CENTRE FOR ECOLOGICAL SCIENCES
INDIAN INSTITUTE OF SCIENCE
BANGALORE 560 012, INDIA
Telephone: 91-080-3600985/309 2635/309 2506
Telefax: 91-080-3601428
E Mail: nvjoshi@ces.iisc.ernet.in

Prof. N.V. Joshi

Date: 5 March 2001

To,
Chairman
Center for Ecological Sciences I.I.Sc.

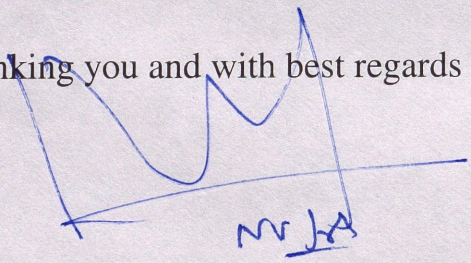
Sub: Payment of rent for the Kumta Field Station from Part II B/NVJ

Dear Sir

May I request you to make the necessary arrangements for using DoEn Part II B / NVJ (instead of /MG) for the payment of rent for the Kumta field station , with effect from 1 Jan 2001?

This arrangement is acceptable to Prof. Madhav Gadgil, and I write this letter to you at his suggestion.

Thanking you and with best regards



Cc:
Prof. Madhav Gadgil

CENTRE FOR ECOLOGICAL SCIENCES
INDIAN INSTITUTE OF SCIENCE
BANGALORE 560 012, INDIA
Telephone: 91-080-3600985/309 2506
Telefax: 91-080-3601428
E Mail: renee@ces.iisc.ernet.in

Dr. Renee Borges

25th June 2001

No Objection Certificate

Certified that Sri. N.V. Joshi is a permanent employee of the Centre for Ecological Sciences, Indian Institute of Science, Bangalore - 560 012 from 18/07/1987 and is at present holding the post of Associate Professor. This Department has no objection to his acquiring Indian Passport.

27 JUN 2001

Dr. Renee Borges
CHAIRMAN
Centre for Ecological Sciences
Indian Institute of Science
BANGALORE-560 012

Date:

Chairperson

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E Mail: renee@ces.iisc.ernet.in

Dr. Renee Borges

25th June 2001

Certificate

Certified that Sri. N.V. Joshi is a permanent employee of the Centre for Ecological Sciences, Indian Institute of Science, Bangalore - 560 012 from 18/07/1987 and is at present holding the post of Associate Professor. He is residing in the quarters allotted by the Institute, and his residential address is:

N.V.Joshi
D-206
New Housing Colony
Indian Institute of Science
Bangalore - 560 012

Date:

27 JUN

Dr. Renee Borges
CHAIRMAN
Centre for Ecological Sciences
Indian Institute of Science
BANGALORE-560 012
Chairperson

CENTRE FOR ECOLOGICAL SCIENCES
Indian Institute of Science
Bangalore 560 012, India

PROF. RAGHAVENDRA GADAGKAR
Chairman

Dated: December 3, 2001

Dear Colleague,

I write this regarding the preparation of the annual report of our activities for the year 2001-02 to be submitted to the Ministry of Environment and Forests. Please note that as per the suggestion of the Monitoring Committee the projects have been regrouped into four themes. This has necessitated changes in the serial number of the projects.

As in previous years, separate detailed reports have to be provided for each project. Annexure 1 gives the list of projects indicating names of individuals who should take responsibility for preparation of reports. You are welcome to include a report on any new project not listed in Annexure 1 but on which work has been carried out during this period. Please mention the year of commencement of each project as indicated in Annexure 1.

Please note from Annexure 2 that the report for each project should be not longer than four A4 size sheets of paper (including tables, figures, etc.,). You are welcome to use single or double line spacing as per your requirement. But please do give me a final print outs including tables and charts so that I can xerox them directly.

I would appreciate it very much if the report reaches me in final form on or before 31st December 2001.

Please submit two copies of all your papers relevant to CES during 2001.

Looking forward to your cooperation and with best regards.

