of geological familiarity). Whereas specific details including maps and satellite images are provided in the Annexure, the key factors are presented in the form of a matrix in Table 6.

Of the 15 sites, Alyar 1b provides an overburden of over 1000m and a tunnel that is practically horizontal. The only other site that permits a tunnel that does not exceed the mandatory 4 degrees slope is Manjalar 6b. This site however is lower in elevation and may not provide the required overburden.

Mahendragiri: a viable option?

In view of the shortcomings of the 13 other sites assessed (the main shortcoming being the steeper slope of the tunnel) it does not seem that there are many alternatives to the Nilgris sites. A probable alternative site may be found further south in the Mahendragiri Hills bordering Kanyakumari-Tirunelveli districts. It is accessible by road and rail and the nearest airport is at Trivandrum. The wind energy farm at the adjoining Aralvaimozhi is globally recognized and can be a source of energy. An added advantage of Mahendragiri Hills is that ISRO has an exclusive facility here. It may be possible to locate the INO Project within the ISRO facility itself. The feasibility of Mahendragiri/ISRO as an alternative site can be explored.

Table 6: Matrix summarizing the characteristics of the 15 alternate sites assessed

Site	Elevation (mASL)	Tunnel length (m)	Slope (deg) required for tunnel	Distance to airport (km)	Local infrastructure				Remarks
					Presence of Govt organizations	Access roads	Electricity	Cell-phone signals	
Alyar 1b	1283	4000	0	60	Yes	Yes	Yes	Yes	Presence of TNEB, hydel dam; periphery of WL Sanctuary
Manjalar 6b	869	2010	4	90	Yes	Yes	Yes	Yes	Irrigation dam; proximity to RF
Pannapatti 4	823	2000	5	70	Yes	No	No	No	Irrigation dam; proximity to RF
Munthal 8	846	1870	5	110	No	Yes	No	No	No dam; lacks infrastructure
Marudhanadi 5a	803	1850	6	80	Yes	Yes	Yes	No	Irrigation dam
Marudhanadi 5b	774	2000	6	80	Yes	No	Yes	No	Irrigation dam
Alyar 1a	671	2490	8	60	Yes	Yes	Yes	Yes	Presence of TNEB, hydel dam; periphery of WL Sanctuary

Site	Elevation (mASL)	Tunnel length (m)	Slope (deg) required for tunnel	Distance to airport (km)	Local infrastructure				Remarks
					Presence of Govt organizations	Access roads	Electricity	Cell-phone signals	
Palar 3	628	2500	8	120	Yes	Yes	Yes	Yes	Irrigation dam; proximity to RF
Sakanutu metti 12	797	1460	8	110	No	Yes	No	Yes	No dam; weak infrastructure
Kanagudi 9	676	2000	9	120	No	Yes	No	No	No dam
Manjalar 6a	708	1810	9	90	Yes	Yes	Yes	Yes	Irrigation dam; proximity to RF
Thirumurthi 2c	630	2000	10	90	Yes	Yes	Yes	Yes	Presence of TNEB, hydel dam; periphery of WL Sanctuary; proximity to Pilgrim centre
Bodi 13	721	1560	10	105	No	Yes	No	No	No dam; proximity to RF
Thirumurthi 2d	664	1720	11	90	Yes	Yes	Yes	Yes	Presence of TNEB, hydel dam; periphery of WL Sanctuary; proximity to Pilgrim centre
Munnar 7	536	2130	12	105	No	No	No	Yes	No dam; lacks infrastructure

Part VI: Environmental Management Plan

Scope
General Considerations of EMP
Compliance with Biosphere Reserves Program/Mandate
Project Elephant
Compliance with Government of India Tiger Reserves' Guidelines and Regulations
Relevance of National Environment Policy & National Wildlife Action Plan
Landscape Vulnerability Map
Background Information for Monitoring Impacts
Crisis Preparedness
Environmental Management Committee
Environmental Management Fund
Strategy for Restoring Wildlife Corridors in the Landscape
Environmental Management Plan for Project INO

Scope

The Environmental Management Plan (EMP) is the most crucial contribution of the present study. The EMP is based on a review of past experiences of development and its impact on the landscape. The analysis is subjected to geographical and time scales so that some general and many specific impacts are identified. After the impacts were identified, both from secondary sources and primary investigations, it was possible to outline mitigation plans. Specific mitigation plans are provided in this section.

Mitigation-preparedness is an important component of any EMP. This is however possible only when sufficient understanding of the happenings in the past is achieved and the implementing agency is in a position to anticipate environmental consequences (good or bad) for every action that the Project mandates. The present study has made an attempt to educate the Project agency through a simple discussion on every aspect of environment, wildlife and ecology that has been touched upon. Wherever appropriate and vital, maps have been provided to show the specific location. Descriptions of habitats have been made simple (without losing focus) and lists of species have been provided to guide mitigation and monitoring during the construction, implementation and operational phases of the Project.

Considering the close proximity to Mudumalai WLS and its location within NBR, the INO Project will be closely watched by the Forest Department and environmental NGOs. It is important that the Project agency is well informed of the various Government programmes, policies and action plans

that govern the landscape. For Project INO cannot be implemented in exclusion to the existing policy frameworks and legislations of the State. For this purpose, the relevant Government of India programmes and action plans such as Project Elephant, Man and Biosphere, Project Tiger and Wildlife Action Plan are briefly discussed.

General Considerations of EMP

An EMP is an implementation plan for mitigation, protection and/or enhancement measures that are recommended in the Environmental Impact Statement (EIS; Part I to Part V of the present report). To this end an EMP includes

- A work plan
- An implementation schedule
- Man-power requirement
- Protocol for monitoring

A work plan guided by detailed maps will help Project agency in achieving the various targets set by the EMP. It is meant to be simple and achievable using the available human and financial resources. For example, the tie-up with the TIFR/NCBS MSc Wildlife Biology Programme is an achievable target. Creating a permanent wildlife research and monitoring facility within the available space is also an achievable target. Dedicating infrastructure like a vehicle for wildlife studies in the landscape is certainly possible. Many such recommendations find a place in the EMP with indications of whom the Project agency should partner with while attempting to implement them.

No work plan is viable in the absence of a clearly defined time schedule. In the present EMP the time schedule has been split into immediate, short-term, mid-term and long-term.

Immediate actions should begin as soon as the EMP is made available and completed before the first construction activity is started (example establishing the Environmental Monitoring Committee; planning the formal tie-up with TIFR/NCBS; reconsidering the proposed tunnel alignment).

Short-term actions should be implemented during the first 3.5 years of the construction phase (example identification of strategies for enhancing the quality of corridors; identifying additional locations and means of safe disposal of muck; identifying degraded habitats where long-term restoration can be attempted).

Mid-term actions are those recommended for the period that begins with the installation of the equipment when the presence of scientists become more felt in the landscape and continues for at least 3 years after the Project becomes operational (example habitat restoration wherever needed; orientation course for field staff/students/faculty on wildlife in general and elephants in particular; planning long-term actions).

Long-term actions require better planning and funding and can be achieved after identifying research partners, sources of funding and specific points of action (example regenerating elephant food plants; enhancing existing corridors; creating by-pass corridors; annual elephant awareness festivals coinciding with Ganesh Chaturti). The planning of long-term actions should however begin

during the 3 years after the Project becomes operational (example establishing the Environmental Management Fund).

Required manpower and a specific protocol (methodology) are also provided. Whereas manpower can be sourced locally (example wildlife trackers), volunteers, students and short-term fellows can be attracted from all over including other countries. Students and faculty of TIFR/NCBS MSc Wildlife Biology Programme is the greatest asset to the INO Project. As of now, there is only one research facility around the Project site; the CES/IISc Field Station at Masinagudi certainly lacks the state-of-the-art infrastructure that many international wildlife research stations are currently equipped with. A state-of-the-art wildlife research facility is virtually absent anywhere in the Western Ghats. Sound infrastructure and competent manpower underline the successful adoption of monitoring protocols.

Compliance with Biosphere Reserves Program/Mandate

In March 1995, all Nations that have adopted the UNESCO-Man and Biosphere Program (UNESCO/MAB) met at Seville (Spain) and adopted the 'Seville Strategy'. The Strategy is basically a vision of Biosphere Reserves in the 21st Century. The four goals set to be achieved, during the 21st Century (Afrinet/MAB, 1995) are:

I: Use Biosphere Reserves to Conserve Natural and Cultural Diversity
II: Utilize Biosphere Reserves as models of land management and of approaches to sustainable development
III: Use Biosphere Reserves for Research, Monitoring, Education and Training
IV: Implement the Biosphere Reserve Concept

The proposed INO Project can easily take head-on the challenge of contributing to the Goals II and III. Specific ways of achieving the targets set by the Goal III are the following:

- Integrate wildlife research with the INO Project by making provisions for a state-of-the-art field research facility within the residential complex at Masinagudi and ear-marking staying facilities for students and researchers who are involved in wildlife studies in the landscape
- Provide a vehicle (four-wheel drive) exclusively for wildlife studies in the landscape
- Make a formal tie-up (immediately) with the TIFR/NCBS MSc Programme in Wildlife Biology such that the students enrolled for the course can use the INO Project facility for their annual field trip. These field trips that last for as much as twenty days at a stretch can be effectively used for collecting high quality base-line data on wildlife in the landscape and for effective monitoring of the short and long-term impacts of the Project. The proximity to Bangalore will make this initiative a fabulous success and least expensive strategy if carefully fabricated

Project Elephant

'Elephants have always been so much a part of India's myths, history, and cultural heritage that protecting and ensuring the survival of this animal means much more to an Indian than protecting just another endangered species' (A Quotation from Anonymous, 1993). In 1991-92, the Government of India formally launched the 'Project Elephant'. Eleven elephant reserves were

designated in India (Anonymous, 1993). Of these Reserve 7 – Nilgiris and Eastern Ghats concerns the INO Project landscape.

The Nilgiris and Eastern Ghats Reserves is the largest in India covering the south Indian states of Tamil Nadu, Kerala, Karnataka and Andhra Pradesh. It has a total spread of 11,000km^2 and an estimated 5000 elephants. The forest divisions included in the Reserve are:

1. Karnataka – Hunsur, Nagarhole NP, Mysore, Bandipur Tiger Reserve, Chamrajnagar, Kollegal, Mandya (part) and Bangalore (outwards from Bannerghetta)
2. Tamil Nadu – Mudumalai WLS, Gudalur (part), Nilgiris North, Satyamangalam, Erode, Dharmapuri and Hosur
3. Kerala – Wyanad WLS, Alattur, Tirunelli, Judrakote, Hilldale, Trisshaleri and Karikara Shola
4. Andhra Pradesh – Chittoor District

The Project Elephant plan document of the Government India (Anonymous, 1993) has classified the issues relating to 'Conservation of Elephant' into two distinct categories:

1. Activities like hunting and capture which affect the number of elephants directly; and
2. Human activities and development programmes leading either to loss of elephant habitat or its qualitative degradation

Human and development activities that have specifically interfered with the movement and survival of elephant populations as have been identified under Project Elephant are:

- Plantation of exotic trees for forestry (and afforestation)
- Mining of extensive forest lands
- Dams and reservoirs that have fragmented prime habitats
- Channels and power transmission corridors that have prevented migration
- Roads and human settlements
- Habitat degradation due to invasive plants, grazing and fire
- A shortage of the preferred food plant (example *Zizyphus xylopyrus* and *Kydia calcina* in Mudumalai WLS; Neelakantan, 1995 and Vencatesan, 2003)

In its strategy and action plan the Project Elephant begins by discussing the issue of corridors; management of elephant ranges and corridors between adjoining habitats. The management plan states 'there can be no hard and fast rule about the design of corridors. The main thing is to ensure that elephant will use them and will not spill over into the adjacent human settlements. The viability of corridors naturally depends on the distances separating the two populations. If the distances are relatively small then the corridor need not be very broad. A corridor of 1km width could be sufficient to see the elephants through. The width will have to be much more if the distances between the two habitats are significantly more. The corridor need not be a very good habitat. It can be degraded vegetation or a monoculture that provides cover for the migrating elephants' (Anonymous, 1993).

Judging by the above description of elephant corridors it becomes clear that the two in the Project landscape are only marginal in terms of quality (see Table). The Singara-Avarahalla corridor is too

narrow and can prove to be a major reason for stress (both on Project personnel and elephants) during the construction and operational phases. The Singara-Mavinhalla corridor is wider (average 2km). However the width was estimated more than 10 years ago (Sivaganesan *et al*, undated) and hence its present condition has to be reassessed.

The Project Elephant plan document has also emphasized that 'preserving the integrity of elephant habitats should not be lost sight of while planning any new development project and appropriate measures to keep the migration corridors of elephant intact must be taken'. The Elephant Task Force appointed by the Government of India has recommended that in landscapes where channels have blocked the movement of elephants, bridges should be built. In fact, the Forest Department had also insisted on bridges to mitigate the impact of flume channels in the Mudumalai landscape (Tyagi, 1995). Baskaran *et al* (1995) have specifically drawn attention to the Masinagudi-Singara canal. It was possible for elephants to cross the canal at several places when the study was undertaken by BNHS in the early 1990s. However, the study has recommended that 'any modification to the canal should have facilities to permit free movement of elephants and other wildlife across the canal. There are several fixed points along the canal where elephants and other wildlife cross the canals. These have to be maintained without any change. Long-term habitat restoration programmes for elephants and other large mammals in the landscape should take into consideration this recommendation. When carefully designed and built in the right location, bridges will be a major relief to elephants and local residents.

In view of the above concerns and recommendations the INO Project should exercise utmost caution in dealing with elephant corridors within the Project landscape. In this context, it is recommended that as far as possible (even if it involved some difficult negotiations with TNEB) alignment 2 of the access tunnel should be avoided and alignment 1 finalized. While this will not only reduce the cost and the volume of excavated muck considerably, the necessity for the purchase of private coffee estate land can be stalled. The private coffee estates in Singara are treated as elephant corridors and Baskaran *et al* (1995) have in fact recommended that the estates are purchased and used to enhance the quality of the Singara-Mavinhalla Corridor. The Project Elephant plan document of the Government of India (Anonymous, 1993) has also recommended the 'securing' of critical migration corridors such as Masinagudi-Singara corridor in Mudumalai.

Compliance with GOI Tiger Reserves' Guidelines and Regulations

The Government of India launched the Project Tiger programme in 1973 to arrest the loss of the tiger and its natural habitat throughout the country. As of now there are 29 tiger reserves in India of which Bandipur and Mudumalai are within the Nilgiri Biosphere Reserve. The Mysore-Ooty highway passes through the 2 tiger reserves. Mudumalai was very recently brought under the purview of the Government of India's Project Tiger programme.

The following information extracted from the ***Compendium of Guidelines and Circulars issued by Director (Project Tiger) New Delhi*** under the auspices of Project Tiger Directorate in GOI/MoEF should be given due consideration by the INO Project.

- Project Tiger implementation by States is governed by the Government of India Guidelines and the Indian Board for Wildlife's Task Force Report on Project Tiger; the 3 cardinal principles of Project Tiger are

1. Elimination of all kinds of exploitation and disturbance from the core area, while rationalizing such activities in the buffer (or multiple use) area
2. Limiting the habitat management to repairing damages inflicted on it by biotic pressures so as to resurrect the habitat in its natural form
3. Researching facts about habitats and wild fauna, while monitoring the changes in flora/fauna owing to Project Tiger initiatives

- As per the Guidelines the buffer zone has two functions:

    1. To provide habitat supplement to the spill over population of wild animals from the core area, conserved with the active cooperation of stakeholder communities
    2. Providing site specific, need based participatory eco-development inputs to local stakeholders for reducing their resource dependency on the core zone and for eliciting their support towards conservation initiatives in the area

- No intensive form of land use like mining, quarrying and the like should be fostered in the buffer zone, and due care should be exercised while granting no objection certificates (NOC) to such activities in private or revenue areas, if any, included in the multiple use area

- Development projects obligated to have a local orientation so that they become part of local area development without upsetting the resource needs and common property resources; appropriate compensations or alternatives to be built in project cost, preferential employment of local people, if necessary after arranging education and training for them

While the above pointers have to be given due consideration, there are certain recommendations that might come in as an advantage to the INO Project. These are:

- Eco-development in multiple use areas of tiger reserves and other protected areas permit the use of rope ways in difficult and remote high altitude areas so as to ensure better economic returns to the local people from the transport of goods; *the possibility of reviving the TNEB winch in Singara may be explored if it serves the purpose*

- Eco-development programmes should also provide building material to the people who are relocated from the core areas; *the possibility of diverting a part of the muck for this purpose has to be carefully explored*

Relevance of National Environment Policy & National Wildlife Action Plan

The Union Cabinet formally approved the National Environment Policy (NEP) on May 18, 2006. NEP 2006 is the response of the Government of India to the Constitution's Articles 48A and 51A(g). By this it is recognised that maintaining a healthy environment is not the State's responsibility alone, but also that of every citizen. The main objectives of NEP 2006 are:

- To protect and conserve critical environmental resources including ecological and life-support systems
- To ensure equitable access to environmental resources for all sections of the society, particularly the poorer communities, across the generations
- To integrate environmental concerns into policies, plans, programmes and projects for economic and social development
- To ensure the efficient use of the environment
- To apply the principles of good governance of environmental resources
- To ensure higher support for environmental by way of public participation, finance and technology

The key concern of NEP 2006 is one that is directly relevant to the monitoring of compliance (of environmental norms, standards and EMP). Involving the impacted local communities in the monitoring of compliance is mandatory to development projects.

The first National Wildlife Action Plan (NWAP) was adopted in 1983 based on the decision taken in the fifteenth meeting of the Indian Board for Wildlife that was held in 1982. The recent NWAP (2002-2016) is more of a vision for long-term conservation of wildlife in India. And in its preamble it states that 'habitat loss caused by developmental projects such as dams, mines, etc compound the problems of wildlife conservation' (MoEF, 2002). The most recent NWAP has also reiterated the need to minimize man-animal conflicts. In stating this NWAP has made it explicit that 'while increasing man-animal conflict is an outcome of shrinkage, fragmentation and deterioration of habitats, it has caused destruction of wildlife and generated animosity against wild animals and protected areas. This is a crucial management issue, which needs to be addressed through innovative approaches'.

For the sake of effective conservation of endangered species and their habitats, the NWAP has recommended that 'all identified areas around Protected Areas and wildlife corridors shall be declared as ecologically fragile under the Environment (Protection) Act, 1986'. This action as envisaged by MoEF/GOI was to be completed by the year 2004. Further while discussing strategies for the restoration of degraded habitats outside the protected areas NWAP has proposed that degraded habitats around each Protected Area and potential corridors be identified where protection and restoration will yield best results. In such areas the key factors responsible for degradation are to be identified and recovery plans are made for restoration. The proposed INO Project should see a great opportunity in this action point.

Landscape Vulnerability Map

The basic map used for the purpose is one of a large scale showing land ownership along the Singara-Masinagudi elephant corridor and the landscape in general. The scale of the map that was used is 1:16,000. The study has superimposed the quality of habitat and the squeeze-zone of the Corridor on the map based on field impressions. The vulnerability of the landscape has been assessed along three dimensions: habitat quality, movement of wildlife, specially elephants, the Singara-Masiangudi road and flume channel intersection through the Singara-Mavinhalla segment of the Corridor and anthropogenic activities such as grazing, fuel and fodder harvest and tourism. The composite map is provided in an electronic form.

Background Information for Monitoring Impacts

The NWAP (2002-2016) has specifically highlighted the need for monitoring and research. A action point that has been emphasized under this objective is to document and assess damage done by large projects and intrusions, such as dams, mines, canal systems, roads and the use of pesticides and chemicals (MoEF, 2002). Background information about the landscape is limited to biodiversity. Information on other aspects of the environment is rather limited. What we have at hand is a set of data on air quality, water quality and noise levels that SACON had provided, based on primary studies in and around the MUSHEP during 1996-97 (Azeez *et al*, 1997a). The decade-old data can be used as the benchmark in the absence of recent field studies on air and water pollution. The available information is provided in Tables 6-8.

Table 6: Suspended particulate matter and other air pollutants in the landscape during 1996-97

Pollutant	Moyar	Maravakandy	Ooty	Permissible limits in sensitive areas
Respirable suspended particulate matter (RSPM)*	41.9 $\mu g/m^3$	43.3 $\mu g/m^3$	96 $\mu g/m^3$	75 $\mu g/m^3$
Non-respirable suspended particulate matter (NRSPM)*	13.7 $\mu g/m^3$	14.1 $\mu g/m^3$	35 $\mu g/m^3$	100 $\mu g/m^3$
NO_x	Below detectable levels	Below detectable levels	120 $\mu g/m^3$	30 $\mu g/m^3$
SO_2	Below detectable levels	Below detectable levels	Below detectable levels	30 $\mu g/m^3$

*24-hour time weighted average; Azeez *et al*, 1997a & b

Table 7: Water quality analysis of samples obtained from the landscape in 1996-97

Parameter	Minimum	Maximum
PH	6.0	7.0
Total solids	174 mg/l	243 mg/l
Oil and grease	No positive results	No positive results
Chloride	30 mg/l	70 mg/l
Sulphate	5.5 mg/l	21.5 mg/l
BOD	2 mg/l	75 mg/l
COD	12 mg/l	72 mg/l

Source: Azeez *et al*, 1997a

Table 8: Noise levels at a distance of around 1m from source in Moyar during 1996-97

Location	Daytime		Night (Average)
	Minimum	Maximum	
Forest	43.9 db	52.2 db	42 db
Residential area	54.7 db	62.5 db	55 db
Powerhouse	68.2 db	72.5 db	73 db
River	71.2 db	72 db	72 db
Flume channel	47.6 db	56.1 db	55 db
Moyar-Masinagudi Road	73 db	82 db	-
Construction equipment used	71 db	98 db	-

Source: Azeez et al, 1997a

Table 9 summarizes the biodiversity information that can be used for monitoring the impact of the INO Project. The information extracted from Azeez *et al* (1997a) is a decade old. Azeez *et al,* 2007 and Silori and Mishra (2001) and the field investigations that Care Earth undertook in 2007-08 have supplemented the information provided in Azeez *et al* (1997a) wherever authenticated.