Yours Sincerely,

(Raghavendra Gadagkar)

Annexure: 1 and 2
rl/CH

Telephone (O):91-80-3601429;3092340; (R):3601758 Cable: CES 'Science' Malleswaram, Bangalore, India
Telex: 0845-8349; FAX: 91-80-3602121, 3601428; 3600683; 3600085 E-Mail: ragh@ces.iisc.ernet.in

ANNEXURE - 1

Project Number	Title	Duration of the Project
	Theme I: Biodiversity and Conservation	
Project 1	Inventory and Monitoring Biodiversity of Western Ghats. (MG)	1996 to -
Project 2	Diversity of Social Insects. (RG)	1985 to -
Project 3	Ecology of Asian Elephants. (RS)	1997 to -
Project 4	Monitoring of Large Mammal Populations. (RS)	1988 to -
Project 5	Community ecology and conservation of rainforest birds in the southern Western Ghats. (RS)	1998 to -
Project 6	Tropical Forest Ecology. (RS)	1997 to -
Project 7	Conservation Genetics and Molecular Ecology. (RS)	1997 to -
Project 8	Biodiversity Policy Studies. (MG)	1999 to -
	Theme II: Behaviour and Evolution	
Project 9	A comparative study of two species of primitively eusocial paper wasps. (RG)	1999 to -
Project 10	Evolution of Social Life in Insects. (RG)	1997 to -
Project 11	Social Behaviour in Canids. (RS)	1997 to -
Project 12	Mathematical and Statistical Ecology. (NVJ)	1997 to -
Project 13	Theoretical Evolutionary Biology. (VN)	1997 to -
Project 14	Molecular Ecology of Insects. (RG)	1996 to -
Project 15	Plant-animal interactions in montane forests of the Western Ghats. (RMB)	1998 to -

Project 16	Characterisation of the Orthopteran fauna of Southern India with regard to their acoustic communication systems. (RB)	1998 to -
Project 17	A Cellular basis for division of labour in *Dictyostellium dicoideum*. (VN)	1998 to -
Project 18	The behavioural ecology of ant-mimicking spiders. (RMB)	2000 to -

Theme III: Climate Change and its Impact

Project 19	Past Climate Change in India. (RS)	1997 to -
Project 20	Climate Variability and Agriculture. (SG)	1996 to -
Project 21	Climate Change and Forests. (NHR)	1996 to -

Theme IV: Ecodevelopment

Project 22	Human Ecology in Uttara Kannada District of Karnataka. (NHR)	1997 to -
Project 23	Bee Keeping. (RG)	1994 to -
Project 24	Integrated Energy Planning. (DKS)	1997 to -
Project 25	Status of Wetlands in Bangalore. (TVR)	1999 to -

ANNEXURE - 2

Format for Preparation of Reports

1. Title
2. Authors
3. Summary (½ page)
4. Objectives (½ page)
5. Methodology (½ page)
6. Results (½ page)
7. Discussion (½ page)
8. Tables and Charts (one page)
9. Recommendations }
10. Publications } ½ page
11. Degrees awarded }

DRAFT

Prof. N H Ravindranath

January 9, 2002

Prof. N V Joshi
Chairman
Centre for Ecological Sciences
Indian Institute of Science

Dear Prof. Joshi,

Sub: allocation of Space in CES

I am writing this letter on space allocation at CES, as I may not be there when you call a meeting of the Faculty, in the next couple of weeks.

1. *Current floor/space occupied:* I currently occupy Rooms 216 and 217 (small rooms) and 320 (medium size).
2. *My contribution to floor space at CES:* The two medium sized rooms 320 and 321 were built using funds (non-building) from a CSIC project for which I was the Principal Investigator.
3. *Request for additional floor space at CES:* I need additional space at CES due to the following reasons;
   - *Current collaborative projects:* I have 3 large collaborative projects with Prof. Sukumar and Prof. N V Joshi. Also, Dr. Ramachandra and I have initiated work on sustainable water
   - *New project on biodiversity:* I am getting a large (> Rs. 1.0 crore) project from the Govt. of India on biodiversity in collaboration with Prof. Madhav Gadgil.
   - *Sirsi staff visiting institute:* CES staff from Sirsi visit Bangalore for analysis, discussion etc., frequently
   - *My contribution to activities of the Ministry of Environment and Forests:* I have contributed more for activities of the Ministry, than any CES faculty, costing so much of time and resources. If any proof is needed, Secretary of MoEF, Advisor, Director and other senior officials of the Ministry will testify
   - *Contribution to CES annual report and publication:* My contribution to the annual report of the MoEF with respect to activities, publications, etc. is second to none. This can be verified from the last 3-4 reports
   - *Promotion of inter-department collaboration:* The Director of the Institute emphasizes in every meeting the need for collaborative R&D between faculty within and particularly, across different departments or centres. I have collaborative research, projects and publications with Prof. Gadgil, Sukumar, Joshi and Dr. Ramachandra.