Table 9: Summary of biodiversity and socio-ecological information that can be used for monitoring the landscape

Attribute	Status
Maturity of vegetation	70% trees less than 150cm GBH
	63% trees less than 15m height
Diversity of wild mammals	28 species
Most common wild mammals around the flume channel	Elephant, sloth bear, chital
Status of sloth bear	Recent conservation assessment of IUCN/Species Survival Commission has placed the sloth bear amongst the 8 most endangered bears of the world
Length of flume channel not useable due to steep slopes	60%
Mammals that cross the bridges along Masinagudi-Maravakandy chainage	Elephant (65% of all usage)
	Cross at 28 points between 1200m and 2700m
Shops in Masinagudi village (2008)	121
Tourist resorts in and around Masinagudi (2008)	61
Human population in Masinagudi Panchayat as per 2001 census and 2007 Panchayat and VAO records	8577 and 12,535
Human population in Singara (2001 census)	302
Existing TNEB quarters at Singara	140
Livestock population in Masinagudi at present	4800
Predominant livestock	Cattle
Endemic plants in the landscape	62 species
Endemic animals in the landscape (amphibians,	11 species

reptiles and birds)	
Endangered animals in the landscape	15 species
Frequently found endemic herb in Mavanhalla-Masinagudi vegetation	*Barleria mysorensis*
Water birds found in the landscape	Little grebe, little cormorant, pond heron, cattle egret, night heron, white-breasted waterhen, yellow-wattled lapwing, sandpiper, small blue kingfisher, pied kingfisher, white-breasted kingfisher
Birds that nest on ground, in burrows and tree-holes in the landscape	Around 30 species; see details in Table 13

Source: Azeez *et al*, 1997a & 2007; Silori and Mishra, 2001; Asian Animal Protection Network; present study by Care Earth

Specifically, some species of plants and animals can be monitored during and after the construction phase and through the life of the INO Project. These species include endemic and endangered species (Schedule I of the Wildlife (Protection) Act 1972) and other bio-indicators. Important species have been listed in Tables 10-13.

Table 10: Endemic plants that are found in the landscape

Category/growth form	Scientific name
Trees	*Actinodaphne angustifolia*
	Allophylus serratus
	Bridelia retusa
	Chionanthus mala-elengi
	Diospyros malabarica
	Glochidion velutinum
	Hymenodictyon orixense
	Ilex malabarica
	Ligustrum perrottetii
	Mallotus intermedius
	Marsdenia brunoniana
	Pleurostylia opposita
	Shorea roxburghii
Shrubs	*Allophylus cobbe*
	Ampelocissus araneosa
	Barleria mysorensis
	Capparis grandiflora
	Crotalaria walkeri
	Decaschistia crotonifolia
	Gynura nitida
	Ixora nigricans
	Jasminum malabaricum
	Memecylon gracile
	Nilgirianthus heyneanus

Category/growth form	Scientific name
	Nilgirianthus perrottetianus
	Orthosiphon wynaadensis
	Sarcostemma brunionianum
	Taxillus cuneatus
	Tylophora pauciflora
Herbs	*Acalypha malabarica*
	Anaphalis aristata
	Andrographis serpyllifolia
	Ceropegia hirsuta
	Crotalaria spectabilis
	Dicliptera cuneata
	Exacum tetragonum
	Fimbristylis woodrowii
	Habenaria viridiflora
	Leucas lavandulaefolia
	Leucas vestita
	Liparis prazeri
	Neanotis indica
	Neanotis wightii
	Peperomia dindigulensis
	Peristylus goodyeroides
	Pimpinella heyneana
	Pimpinella wallichiana
	Plectranthus wightii
	Polystachya flavescens
	Smithia conferata
	Sonerila tenera
	Strobilanthes consanguineus
	Swertia angustifolia
	Thesium wightianum
Grasses	*Anthraxon depressus*
	Arundinella purpurea
	Brachiaria semiundulata
	Isachne libosa
	Paspalum canarae
	Themeda quadrivalvis
	Triopogon bromoides

Source: Azeez *et al*, 2007; present study by Care Earth

Table 11: Endemic animals found in the landscape

Category/class	Scientific name
Amphibians	*Indirana sp*
	Nyctibatrchus sp
	Philautus sp
Reptiles	*Cnemaspis sp*
	Calotes ellioti
	Calotes grandisquamis
	Calotes nemoricola
	Trimeresurus malabaricus
	Hypnale hypnale
Birds	*Myiophonus horsfieldii*
	Psittacula columboides

Source: Azeez *et al*, 2007; present study by Care Earth

Table 12: Endangered animals listed under Schedule I of Wildlife (Protection) Act 1972 found in the landscape

Category/class	Common English name
Mammals	Tiger
	Leopard
	Indian elephant
	Gaur
	Four-horned antelope
	Blackbuck
	Mouse deer
	Pangolin
	Giant squirrel
Birds	Shikra
	Spoonbill
	Peafowl
Reptiles	Indian python
	Indian soft-shell turtle
	Marsh crocodile

Source: Sivaganesan *et al* (undated); Azeez *et al*, 2007; present study by Care Earth

Table 13: Birds that nest on ground, in burrows and in tree-holes that are known from the landscape

Nesting site	Common English name
Ground	Grey partridge
	Jungle bush quail
	Grey jungle fowl
	Peafowl
	Large-tailed nightjar
	Yellow-wattled lapwing
Burrows on embankments	Lesser pied kingfisher
	Small blue kingfisher
	White-breasted kingfisher
	Small green bee-eater
Tree-holes	Rose-ringed parakeet
	Blossom-headed parakeet
	Blue-winged parakeet
	Indian lorikeet
	Collared scops owl
	Spotted owlet
	Indian roller
	Hoopoe
	Small green barbet
	Large green barbet
	Crimson-breasted barbet
	Golden-backed woodpecker
	Pigmy woodpecker
	Scaly-bellied woodpecker
	Black-headed myna
	Indian myna
	Jungle myna
	Magpie robin
	Pied bush chat
	Indian robin
	Grey tit
	Yellow-throated sparrow

Source: Azeez *et al*, 2007; present studies by Care Earth

Crisis Preparedness

Projects that are located within wilderness and remote landscapes need to be more prepared for dealing with crisis than those within cities and institutions with basic infrastructure. Wild animal behaviour and movement can be rather unpredictable that unforeseen crises are often imminent. Drivers need to be from the local residents such that they are wildlife 'friendly'. A driver who gets agitated at the sight of a charging elephant or a large snake crossing the road can prove to be

disastrous. Choosing the right vehicles for the terrain and the right person as the driver is one of the first steps in crisis preparedness.

Scientists, students and other support staff that are trained in urban institutions are not quite used to living in remote areas (where there is a lack of socializing and entertainment) and are prone to psychological trauma leading to depression and suicides. The Project must bear this in mind while recruiting personnel.

The Project site is prone to wildfires during summer. Whereas fire-control measures are easily put in place within built spaces and infrastructure, a fire that breaks out in the adjoining habitat may not only prove devastating but can also lead to anxiety and conflicts with the Forest personnel. The Project should recruit firewatchers as directed by the Forest Department and keep constant vigil throughout the dry season.

It will be useful to erect a tall watchtower within the Project site. The tower located at a strategic point within the site will aid the observation and monitoring of wildlife movements and probable spread of wildfire. Periodic surveillance from the watchtower will enhance the quality of crisis preparedness amongst the Project personnel.

The close proximity to the wildlife sanctuary and animal corridors does not permit the use of trenches and electric fences to protect the Project infrastructure from elephants and other large mammals. The infrastructure and outdoor equipment should be specifically designed to accommodate free movement of wild animals at all times.

There are cave-dwelling animals in the landscape. Some bats and swifts (birds) are quite adapted to living within deep caves. As the approach tunnel and accessory tunnels will be dry, it is likely that birds, mammals and sometimes reptiles will take shelter within the tunnels and the caverns. Their presence and droppings may interfere with the otherwise neutral zone that the Project envisages underground. Safe ways of keeping the intruders out have to be put in place at the very onset of the Project.

Environmental Management Committee

For effective implementation of the EMP and for compliance of the EIA mandate, an Environmental Management Committee (EMC) has to be established. The EMC should be chaired by a senior scientist/administrator other than those involved directly in the INO Project. Two or three members may be drawn from the INO Project team. The site engineer will be a member throughout the construction phase and till such time as deemed necessary. The following shall be made ex-officio members of the EMC.

1. Nominee/representative of Care Earth
2. Nominee/representative of SACON
3. Nominee/representative of the TN Forest Department
4. Nominee/representative of TNEB
5. Nominee/representative of local NGOs
6. Nominee/representative of local Panchayat

7. Nominee/representative of residents' welfare association or an equivalent body
8. Nominee/representative of the Singara Estates

The EMC must be constituted as soon as the EMP is formally endorsed. The EMC will ensure the compliance by the INO Project, of the recommendations made by the EMP. The EMC will review and take stock of the way the Environmental Management Fund is utilized. The EMC will meet regularly and prepare EMP compliance reports on a quarterly, half-yearly and annual basis as relevant. Guidelines on the tenure of the Chairman and other members and the mode of recruitment shall be outlined and adopted by the EMC as appropriate.

Environmental Management Fund

The EIA has mandated that environmental costs have to be built into the overall project costs/budget. While the immediate (example buying private lands) and short-term costs (safe disposal of muck) will be met out of the total cost during the construction phase, an exclusive Environmental Management Fund (EMF) has to be established for supporting the mid-term and long-term execution of the EMP. The fund should be to the tune of at least 10% of the total Project cost. The following activities can be within the scope of the EMF:

- Habitat restoration by planting important native plants (example food plants of elephants)
- Providing support to fire prevention/fighting and wildlife disease surveillance and control
- Creation and maintenance of water-holes along the corridors; maintenance of existing water bodies including streams and rivers (locally) to ensure a quality of water that is safe to wildlife, people and aquatic biodiversity
- Supporting short-term projects on ecology and wildlife that will feed into the EMP and long-term monitoring and restoration plans
- Mitigation of human-wildlife conflicts that might be catalysed by the Project
- Creating greater environmental awareness amongst local residents and visitors
- Maintenance of the infrastructure needed to implement the EMP

Strategy for Restoring Wildlife Corridors in the Landscape

Wildlife corridors are well established and intensively used geographical spaces through historical times that it is not easy to create newer ones. Enhancing the connectivity, extent and quality are some of the ways in which wildlife corridors can be ecologically restored. The Moyar-Avarahalla Corridor, in its present form, is fragmented that the movement of animals is through two clearly discernable segments. Ecological restoration of the Corridor would reduce the dependence on the squeeze-zone as the only passage. The following strategies have been outlined for ecological restoration of the Moyar-Avarahalla Corridor.

- Human interference with the movement of wildlife to drink from the existing waterholes should be strictly controlled. This will involve, amongst other actions, a strict control of vehicles that are being taken in and washed, especially in the Singara-Mavinhalla segment of the Corridor. Use of boulders excavated from the tunnel along the periphery of the waterhole can prevent vehicles from reaching the water.

- Sustained effort should be made to control the spread of invasive plants like *Lantana, Parthenium* and *Prosopis* throughout the Corridor. The INO Project can specifically focus on the Singara-Mavinhalla segment.

- The 4ha earmarked for the INO Project within the TNEB land at Masinagudi must be restored and annexed with the Moyar-Avarahalla segment of the Corridor. As restoration will attract elephants and other wildlife in the long-term, the design has to be carefully drawn under the guidance of wildlife experts.

- Recurrent fires can be avoided by appropriate habitat restoration. Periodic removal of *Lantana* is one of the effective means of reducing the frequency and intensity of fire during the dry season.

- The existing unused private and TNEB land bordering the Singara-Masinagudi road and elsewhere within the Singara-Mavinhalla segment should not be put to any other land use. This is best achieved by buying up as much of the available land as possible.

Environmental Management Plan for Project INO

The Environmental Management Plan is the most vital contribution of the present study. And judging by the detailed overview and results that have been presented, it is evident that the EMP is the outcome of an objective assessment of the impact caused by the development processes in the past in and around Masinagudi village Panchayat. The following section details the principles and the specific action points that need to be incorporated into the planning and implementation process of Project INO. It is also important that care is taken to ensure that these form an integral part of all implementation mechanisms and contractual agreements of Project INO.

- In principle, Project INO should adopt the 'Elephant' as its nominate species. Following this, a minimum of 10% of the total project cost (under direct and indirect support, as well as support in the form of providing facilities) should be earmarked as the corpus for the conservation of the elephant. This should be further strengthened by annual grants/budgetary allocation to the initiative.

- The corpus thus created should be managed by a working group/unit that will develop the norms, guidelines and implementation procedures for the conservation programme. This group will necessarily have the representation of Project INO, the Tamil Nadu Forest Department, reputed non-governmental organisations and academic/research institutions and most importantly, the local elected Panchayat and Gram Sabha.

- The conservation programme should be holistic and not operated on an ad hoc basis. The programme should be subjected to periodic review, including a community-based review.

- Project INO should undertake concrete measures to consult the Elected Panchyat and the Gram Sabha to ensure that they do not remain yet another 'alien' instituion in the landscape. It is important that a two way communication process be established with these institutions.

- The vulnerability map developed for the EMP highlights Singara– Mavinhalla segment of the corridor as one of the two critical areas within the landscape. The project as it is being proposed currently will only compound the existing stress on this zone.

- It is recommended, both in the interest of the Project and wildlife, that the entire infrastructure (underground and aboveground) be restricted to Singara. This recommendation has been made, as the 4ha land earmarked within the TNEB campus at Masinagudi is a part of the Moyar-Avarahalla segment of the Corridor where there is immense movement of wildlife (including elephants). The only waterhole that exists here is very close to the Project site and there is a lot of wildlife movement in this habitat during summer (see vulnerability map)

- Irrespective of the land use in the project site, compensatory mechanisms for re-vegetation need to be evolved and implemented. The project team needs to recognise that trees alone do not make a forest. Appropriate location for revegetation will have to be identified in consultation with the Forest Department, TNEB, NGOs and residents; a potential site is the 4ha adjoining the PUSHEP guesthouse at Masinagudi earmarked for the INO Project.

- Compensating the loss of vegetation should not however be done by planting trees along the Singara-Masinagudi road. In fact, planting trees along the roads will only aggravate human-wildlife conflicts as avenues of trees tend to attract animals closer to roads. When these animals attempt to cross roads attracted by trees on the other side (example primates; macaques and langur that are abundant in the landscape), they are run over by passing vehicles.

- There are suggestions of creating gardens within the Project site and this should not be done. The project, even in its expansion phase, should strongly deter from any of the routine 'beautification' processes such as laying of lawns or creating ornamental shrubbery. This needs to be incorporated into the DPR.

- The EIA report has categorically stated that there should be no parallel fencing made anywhere along the road between Singara and Masinagudi. Fencing in any form anywhere will prove detrimental to wildlife in the landscape. Temporary walls (if absolutely needed) would be the most ideal option after specifying the area that will be thus cordoned during the 5 years of construction and installation of equipment.

- A volume of 67,500m^3 of muck that may be left unused will create a mound that is much larger than what is presently there at Singara. Leaving this huge volume unused and covering it with earth for growing plants (trees) does not seem a viable proposal. There is need for better management plan when it concerns the disposal of muck. In fact, disposal of muck is certainly the greatest environmental impact the INO Project is likely to cause in the landscape.

- There should be a complete cessation of activities during the months November to February excluding localised activities of limited or no immecdiate impact to wildlife within Singara. There should also be no movement of vehicles of Project INO/ implementing agency/contractor during the elephant movement hours (3 Am until 6 Am and between

4.00 pm until 8. PM). The night hours are critical for the other wildlife. Hence the vehicular movement of Project INO should be only between 6 am and 4 pm.

- Based on the existing vehicular movement on the Masinagudi-Singara Road it is being proposed that only 4 trips of heavy vehicles (which entails that the vehicle moves 8 times to and fro) be allowed per day.

- In accordance with the existing norms of the GOI, the heavy vehicles can be of only 8 tonnes capacity (either individually or caravans of three vehicles whose total capacity cannot exceed the norms). Adherence to this norm will ensure that the habitat integrity is preserved, and that there is no demand for laying new/additional roads.

- It should be ensured through the EMC and the trackers that the vehicles do not engage in washing, cleaning operations on the Masinagudi-Singara Road. Parking space should be found within Singara.

- Project INO should not in any manner allow the establishment of any additional service provider such as travel and tour operators, catering etc. in Singara.

- The Project plan must to the extent possible engage, local laborers, who are in a manner are the residual effect of the Pykara project. Strict monitoring of their condition and activities must be ensured by the EMC.

- The indigenous population at the Singara and Masinagudi is small, but comprises of extremely capable trackers/wildlife guides. It is absolutely important that a viable number of indigenous people are employed right from the beginning as trackers. They in turn can be engaged to monitor vehicular movement, movement of wildlife, forest fire mitigation, etc. This once again should be an integral component of the conservation initiative of Project INO

- Nature's services that the INO Project personnel will enjoy include 'relaxation' (recreation) thanks to the proximity of Mudumalai WLS and the Maravakandy Reservoir. Willingness to pay amongst the small fraction of INO Project staff and visiting scientists/students can be translated into kind appropriately so that the aesthetic and recreation service benefits that they enjoy will also provide economic incentives to a larger spectrum of local residents. A contributory 'nature conservation fund' is to be considered.

- The National Wildlife Action Plan for 2002-2016 has reiterated the need to identify and preserve wildlife corridors. It has been proposed that all wildlife corridors be given the status of 'ecologically sensitive areas' under the provisions of the Environmental (Protection) Act, 1986. The INO Project should honor the commitment.

- Herds of elephants may continue to roam in the adjoining habitats despite the construction activities. Variations between individuals of elephants in their sensitivities to noise, vibrations and the smell of explosives have not been understood. INO Project should post a competent team of wildlife biologists (and trackers) to monitor the elephants both during construction and operational phases. The Project should be sensitive to precautionary

recommendations that the experts (Environmental Monitoring Committee) provide from time to time.

- A watchtower located at a strategic point within the Project site will greatly aid the monitoring of wildlife movement both in the short and long terms.

- The tie-up with the TIFR/NCBS MSc Wildlife Biology Programme is an achievable target. Creating a permanent wildlife research and monitoring facility within the available space is also an achievable target. Dedicating infrastructure like a vehicle for wildlife studies in the landscape is certainly possible. Many such recommendations that find a place in the EMP with indications of whom the Project agency should partner with while attempting to implement them must be given the due consideration.

- The proposed INO Project can easily take head-on the challenge of contributing to the Goals II and III of the 1995 Seville Strategy of the Man and Biosphere Program. Specific ways of achieving the targets set by the Goal III are the following:

    - Integrate wildlife research with the INO Project by making provisions for a state-of-the-art field research facility within the residential complex and ear-marking staying facilities for students and researchers who are involved in wildlife studies in the landscape
    - Provide a vehicle (four-wheel drive) exclusively for wildlife studies in the landscape
    - Make a formal tie-up (immediately) with the TIFR/NCBS MSc Programme in Wildlife Biology such that the students enrolled for the course can use the INO Project facility for their annual field trip. These field trips that last for as much as twenty days at a stretch can be effectively used for collecting high quality base-line data on wildlife in the landscape and for effective monitoring of the short and long-term impacts of the Project. The proximity to Bangalore will make this initiative a fabulous success and least expensive strategy if carefully fabricated

- While the above pointers have to be given due consideration, there are certain recommendations that might come in as an advantage to the INO Project. These are:

- Eco-development in multiple use areas of tiger reserves and other protected areas permit the use of rope ways in difficult and remote high altitude areas so as to ensure better economic returns to the local people from the transport of goods; *the possibility of reviving the TNEB winch in Singara may be explored if it serves the purpose*

- Eco-development programs should also provide building material to the people who are relocated from the core areas (example the proposed relocation from the Mudumalai WLS); *the possibility of diverting a part of the muck for this purpose has to be carefully explored*

- The private lands that are up for sale between Singara and Masinagudi should all be bought by the INO Project and through negotiations with TNEB, Forest Department and the Estates; the habitats can be managed exclusively to complement the Corridor.