Once again, I request you to keep in mind my need for additional space, especially as the funds are provided by the MoEF and I have major collaborative R&D activities with four faculty of CES.

Thanking You,
Yours Sincerely,

(N H Ravindranath)

CENTRE FOR ECOLOGICAL SCIENCES
Indian Institute of Science
Bangalore 560 012, India

PROF. R. SUKUMAR
Associate Professor & Officiating Chairman

Dated: May 23, 2002

Prof. P. Balaram
Chairman
Division of Biological Sciences
Indian Institute of Science
BANGALORE 560012.

Dear Prof. Balaram,

I will be in Cambodia attending a meeting of the Asian Elephant Specialist Group of IUCN –World Conservation Union from 27th to 31st May 2002 (Refer approval letter No. R(IA)P.V.375(S)2047 dated 10th May 2002).

Prof. N.V. Joshi, Associate Professor will look after the duties of chairman for the above period.

Yours sincerely,

(PROF. R. SUKUMAR)
CHAIRMAN
Centre for Ecological Sciences
Indian Institute of Science
BANGALORE-560 012

cc: Prof. N.V. Joshi, CES
Bills Section

rl/OFFCH

Telephone (O):91-80-3600382;3942786; (R)3620939 Cable: CES 'Science' Malleswaram, Bangalore, India Telex: 0845-8349; FAX: 91-80-3601280, 3601428; 3600683; 3600085 E-Mail: rsuku@ces.iisc.ernet.in

CENTRE FOR ECOLOGICAL SCIENCES
Indian Institute of Science
Bangalore 560 012, India

PROF. RAGHAVENDRA GADAGKAR
Chairman

Dated: September 19, 2002

Prof. Govardhan Mehta
Director
Indian Institute of Science
Bangalore 560012

Dear Prof. Mehta,

Thank you for your letter No. R(IA)400-11/2000-3168 dated 29th August 2002. I am happy to inform you that I have handed over charge as Chairman of CES to Prof. Niranjan V. Joshi with effect from the afternoon of Thursday, the 19th September 2002.

Thanking you and with best regards,

Yours Sincerely,

(PROF. RAGHAVENDRA GADAGKAR)

cc: Prof. Niranjan V. Joshi, CES

File : RG P V
rl/CH

Telephone (O):91-80-3601429;3942340; (R):3601758 Cable: CES 'Science' Malleswaram, Bangalore, India
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CENTRE FOR ECOLOGICAL SCIENCES
INDIAN INSTITUTE OF SCIENCE
BANGALORE 560 012, INDIA
Telephone: 91-080-23600985 / 2293 3099/ 2293 2506
Telefax: 91-080-23601428 / 23600085 / 23601683 (attn: CES/TVR)
E Mail: cestvr@ces.iisc.ernet.in
energy@ces.iisc.ernet.in
ram@ces.iisc.ernet.in
Web URL http://ces.iisc.ernet.in/energy/Welcome.html

DR. T.V. RAMACHANDRA

CES/TVR/ISRO-STC/77242/2006
November 24, 2006

The Convener
ISRO-IISC Space Technology Cell
Indian Institute of Science Campus
Bangalore- 560 012

CHAIRMAN
Centre for Ecological Sciences
Indian Institute of Science
BANGALORE-560 012

Dear Sir,

Sub: Submission of research proposal entitled "Geospatial Modelling of Landslide Susceptible Zones"

Ref: Your email dated November 16, 2006.

Please find enclosed herewith two copies of the research proposal entitled "Geospatial Modelling of Landslide Susceptible Zones" in response to your recent email. E-version of the same has been sent through email. Please acknowledge the receipt of this letter and keep me informed of the status.

Thank you,

Yours sincerely,

T.V. Ramachandra

(Dr. T.V. Ramachandra)

CC: 1. Prof. N.V. Joshi, C.E.S., I.I.Sc.
2. Dr. P.G. Diwakar, RRSC/ ISRO, 40th Main, Iswarnagar, Banashankari, B'lore- 76

Research Proposal

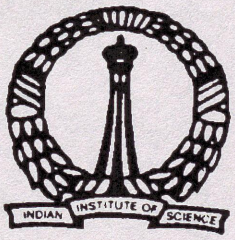
Project Title: **GEOSPATIAL MODELLING OF LANDSLIDE SUSCEPTIBLE ZONES**

Submitted to:

ISRO – IISc Space Technology Cell
Indian Institute of Science
Bangalore 560 012

Investigator(s) from IISc: **Dr. T.V. Ramachandra**
Dr. N.V. Joshi

Co-investigator(s) from ISRO: **Dr. P.G. Diwakar**
RRSC/ISRO



Centre for Ecological Sciences
Indian Institute of Science,
Bangalore 560 012

23rd November 2006

APPLICATION FOR GRANT OF RESEARCH / DEVELOPMENT PROJECT

SECTION –A

1	Title of research/ development Proposal	**Geospatial Modelling of Landslide Susceptible Zones**
2	Name of the Principal Investigator and Address	**DR. T.V. RAMACHANDRA** Centre for Ecological Sciences Indian Institute of Science
	Name of the Co- Investigator (s) and Address	**DR. N.V. JOSHI** Centre for Ecological Sciences Indian Institute of Science
	Name of the Co-Investigator(s) from ISRO and Address	**DR. P.G. DIWAKAR** RRSC/ISRO, 40th Main, Banashanakari, Bangalore 560076
3	Proposed duration of the research/development proposal	36 months (3 years)
	Proposed date of commencement of project	April 1, 2007
4	Amount of grant proposed for	Rs. 5,55,450 (See Appendix – A for details)
5	Department of the institution where R & D project will be carried out	Centre for Ecological Sciences Indian Institute of Science
	Other department if any, which will co-operate in this study	RRSC/ISRO
	Details of financial support sought/obtained from other agencies	Karnataka State Remote Sensing Application Centre - Base layers required for spatial analysis
6	Specific Aim of the Project	Appendix B
	Summary of Proposed research/facilities and objectives (brief statement about the proposed investigation, its conduct and the anticipated results in not more than 300 words)	Appendix B
	Key words	Appendix B
	Classification of the project	
7	Background and justification (Basis for the proposal with a brief review of the state of the art in the subject, followed by an outline of the relevance and importance of the project, in particular, towards research/development/design related to ISRO programs	Appendix C
8	Approach (details of the actual approach indicating how each of the objective listed in item 6 (a) will be achieved); deliverables, Task schedule and bar chart	Appendix C
9	Previous work done in this or related fields 9Describe briefly any work done that is particularly pertinent to the proposal & list: (I) your personal publications in this & related areas	Appendix C
10	Expected Contributions from ISRO collaborators	Appendix C

I certify that a detailed technical report describing the research work/ procedure and its findings will be submitted before the closure of the project.

T. V. Ramachandra

Date: 23rd November 2006

Signature of the Principal Investigator

APPENDIX – A

Title of the Project
Amount of Grant Proposed

Grants (In Lakhs of Rupees)	I Year	II Year	III Year	Total
(a) Salary	108000	108000	108000	324000
(b) Equipment[⊗]				
(c) Working Expenses*	65000	35000	59000	159000
Sub-Total	173000	143000	167000	483000
(d) IISc Overheads ≈@15%	25950	21450	25050	72450
Total	198950	164450	192050	
Grand Total				555450

#Salary for **one project assistant**: Rs. 9,000 per month

[⊗]List of Equipments (Give below)
Sl No., Name of the Equipment, Make, Approximate Cost
Equipments such as clinometers, GPS, soil analysis kits, etc. are available with us.

*Working Expenses include Stationary, Consumables and components, chemicals, minor fabrication costs (which ever is needed), TA/DA, etc. (Give a list of important consumable/components with approximate cost).

Working Expenses:
This would include:

- Remote Sensing data: would be purchased during 1st and 3rd year (Rs 30000 per year: to overlap with landslide dates and for validation of model)
- Travel expenses per year would be Rs.20,000 for first two years and Rs.15000 for the third year (to visit landslide sites and also regions susceptible for landslides).
- Contingency expenses (Stationary, Consumables, computer consumables, photo copying, expenses during discussion meeting, vehicle fuel expenses, etc.). This would be about Rs.15000 per year for the first two years and Rs 14000 during the third year.

APPENDIX – B

Project Title: **Geospatial Modelling of Landslide Susceptible Zones**

1. SPECIFIC AIM/ OBJECTIVE OF THE PROJECT:

Objectives of the proposed work are:

- To understand the process and dynamics of landslide
  - Spatial mapping of landslide prone zones
  - To identify the triggering and quasi-static factors
- To model the spatial and temporal processes inducing landslide
- To predict landslide susceptibility in geospatial environment using Fuzzy Logic, probability techniques, statistical methods, etc.
- To suggest and recommend appropriate mitigation measures