Unauthorized movement of vehicles can be strictly curbed through such a cooperative process

- In the event that a situation arises wherein the above recommendations are not acceptable to the INO Project or the other interest groups, there are options for relocating the Project outside the Nilgiris. A number of potential sites have been identified during the present study of which the following seem to offer the greatest potential:

    5. The Palani Hills landscape can be approached from Madurai and Coimbatore, both cities with airport and necessary infrastructure. Six sites including one each in Palar and Pannapatti and two each in Marudhanadi and Manjalar were assessed here. Of these only the sites at Palar and Pannapatti offer the required 1300m of overburden. Such an overburden can be achieved when the tunnel length is around 3700m in Pannapatti. If however, there can be some flexibility in the overburden or the overall slope of the tunnel the sites in Manjalar would be the most appropriate for the Project.

    6. Munnar, Munthal, Kanagudi, Sakanutu Metti and Bodi are the five sites assessed in the Cumbum-Theni landscape. The landscape is best accessed from Madurai. The maximum distance from the airport is 120km. In both Kanagudi and Munthal the required overburden of 1300m can be obtained when the tunnel is less than 4000m; Kanagudi being the best requiring only 3160m. Considering all other conditions, Kanagudi (located near Bodinayakanur) seems to be the best alternative site for the INO Project.

    7. Yet another potential site is further south in the Mahendragiri Hills bordering Kanyakumari-Tirunelveli districts. It is accessible by road and rail and the nearest airport is at Trivandrum. An added advantage of Mahendragiri Hills is that ISRO has an exclusive facility here. It may be possible to locate the INO Project within the ISRO facility.

The Union Cabinet formally approved the National Environment Policy (NEP) on May 18, 2006. The key concern of NEP 2006 is one that is directly relevant to the monitoring of compliance (of environmental norms, standards and EMP). Involving the impacted local communities in the monitoring of compliance is mandatory to development projects.

Finally, in compliance with the NEP, the INO Project *must* prepare an Action Plan indicating how it will adopt the recommendations of the EMP. The Action Plan is ‘immediate action’ and the job should be entrusted with the Environmental Monitoring Committee and well before any construction begins at Singara.

Part VII: Annexure

Framework for Maintaining Environmental Data
Schedule for Review
Strategy for Mid-way Correction
Indicators of Environmental Changes
Minutes of Brainstorming Discussion Meetings
Photos of alternate sites
Sources of Information

Framework for Maintaining Environmental Data

A framework for maintaining environmental data basically aims at creating a standardized procedure and format for collecting, storing and processing data and a practical time schedule for the various sampling events. Such a framework is meant to be a tool that enhances consistency (minimizing observer biases and inadvertent omissions) and comparability within and between sets of data collected by different observers at different times (often independently). The data thus generated can be stored both electronically and as hard copies. Collection of sample specimen as vouchers for species identification can be minimal and restricted to those where absolutely essential. Table 14 outlines some important variables that need to be observed/measured in the field during the sampling exercises.

Table 14: Commonly observed/measured physical and biological variables for compiling baseline information for assessing and monitoring environmental impacts

Nature of information	Equipment required	Proof of identify	Scope of the information
Observer(s)	Paper & pencil; hand-held tape recorder	Name	Assessing consistency and observer bias
Date	Paper & pencil; hand-held tape recorder	-	Time series analysis; estimating seasonal variations
Weather conditions	Paper & pencil; hand-held tape recorder; light meter; thermometer; rain gauge; hygrometer	-	Assessing consistency and observer bias; understanding response of biodiversity to local weather conditions

Nature of information	Equipment required	Proof of identify	Scope of the information
Time and duration	Paper & pencil; hand-held tape recorder; clock	-	Control sampling effort; assessing daily activity patterns
Distance or area covered	Paper & pencil; hand-held tape recorder; map; camera	GPS; photographs	Control sampling effort; benchmark for future assessments
Mode of transport	Motorcycle; four-wheeled vehicle (ideally low noise/petrol driven)	-	Control sampling effort; safer to use vehicles during the nights and where elephants and other large mammals move frequently
Topography	Paper & pencil; hand-held tape recorder; map; camera	GPS; photographs	Ecological analysis
Species richness (diversity)	Paper & pencil; hand-held tape recorder; map; camera; nets; traps; herbarium kit; plastic bags and forceps for collecting dead animals, animal remains and excreta; binoculars; GPS and range-finder; measuring tapes	Photographs; voice recordings (birds, frogs, mammals, insects); shells (snails); feathers (birds); hair, horn and scats (mammals); slough (snakes); botanical collections	Assessing and monitoring changes in biodiversity; monitoring changes in population size and density; assessing invasive species
Water quality	PH meter/litmus paper; paper & pencil; containers for collecting sample; thermometer; camera; fish and plankton nets	Samples and photographs	Assessing impact of pollution, run off and eutrophication; water stress
Air and noise pollution	Standard equipment as recommended by PCB	-	Monitoring ambient pollution
Oral interviews	Paper & pencil; hand-held tape recorder; camera	Recordings; photographs	Socio-ecological analysis
Printed information	Camera; scanner/copier	Local dailies; pamphlets; slogans and scripts on walls, rocks, etc	Socio-ecological analysis; public perceptions

It is important the Project dedicated 2-3 trained field personnel for the purpose of environmental assessment and monitoring. While sporadic events like forest fires and other accidents that involve humans or wildlife have to be documented in an opportunistic manner, routine data collection should adopt a stringent time schedule. Thus while sampling pollution can adopt a time interval of 3 months or a seasonal chart, biodiversity requires more regular assessment. Amongst biodiversity plants can be sampled adopting a seasonal chart (as they are not mobile), animals will have to be counted daily (example elephants) during certain seasons of higher local activity and weekly or monthly depending on the species and mobility.

Birds (being highly mobile) can be treated broadly as breeding/resident and migratory species. The time and duration of the sampling should be appropriately fixed. The diversity and density of hole-nesting birds in the project site, for instance, can only be assessed during the breeding season. The EMC shall guide the field personnel in choosing the best strategy for gathering the appropriate data/information.

Table 14 is only suggestive. There can be many other variables that prove to be critical to monitoring the impacts of the Project. A geographical information system (GIS) should be developed exclusively for monitoring the impacts of the Project. Using the baseline information as the 'zero' point, yearly changes can be monitored and projected using the GIS.

Schedule for Review

Periodical reviews of the implementation of the EMP will help in adapting and reinforcing its recommendations. The following time schedule may be adopted for the purpose:

Immediate reviews should begin as soon as the EMP is made available and completed before the first construction activity is started (example establishing the Environmental Monitoring Committee (EMC); planning the formal tie-up with TIFR/NCBS; negotiating with TNEB about realignment of the portal and tunnel; accommodating the entire Project infrastructure within Singara and the coffee estate; redrafting the Project proposal in the light of the Government of India guidelines for the management of Biosphere Reserves, Project Elephant and Project Tiger Reserves, and other relevant National Policies; considering the relocation of the Project elsewhere)

Short-term reviews should be on at least once every three months during the first 3.5 years of the construction phase (example identification of strategies for enhancing the quality of corridors; ground work for aboveground infrastructure within the coffee estate; identifying additional locations and means of safe disposal of muck; identifying degraded habitats where long-term restoration can be attempted; others as recommended by the EMC)

Mid-term reviews are those recommended for the period that begins with the installation of the equipment when the presence of scientists become more felt in the landscape and continues for at least 3 years after the Project becomes operational. The reviews can be once in 6 months (example habitat restoration wherever needed; orientation course for field staff/students/faculty on wildlife in general and elephants in particular; planning long-term actions; preparing action taken/compliance reports; others as recommended by the EMC)

Long-term reviews are annual for planning and sourcing funding for environmental mitigation; can begin after identifying research partners, sources of funding and specific points of action (example regenerating elephant food plants; enhancing existing corridors; creating by-pass corridors; annual elephant awareness festivals coinciding with Ganesh Chaturti). The review of long-term actions should however be ideal when begun during the first 3 years after the Project becomes operational (example establishing the Environmental Management Fund independent of the estimated Project costs).

Strategy for Mid-way Correction

Mid-way corrections are inevitable in any EMP implementation process as unforeseen hurdles frequently render the course bumpy. Hurdles may emerge in the form of unpredictable behaviour of wildlife, accidental forest fires, inclement weather patterns, outbreak of a local human or livestock epidemic, accidents that involve human beings other than the Project personnel, delay in funds, communal unrest and political changes. Suggestions for corrections normally emerge during the various reviews. However, certain situations will demand emergency meetings of the EMC. Specific corrective measures that emerge during the reviews have to be documented and the course of action clearly spelt out. Whenever the need for increased manpower or human resource arises, the EMC is the sole authority on identifying the quantum and source of the same.

Indicators of Environmental Changes

Part VI (EMP) provides a set of background information for monitoring environmental impacts. Changes in the environment can be assessed/monitored using some simple and reliable indicators picked out of the background information. Table 15 lists some of the indicators that are relevant to the INO Project landscape. When carefully documented, the information can be of great value to the planning of future scientific and development projects.

Table 15: Environmental attributes and indicators of negative impacts

Attributes of the Environment	Indicators	Temporal/spatial scales
Air pollution (suspended particulate matter)	Smog and poor visibility; deposits on foliage and canopy; change in the coat colouration of animals	Often seasonal; more likely during the construction phase; local
Air pollution (general)	Respiratory ailments in residents; skin allergies	Long-term; both local and widespread
Noise pollution	Stress in residents; animals deserting the site; reduction in yield of livestock	More likely during the construction phase; local
Water pollution	Murkiness; eutrophication; death and decay of aquatic plants and animals; steady decline in aquatic biodiversity; morbidity in humans, livestock and wildlife	During construction phase and long-term; both local and widespread

Attributes of the Environment	Indicators	Temporal/spatial scales
Habitat degradation	Overall reduction in biodiversity (species and abundance)	During construction phase and long-term; local
	Declines in common species of plants and animals	During construction phase and long-term; local
	Increase in invasive species	During construction phase and long-term; local
	Increase in fire and grazing	During construction phase and long-term; local
	More human-animal conflicts	During construction phase and long-term; local and widespread
	More road kills (especially of smaller animals)	During construction phase and long-term; local
	Water stress	During construction phase and long-term; local
Habitat degradation	Decline in hole-nesting birds	During construction phase; local
	Decline in burrow/ground birds	During construction phase; local
	Less movement of wildlife through corridors	During construction phase and long-term; local
Socio-ecological factors	People continue to resent the Project	During construction phase and long-term; local and widespread
	Misconceptions of the Project prevail	During construction phase and long-term; local and widespread
	Increase in hostility towards outsiders visiting the Project site	During construction phase and long-term; local
	Immigration of people seeking job opportunities	During construction phase; local
	Proliferation of petty shops/infrastructure	During construction phase and long-term; local

Minutes of Brainstorming Discussion Meetings

INDIA-BASED NEUTRINO OBSERVATORY (INO): A meeting on the Ecological Issues of the Project

August 20, 2007

The Institute of Mathematical Sciences
Institutional Area, Taramani
Chennai 600 113

Proceedings of the Meeting

Dr M V N Murthy (IMSc), on behalf of the INO team welcomed the participants to the meeting and initiated the process through a comprehensive presentation on the INO. Structured to reach to a non-physicist audience, the presentation included the following components: the INO and its goals, the multi-institutional collaboration that the project envisages, the engineering and environment components and the proposed outreach programme. Dedicating his talk to Prof CVK Baba (1935-2006), MVNM also highlighted the fact that a number of informal discussions that have taken place since the project was envisaged. He informed the group that the Detailed Project Report has been finalised.