2. SUMMARY OF PROPOSED RESEARCH:

Environmental disasters are events that are either due to natural phenomenon or human induced that impacts humans and properties. The impact of disasters is rapidly increasing and the cost to global economy exceeds 0.5 million dollars per year of which more than 75 percent represents direct cost of the damage and the rest account for the cost of predicting, preventing and mitigating disasters. Global mean of death tolls is around 50,000, which varies from year to year. About 95% of the death occurs in developing countries and economic loss amounts to 10% of GNP. In India, environmental hazards like landslides, famine, drought, floods, cyclones and earthquakes have taken a toll of 1.6 millions since 1960. The impact of disasters could be minimised through a proper disaster management, including disaster prevention (land use planning, legislation, hazard and risk assessment), disaster preparedness (forecasting / warning / prediction) and rapid and adequate relief. **We propose to undertake a study involving landslide hazard zonation, monitoring and modelling in central Western Ghats, to mitigate the effects of landslides.** This is based on temporal remote sensing data for the mapping of relevant input data. Data analysis would include both qualitative and quantitative approach on multidisciplinary data sets. The landslides which are quick or fast can cause heavy damage. So mapping of landslide susceptibility zones becomes important to mitigate landslide. Remote-sensing and GIS with tools like probability, bivariate and multivariate statistics and fuzzy logic help in landslide prone zonation. The mapping of landslide will help decision makers in planning mitigation measures and even planning developmental activity.

Keywords: Environment, GIS, Remote Sensing, Spatial and temporal analysis, land use, Western Ghats, Land slides, Susceptibility zones, Modelling, fuzzy logic

APPENDIX – C

Project Title: **Geospatial Modelling of Landslide Susceptible Zones**

Background and Justification

Natural hazards are an integral component of life on Earth (ICSU, 2005). The number of recorded natural hazards has increased in the last 50 years with the greatest increase in frequency attributed to hydrometeorological disasters, with a lesser increase attributed to biological disasters and a slightly lesser increase attributed to geological disasters (ICSU, 2005). Moreover, the number of natural hazards culminating in disasters also has tremendously increased. Natural disasters were especially prolific in 2005. Quite timely, international interest in the geological and archaeological fields has focussed since 2002 on the theme of rapid and catastrophic environmental changes and human and ecosystem responses occurring in the last millennia. According to the ICSU, for the period 1994–2003, landslides accounted for 4.5% of the total number of events (ICSU, 2005). Landslides are natural geological processes that constantly evolve and reshape the Earth's surface. Landslides costs in India and other countries are quite similar in magnitude i.e., few crores per year. Increase in population and rapid urbanisation has led to expansion of construction activities in hilly terrains and has catapulted frequency of landslides to dramatic proportions in recent decades. Although natural hazards may occur in many parts of the world, their consequences depend on the relationship between the magnitude of natural phenomena and the vulnerability of human settlements to such an event (Alca´ntara-Ayala, 2002). Consequently, natural phenomena are more destructive in developing countries because of economic, political, social and cultural factors, which increase the vulnerability of these countries to natural hazards (M Guinau et.al, 2002). Landslide hazards in Kumaun-Garhwal Himalaya in 1998 and subsequent tragedies in Himalaya and Western Ghats in early 21st Century exposed the state of preparedness of the state machinery for combating such eventualities and also the need for detailed extensive risk assessment studies in the hazard prone hilly regions of India. The neglect of traditional land and water management practices without any viable alternatives has aggravated the situation.

Along Western Ghats , very little work has been carried out, even though landslides account for 4.5% of damages. Developmental activities such as Konkan rail network, hydroelectric projects across Sharavathi river and Kali, naval sea bird project at Karwar have enhanced the episodes of landslides. Table 1, gives the statistics of life and property in Western Ghats in the recent past. ***This necessitates prioritizing landslide susceptible zones to minimize the damages due to landslide events.***

Table 1: Loss of life and property

Place and date	Damage to Life	Damage to Property
Karwar-Mumbai, 24/06/03++	34 dead, 25 injured	Train derailed
Uttara Kannada, 24/06/03+	2 killed	
Jui village (Raigad), 27/07/05*	100-150 dead	
Kondivita (Raigad), 27/07/05*	20 killed	3-4 houses destroyed
Mahad (Raigad), 30/07/05*		30-35 houses buried
NH17 (Mumbai –Mangalore) 05/08/05 **		Road blocked
Sakinaka (Andheri East), 30/07/05*	90 dead	35 houses buried
Idukki district, 27/07/06 #	Seven dead	
Mercara, 5/07/06 **	Six dead, one injured	2 houses destroyed
NH17 (Sadashivghar, Mumbai –Mangalore) 10/07/06 **		Road blocked
Siddapura 11/08/06##		Crops, plantation worth lakhs destroyed

+ www.landslidecentre.org/database.htm (24/10/06), *Ministry of home affairs national disaster management division,Sitrep-33,31July,2005, http://www.rediff.com/news/2003 /jun/23, #http://mangalorean.com/news.php?newstype=local&newsid=17552,
**field observation, ## news paper (Vijaya Karnataka),

Review of Current Scenario

Chung C.-J. F. and Fabbria. G. developed joint conditional probability model to represent a measure of a future landslide hazard. A training set consisting of the earlier landslides and the geographical information system-based multi-layer spatial data in the study area was used to construct the prediction maps. Mehmet. L. S. and Vedat D. have evaluated and compared the results of multivariate (logical regression) and bivariate (landslide susceptibility) methods in Geographical Information System (GIS) based landslide susceptibility assessment procedures. Marta. G., et al. (2005) study included (1) detailed field work to produce a high-resolution inventory landslide map at 1: 10,000 scale, and (2) a selection of the relevant instability factors from a Terrain Units Map. Based on these, zones were marked to the propensity to landslides. Aldo. C., et. al (2002) applied the multivariate methods, the Conditional Analysis to a subdivide the territory into Unique Condition Units. Lee S (2006) used data-derived (frequency ratio) and knowledge-derived models (fuzzy operator) in geographic information system (GIS). Lee S. (2004) did landslide susceptibility mapping through bayesian probability model, a likelihood ratio and statistical model, logistic regression and Geographic Information System (GIS). The logistic regression model had higher prediction accuracy than the likelihood ratio model. Ermini. L., et al. (2005) forecast landslide susceptibility through the application of Artificial Neural Networks (ANNs) using Multi-Layered Perceptron

(MLP) and also Probabilistic Neural Network (PNN) family. Glade. T., et. al., (2000) using "Antecedent Daily Rainfall Model" computes thresholds for rainfall triggering landslides. The calculated thresholds show regional differences in susceptibility of a given landscape to landslide-triggering rainfall. Lee, S and Dan. N. T., (2005) evaluates the susceptibility of landslides focussing on the relationship between tectonic fractures and landslides. The influencing factors of landslide occurrence were: distance from a tectonic fracture, slope, aspect, curvature, soil, and vegetative land cover. Bhasin R et al (2001) emphasis the triggering mechanisms that contribute to the release and creep of natural slopes in the region. They carry out geotechnical investigations in the affected areas and indicate that both the overlying soil and the discrete joint surfaces in the bedrock have moved during the landslide activity. Patrick L et al., (2001) worked on natural and human induced landslides in the Garhwal Himalaya of northern India. These landslides mainly comprised shallow failures in regolith and highly weathered bedrock involving avalanches, slides, and flows. Approximately, two-thirds of the previous landslides in this region were initiated or accelerated by human activity accelerating denudation in this region, in the removal of slope toes at road cuts. Paul S. K. et al.(2000), attributes the distressed state of the rock mass in the Himalayan region due to the ongoing northward drift of the Indian plate. Rautela. P. and Lakhera R. C., (2000) testify that slope, aspect, geology, tectonic planes, drainage, and land use all influence landslides based on field observations. These parameters were considered in the statistical index method for landslide hazard zonation. Weidinger J. T.,(1998) carried out hazard analysis and show that. lithotectonic and climatic conditions led to the destabilisation and failure of carbonate bedrock. Anbalagan R and Singh B., (1996), expressed risk as a function of hazard probability and damage potential and proposed mapping techniques for prioritising landslide hazard management. and risk map indicates the. Panikkar S.V. and Subramanyan V., (1996), worked on geomorphic evaluation of the landslides around Dehradun and Mussoorie. The important causes were found to be lithology, proximity to the active faults (Main Boundary Thrust and Sairku fault), slope angle and aspect, lateral erosion by stream undercutting and deforestation due to human interference. The triggering factors include rainfall and seismicity. Haigh M.J., et. al.(1988), identified variables that correlate with accelerated landslide activity and suggest that rockfalling may be predictable from measures of the frequency of enlarged joints in the roadcut supported by members of an inter-related complex of variables including slope angle, roadcut height, apparent dip, rock strength, and upslope vegetation cover. Balkema, A 1990, used remote sensing data for detecting potential sites for landslides/rockfalls in the Deccan Trap lava terrain of Western India. Jayakumar, M., Vinayan, P. K.,(1989), determined areas susceptible to landslides by delineating differences in vegetation and soil moisture, and unique characteristics of terrain in terms of geology, geomorphology and drainage structure. Unconfined compression tests were used to evaluate qualitative loss in strength due to an increase in moisture content. Ramana. V., Goete B.S.,(1990) presents the case histories of two catastrophic landslips in hard rock terrains with varied climatic and geological environments in Nilgiri hills. The weathered state of the rock masses in both the cases, showing good agreement with their physical state, accounts for the landslips. Nagarajan, R and Khire M V 1998, worked on debris slide occurred due to the development of hydrostatic pressure at the base of colluvial material, such that slope failure took place at the rock/soil interface that resulted in extensive damage to property and killed 20 people in addition to numerous animals. Nagarajan, R et al., 2000 used spatial and tempo-