INO in a nutshell is a pure science project which studies the interaction of weakly interacting, naturally occurring particles called the 'Neutrinos'. The quantum mechanical phenomenon of neutrino oscillation is the core interest of the current project. India has been a pioneer in establishing a laboratory for the study of neutrinos, in the erstwhile Kolar Gold Fields which had to be shut down due to operational reasons. The vision of project INO can be summarised as follows: facilitate multi-centric study, rejuvenate interest in physics at the collegiate level, share expertise and establish a world class laboratory in terms of reach and scope. Criteria that have been used for site selection include are as follows:

1. A known history of the site
2. Depth in excess of 1000 m all around
3. Access in terms of roads and infrastructure
4. Ease of construction, material handling and quality of labour
5. Government custodianship of the site
6. Stable rock quality
7. Minimal disturbance to the local environment
8. Access to major cities

Taking into consideration the above criteria, the INO is being proposed to be located at the villages of Singara and Masinagudi of Gudalur taluk, Nilgiris district.

The INO envisages the following broad infrastructure: 2 caverns and one tunnel of 2370 m at Singara. The tunnel would be 7.5 m in diameter and shaped as a D, with vehicle pockets at every

500m. All services would operate through the tunnel and an auxiliary tunnel (an issue which the authorities certifying the safety parameters need to be convinced about). 50 m of the tunnel would run through the land owned by the Tamil Nadu Electricity Board, 500 m through a privately owned coffee estate and the rest through the Reserved Forest to culminate under a peak. The geological features of the site have been checked, using the baseline information provided by project PUSHEP which has been a critical factor for the selection of the current site. Issues such as the minimal tree cutting that is required further strengthen the merit of the site.

It was also mentioned that the two caverns would eventually host a number of detectors, of which the ICAL would be the first. The ICAL has active detector layers sandwiched between iron plates. It was also stressed that no laboratory can operate without related activities.

The construction phase of the project would span over a period of five years, of which 36 months would be devoted to the tunnelling and related operations, the engineering aspect would entail about 6 months and the establishment of the detector, viz ICAL would take about 12 months. MVNM also stressed that precautionary measures such as the use of controlled blasting and one-time transportation of the ICAL have already been factored into the project. Facilities for the resident staff such as housing and guesthouse would be constructed in the land (4ha) owned by the Tamil Nadu Electricity Board at Masinagudi. In view of certain concerns raised by environmentalists and development workers, a major component of INO viz.surface laboratory has been shifted to Mysore University. The commitment of the INO project to protect the local environment was also highlighted.

Dr R J Ranjit Daniels, Care Earth, Chennai, in his presentation highlighted the fact that the villages that have been selected as the potential project site for INO are part of the Nilgiri Biosphere Reserve (NBR), the first biosphere reserve officially notified by India, and subsequently recognised by UNESCO. Also, the villages are within the immediate vicinity of the Mudumalai Wildlife Sanctuary which has the single largest population of the Asian Elephant.

Biosphere Reserves are intended to fulfil three complementary functions:

1. A conservation function: to preserve genetic resources, species, ecosystems and landscapes
2. A development function: to foster sustainable economic and human development
3. A logistic support function: to support demonstration projects, environmental education and training, and research and monitoring related to local, national and global issues of conservation and sustainable development

One of the key concerns expressed by RJRD was the disposal of the muck which entails frequent lorry trips. Further, the muck disposal site of TNEB is too small to accommodate the muck that will be generated.

Dr Jean-Phillipe Puyravaud, IT Power India Limited, Pondicherry, highlighted the importance of the Sigur region in his presentation titled: The Sigur Region: Ecological Challenges. He highlighted the fact that the project documents of INO do not provide enough management data on the project. Further, the rapid assessment conducted by SACON does not provide the information required for the project. However, since the assessment report adheres to the guidelines set by the

Government of India, it may be of use to obtain the necessary permissions, which is the most worrisome aspect of the project.

JPP also stressed the importance of recognising the entire landscape as an elephant habitat, and that this has been fragmented rather heavily due to expanding human habitations especially along the river. Further aggravating the problem is the presence of human related activities such as agriculture, fencing to cordon domestic animals and removal of biomass. It is to be recognised that the presence of tall grass only around Singara Reserve Forest makes this area especially attractive to elephants. Cautioning that the INO project may result in the creation of dispersed habitats, JPP highlighted the following risks that need to be assessed:

1. Landscape fragmentation
2. Closure of important corridor
3. Widespread disturbance during construction
4. Settlement of population
5. Constant disturbance after construction
6. Quarters and facilities
7. Domestic animals, wastes, water demand, electric lines etc.

Dr P S Easa of Wildlife Trust of India, New Delhi, in his remarks highlighted the following issues:

1. The environmental costs have not been worked out in detail in project INO.
2. The rapid assessment of SACON has only qualitative information and not the details required by the project.
3. There is a need to develop a comprehensive Environmental Management Plan that will not only enumerate the issues and problems, but also seek ways and means to study, analyse and mitigate the problems..
4. The social response which INO proposes should commence from the beginning to instil confidence in the local population.
5. By mainstreaming ecological and social concerns, the project proposal of INO should serve as a model for future.
6. The rapid assessment report of SACON needs to be re-examined.
7. The project also needs to recognise and accord importance to the behaviour of elephants especially their communication. The impact of the tunnelling activity on the communication of elephants needs to be realised, since any adverse impact on this may lead to increased human-elephant conflict.
8. PUSHEP was a long-term government project. Hence the on course modifications or changes in project implementation remain unknown. Although it is well recognised that the project caused considerable impact on local environment, there have been no studies on this.
9. The importance of the Singara – Masinagudi region is well demonstrated by the number of studies that have been conducted here.
10. The importance of assessing the net availability of ecological and physical infrastructure was also stressed upon.
11. Muck disposal is also of great concern and it is important to make the labourers and contractors aware of the sensitivity of the region.

Dr K Thiyagesan of AVC College, Manampandal in his remarks, reiterated the inadequacy of the rapid assessment study conducted by SACON. KT also expressed his concern on the blasting for creating the tunnel, the vibrations of which may cause serious impact on the communication process of mammals especially elephants. Tunnel boring as an option to minimise ecological impact was suggested by KT. He also requested the INO project team to explore other sites that are more feasible, within the same landscape.

Dr C Arivazhagan of the Centre for Ecological Sciences, IISc, recommended that INO project be located at an alternate site near Theni, which has similar geological features. This was because of the large-scale fragmentation of habitat that the current project would cause. The Masinagudi Moyar corridor is a link between the Eastern and Western Ghats, and hence critical. About 120 elephants use this corridor and have a strong fidelity to the region. Dr Arivazhagan stressed the importance of understanding elephant migration periods.

Discussion

The following section summarises the discussion that took place during and after the presentations.

1. An Environmental Impact Study is a scientific study and not just a tool for obtaining governmental clearance.
2. The EIA should be in cognisance with the components of the project; the results of which can be used for the management of the project.
3. The proposed project site lies within the NBR that supports a contiguous population of not less than 5000 (current estimates place the numbers at 6200) elephants which is the single largest population in Asia and has been identified as a key Project Elephant site.
4. The Moyar-Masinagudi Corridor is an important link between the Eastern and Western Ghats.
5. The elephant is the flagship species of the landscape, not to the disregard of other species.
6. Due to rampant fragmentation and manipulation of the landscape, the elephants are forced to find pathways and corridors. Contrary to popular belief, corridors are only bottlenecks, reflecting the shrinkage of habitat.
7. In the absence of data on the impact that PUSHEP caused, there is a need to study and analyse the direct and collateral impacts that were caused by the project.
8. In this context, it is important to realise the potential impact that the project could cause to the human population. Issues such as expanding family size, spread of disease through domestic animals, encroachment, poaching of small animals, removal of biomass, accidental fire, overlapping use between humans and elephants needs to be recognised.
9. The issue of social responsibility of the project needs to be carefully examined. Routine provisions may offset the ecological mandate of the project. One possibility could be the identification and use of the real local people as workers in the project.
10. Guidelines of each phase of the project need to be examined from a socio-ecological perspective.
11. Land ownership is a contentious issue in the landscape, and so is the issue of local versus settler and this needs to be strongly recognised.
12. Theni-Cumbum as an alternate site needs to be examined since it is part of the Western Ghats and the rock quality is bound to be the same.

The next step forward

Facilitating this part of the meeting, MVNM highlighted the need to keep the current process ongoing. The first step forward would be to compile and disseminate a report on the meeting. The second step would be to evolve an Environmental Management Plan that will seek to minimise to the least possible detrimental impact. Concrete suggestions in the EMP would be implemented under the guidance of an Environmental Management Committee in real time. The mechanism to keep this interaction alive needs to be evolved.

Prof Indumathi (IMSc) summarised the process as follows: Project INO has three major components on which facts need to be obtained viz. Physics, Engineering and Ecology. While the first two will be the mandate of the INO Project Team, for ecological issues, the contact agency would be Care Earth. The data thus obtained would be used to strengthen the Detailed Project Report (DPR). This will also decide the action component and help evolve an inclusive approach.

Dr N Mondal (TIFR) recommended that the Frequently Asked Questions on the project be widely disseminated. A comprehensive project report incorporating the ecological concerns and also corrections needs to be developed. He further recommended the involvement of ecologists in the development of the project report. Prof. Mani suggested that ecologists may also be involved in project implementation. This was further strengthened by Prof. Kamales Kar who suggested the constitution of an INO- Environment Committee. The need to have a mechanism in place for dissemination was also stressed upon.