ral multi-layered information is required to assess landslide hazard susceptibility. The study highlights the utility of temporal remote sensing data and knowledge based Geographical Information Systems for collection, integration and analysis of spatially-oriented data, as well as in finding out the inherent relation between separate entities in parts of Western Ghats in India. Gupta H.S, (2001) determined the erosional potential & slop stability characteristics of a small catchment zone from a highly important terrain segment of biodiversity hotspot in peninsular India.

This review highlights the need to undertake studies in Western Ghats to mitigate effects of landslide which entails identification, mapping and analysis of the hazard zones. For landslide modelling various techniques could be adopted like statistical, probabilistic, neural network and fuzzy logic. Variables are broadly grouped into two categories: (1) preparatory variables or quasi static variables, which make the slope susceptible to failure without triggering it, such as geology, slope gradient, and aspect, elevation, soil, vegetation cover and long-term drainage patterns and weathering; and (2) the triggering variables or dynamic variables such as heavy rainfall, glacier outburst, seismic activity, etc.

Approach

Data collection: This involves the collection of primary data and secondary data. Secondary data collection involves data collection from government organization, soil and rock sample collection and socio economic survey. Field survey involves collection of landslide location points (longitude and latitude) using the Global positioning system (GPS), soil and rock sample collection from the location of landslide. Socio-economic survey is for collection of dates and frequency of landslide, to know the loss of life and property. Soil and rock sample will be collected to conduct and compressive-strength tests, and consistency limits. Point load and Schmidt hammer tests would be made on rock outcrops. Data collected can be point data of rainfall or satellite images or hard copy and even the soft copy of various themes. The various data required are

- Lineament map, soil map, lithology map: Natural Resources Data Management System (NRDMS), Karnataka state remote sensing application centre (KSRSAC), Geological Survey of India
- Topographical map: Survey of India (SOI)
- Rainfall data: Indian Meteorological department, Bureau of economic and statistics, District collectors (DC) office
- Remote sensing data: National Remote Sensing Agency (NRSA) and Global Land Cover Facility (GLCF)
- Topographic data from Shuttle Radar Topographic Mission (SRTM): Global Land Cover Facility (GLCF)

The strategy and the approach to landslide hazard mapping will be based on the current state-of-the-art, taking fullest advantage of the enormous amount of information and data on landslides, published and unpublished. The thematic factor maps that will be used in hazard mapping on a GIS platform are as listed in Table 3.

Table 3: List of data and data sources for the Landslide Zonation Modelling

Sl.No.	Thematic maps	Data Source	Year	Scale
1.	Landuse	Karnataka State Remote Sensing Application Center NRSA IRS-P6 LISS 3, PAN MODIS*		 23.5m, 5.8m 250m, 500m
2.	Landcover	Karnataka State Remote Sensing Application Center NRSA IRS-P6 LISS 3, PAN MODIS*		 23.5m, 5.8m 250, 500m
3.	Rainfall	District collector's office, India Meteorological Department	1901-2005	Taluk wise rain gauge data
4.	Road Network	Karnataka State Remote Sensing Application Center, SOI	1978	1:50000
5.	Rail Network	Karnataka State Remote Sensing Application Center, NRSA IRS-P6	2007, 2009	5.8m
6.	Seismic Zonation Map	Geological Survey of India	2000	1:1 million
7.	Drainage Network	Survey of India	1978	1:50000
8.	Slope	Survey of India Shuttel Radar Topographic Mission#	1978 2001	1:50000 90m
9.	Aspect, Curvature	Survey of India, Shuttel Radar Topographic Mission#	1978 2001	1:50000 90m
10.	Vegetation map	Forest department		
11.	Geology map (lithology, lineaments)	Geological Survey of India, Karnataka State Remote Sensing Application Center NRSA IRS P6	 2007	1:250,000 5.8m
12.	Landslide details	Socioeconomic survey, and field work		
13.	Soil map(soil texture, depth, type)	National Bureau of Soil Survey and Land Use Planning, Natural Resources Data Management System	1998	1:1 million
14.	Human settlement and Developmental projects	District administrators office		