The following timetable was agreed upon for taking forward the current process and evolving an Environmental Management Plan, with Care Earth as the nodal agency:

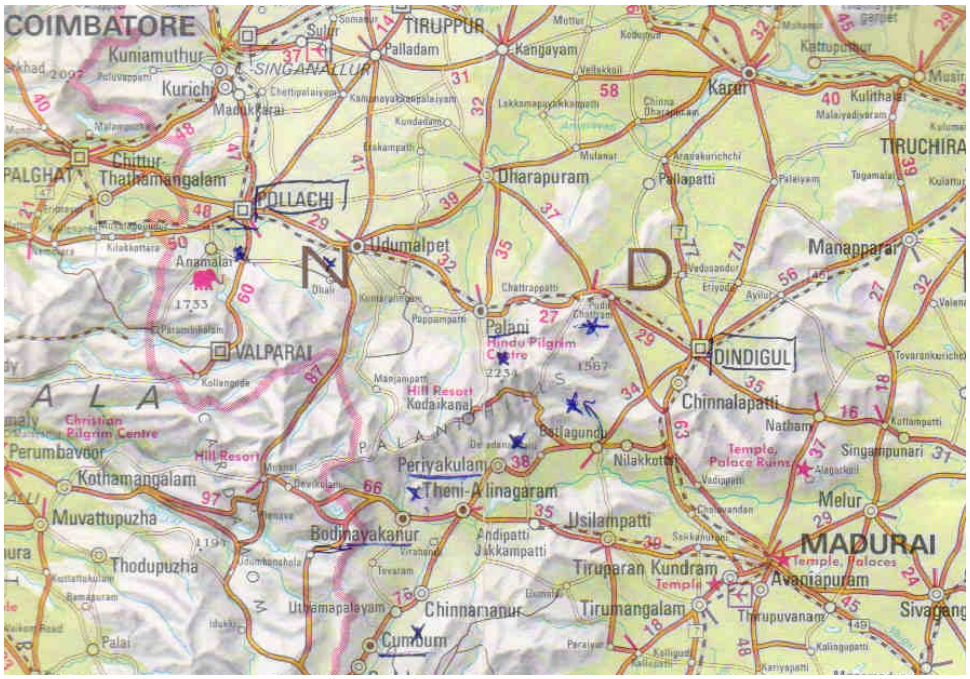
Activity/Month 2007		Sept	Oct	Nov	Dec
Report of the Meeting (Aug 31)					
Compilation of data and identification of gaps		+	+		
Field activity		+	+	+	
Consolidation of data				+	+
Development of the Report	2 meetings				+

The meeting concluded with Prof G Rajasekaran (IMSc) thanking the participants.

List of Participants

Prof Naba K Mondal (INO Spokesperson/TIFR, Mumbai) Prof V M Datar (BARC) Prof M V N Murthy (IMSc) Prof D Indumathi (IMSc) Prof G Rajasekaran (IMSc) Prof H S Mani (IMSc) Prof Kamales Kar (Saha Institute of Nuclear Physics, Kolkata)	Thiru N Sreenivasn (IMSc) Dr R J Ranjit Daniels (Care Earth) Dr Jayshree Vencatesan (Care Earth) Dr P S Easa (Care Earth) Dr. J-P Puyravaud, IT POWER India Limited, Pondicherry Dr K Thiyagesan (AVC College, Mayiladuthurai) Dr C Arivazhagan (AERCC/IISc, Mudumalai)

Photos of alternate sites



Map Showing the Sites Visited.

Alyar: Taken at N 10° 28' 23.02", E 76° 57' 12.56", showing the mountain in the south where tunnel portal could be located.

Alyar: Forest Department check-post and assessed site on the right side.

The Google Earth image shows the direction and the projection on the terrain of a tunnel 2490m long and overburden of 671m in Alyar 1a.

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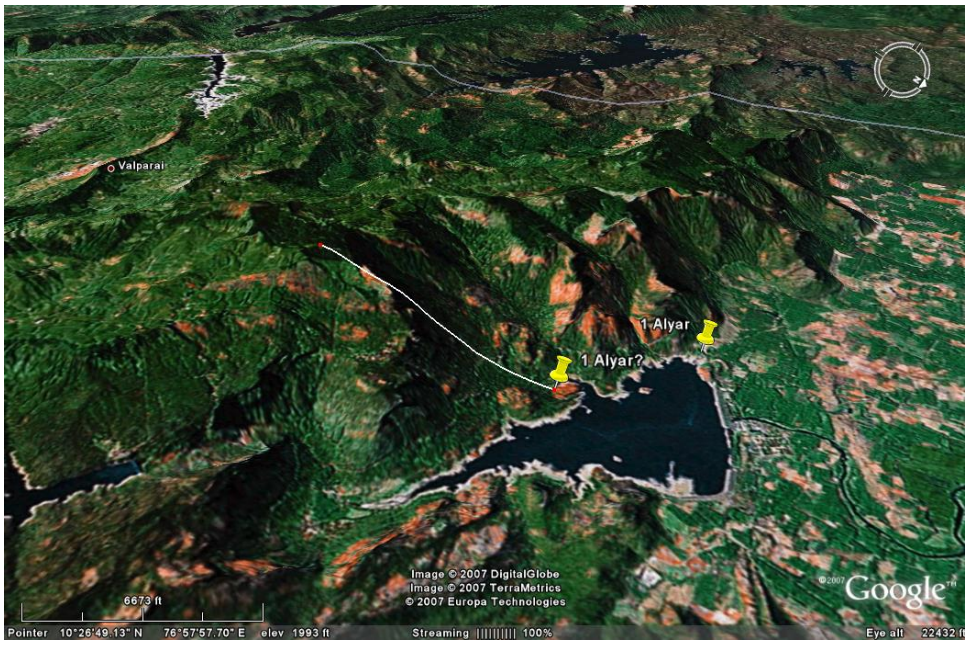
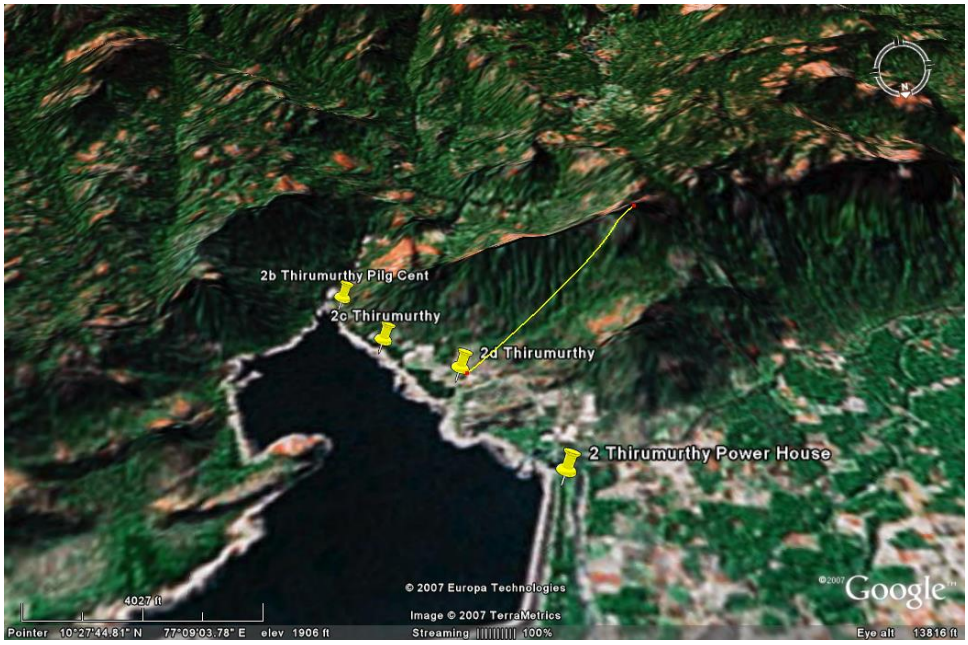


Alyar 1b seems very suitable because of the terrain (easy access, fringes of the national park, steep slope and high elevation). Using a Google image a tunnel of length 4000m has been constructed beneath an elevation range of 1283m.

Site Thirumurthi 2c: view from plantations to the Indira Gandhi National Park and Wildlife Sanctuary.

The Google Earth image shows the site Thirumurthi 2c with projection on the terrain of a tunnel 2000m long and overburden of 630m.

Site Thirumurthi 2d: view to the Indira Gandhi National Park and Wildlife Sanctuary.

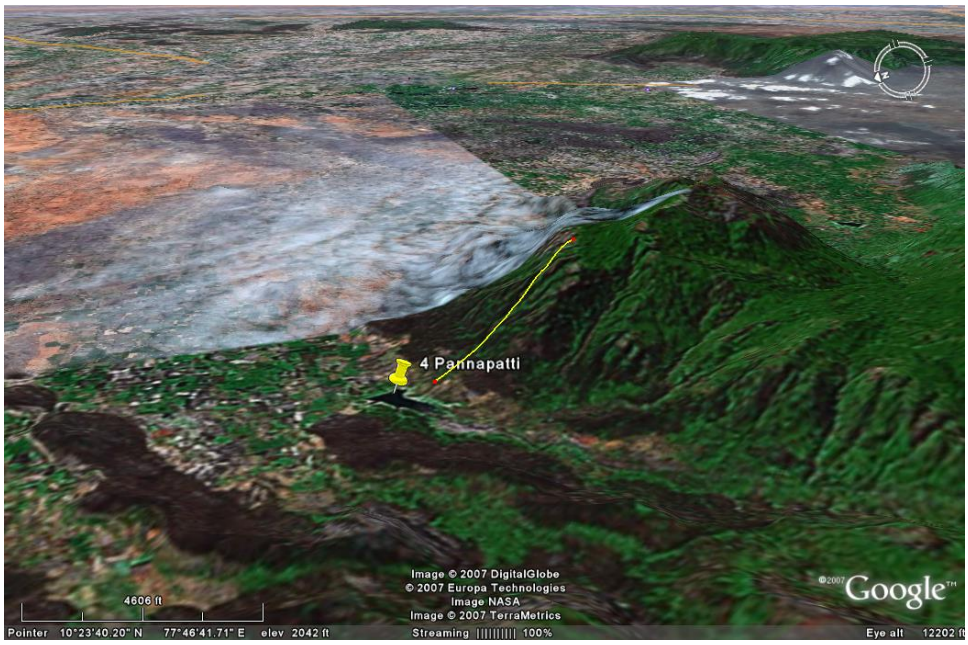


The Google Earth image shows the site Thirumurthi 2d with projection on the terrain of a tunnel 1720m long and overburden of 664m.

Site Palar 3, with forestland in the centre of the photograph and earth road parallel to the dam on the right side.

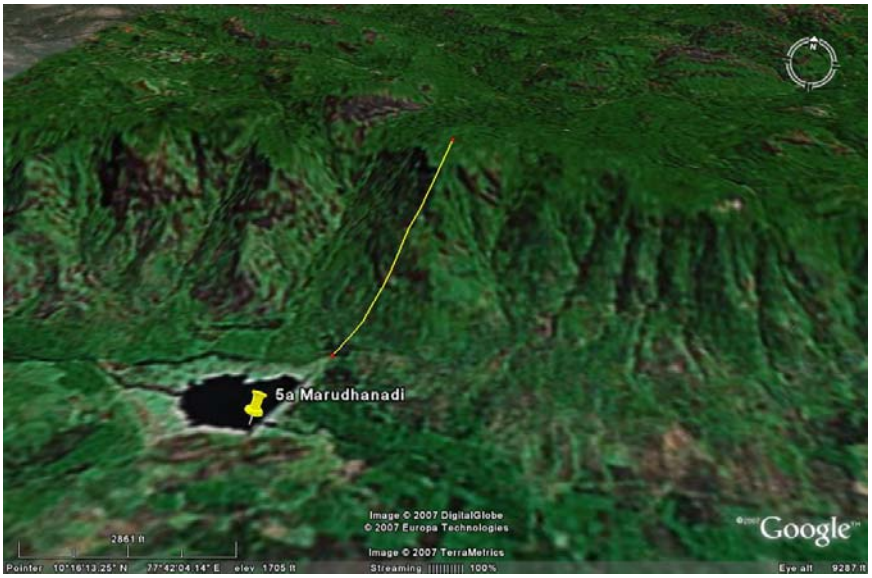
The Google Earth image shows the site Palar 3 with projection on the terrain of a tunnel 2500m long and overburden of 628m.

View of the Pannapati Dam with, at the bottom of the hill; a site assessed for the tunnel portal.



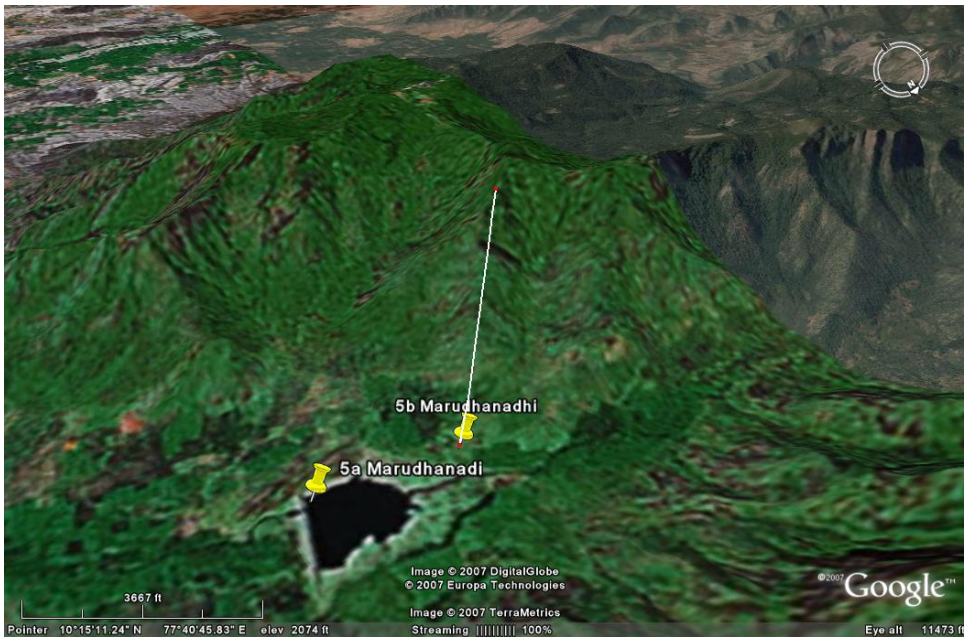
The Google Earth image shows the site Pannapati 4 with projection on the terrain of a tunnel 2000m long and overburden of 823m.

View of the Marudhanadi 5a Dam with, at the bottom of the hill, a site assessed for the INO project.



The Google Earth image shows the site Marudhanidi 5a with a projection on the terrain of a tunnel 1850m long and overburden of 803m.

View of the Marudhanadi 5b site from the dam.

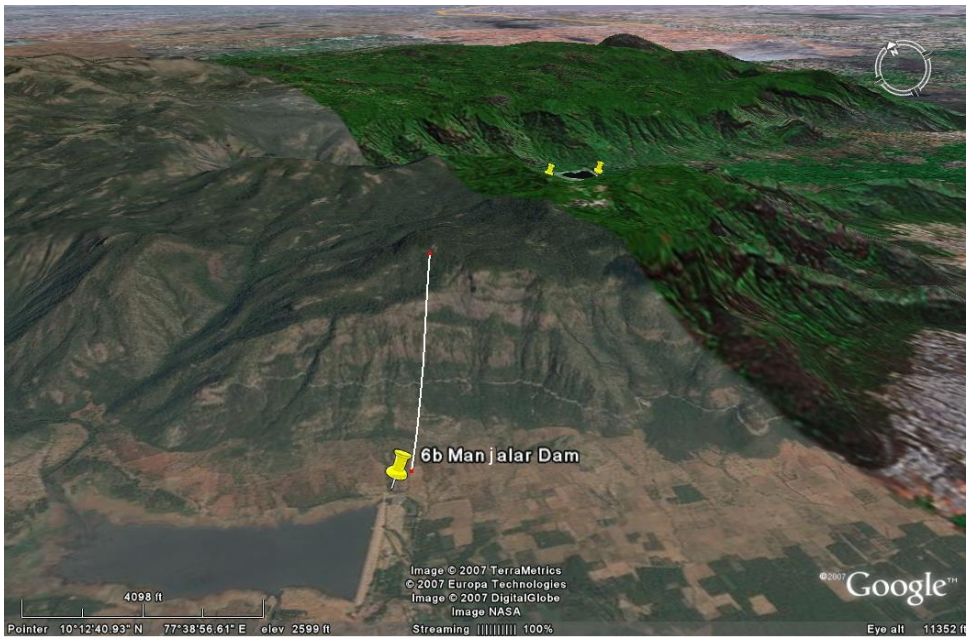


The Google Earth image shows the site Marudhanidi 5b with projection on the terrain of a tunnel 2000m long and overburden of 774m.

Site Manjalar 6a. View from a mango plantation.

The Google Earth image shows the site Manjalar 6a with projection on the terrain of a tunnel 1810m long and overburden of 708m.

Site assessed at Manjalar for the tunnel portal.

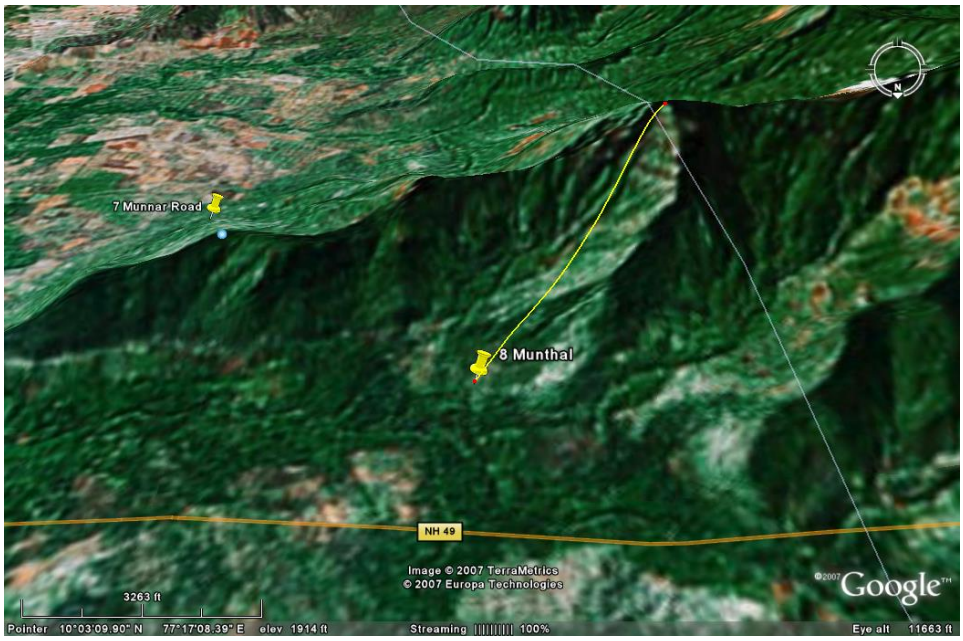


The Google Earth image shows the site Manjalar 6b with projection on the terrain of a tunnel 2010m long and overburden of 869m.

Site Munnar 7: view of the foothills and the plain.

Google Earth image shows the site Munnar 7 with projection on the terrain of a tunnel 2130m long and overburden of 536m.

Site Munthal 8, location assessed for a tunnel portal. The photograph is taken from the asphalt road.



The Google Earth image shows the site Munthal 8 with projection on the terrain of a tunnel 1870m long and overburden of 846m.

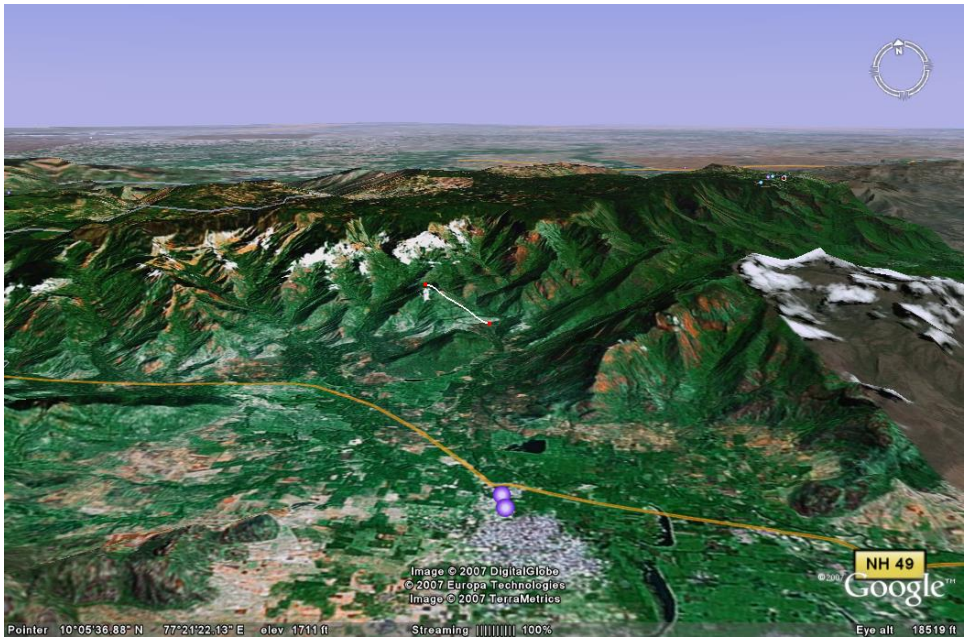
Site Kanagudi 9; location assessed for a tunnel portal.

The Google Earth image shows the site Kanagudi 9 with projection on the terrain of a tunnel 2000m long and overburden of 676m.

Site Sakamutu Metti 12, location assessed for a tunnel portal.

The Google Earth image shows the site Sakamutu Metti 12 with projection on the terrain of a tunnel 1344m long and overburden of 797m.

View of a site assessed at Bodi for a tunnel portal.



The Google Earth image shows the site Bodi 13 with projection on the terrain of a tunnel 1560m long and overburden of 721m.

Sources of Information

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