*http://www.modis.gsfc.nasa.gov, #http://glcfapp.umiacs.umd.edu:8080/esdi/index.jsp

Data Analysis

Soil depth, soil type, soil permeability, road network and drainage network for the district are available in digital format. Digital elevation Model (DEM) would be generated using distance-weighted average, where weight equal to the reciprocal of the distance squared between two points. From generated DEM aspect, curvature and slope map will be generated. The mean annual rainfall distribution map will be generated by Kriging techniques based on weighted averages. These spatial layers will be integrated in GIS environment. Socio-economic survey will be conducted for collection of dates and frequency of landslide, to know the loss of life and property. The remote sensing data will be classified using supervised classification algorithm with training data and ground control

points. The land-cover map will be generated by using either slope based or distance based vegetation indices depending on vegetation cover in the region. All the data analysed will be given as input to fuzzy logic after assigning weights and on defining membership function. The output will be landslide susceptibility index. Using the computed index the values are mapped to produce and landslide susceptibility map. A training set consisting of the earlier landslides and the geographical information system-based multi-layer spatial data in the study area will be used to construct the prediction maps. The susceptibility map generated will be used for landslide risk management that helps in arriving at appropriate mitigation measures. This will help the development authorities and the conservationist in planning the activities required. Several different methods and techniques for evaluating landslide hazard and risk have been proposed or tested (Brabb, 1984; Carrara, 1989; Nieto, 1989). Operational and conceptual differences in the techniques used so far include: general underlying assumptions; the type of mapping unit selected for the investigation; and the techniques and tools favoured for the analysis and the hazard assessment. The model, therefore, works on the assumption that ''slope-failure in the future will be more likely to occur under those conditions which led to past and present instability'' (Varnes et al., 1984; Carrara et al., 1991; Hutchinson, 1995). As already occurred landslide are important, landslide are detected using digital image processing (image subtraction) and verified by field work. Soil and rock sample will be collected to conduct and compressive-strength tests, and consistency limits. The relationships between parameters will be analysed using statistical tools like, discriminant analysis, linear and logistic regression, Bayesian probability or weight of evidence and fuzzy logic (Juang et al. 1992; Binaghi et al. 1998; Ercanoglu and Gokceoglu 2002). The established relationships of parameters are mapped to generate landslide hazard zonation map.The susceptibility map generated will for can be used for landslide risk management and map helps in arriving at appropriate mitigation measures.

Facilities Available and Equipment to be procured: We need to purchase Remote sensing data (landslide detection), LISS data, PAN from NRSA (coinciding with the dates of landslides)
Equipment available with us: Inclinometer to measure the angles of slope and elevation. GPS (for training data collection), soil analysis kits, etc. are available with us. Equipments required for geological investigations would be borrowed from Department of Geology, University of Mysore.

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Task schedule (Important Milestones for research reviews/completion of tasks – Please indicate Milestones that will be presented at Annual in House Seminar): The proposed work would require time period of **36 months** from the date of commencement of the project.
Table 2: Time frame for the work.

		2007-08				2008-09				2009-10			
		Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar
1.	Reconnaissance Survey #	*											
2.	Literature review	*	*	*	*	*	*	*	*	*	*		
3.	Field visit	*	*	*	*	*	*	*	*	*	*	*	
4.	Data collection	*	*	*	*	*	*			*			
5.	Data analysis				*	*	*	*	*		*		
6.	Development of geodpatial model					*	*	*	*	*			
7.	Publications					*	*	*	*	*	*		
8.	Validation of Model								*		*		
9.	Sensitivity Model									*		*	
10.	Report generation				*				*			*	*

#: Reconnaissance survey was carried out during post monsoon period

Please Note:

1) Field visits during rainy season (June, July and August) will be restricted to two
2) Validation of the model requires field visits.

Deliverables (To include the interim and Final Technical report): Mapping, monitoring and Modelling techniques would be useful in mitigating hazards due to landslides. The susceptibility map generated will be useful in landslide risk management and also helps in arriving at appropriate mitigation measures. This will aid the development authorities in regional planning.

NVJ

CENTRE FOR ECOLOGICAL SCIENCES
Indian Institute of Science
Bangalore 560 012,

February 29, 2008

Prof. R. SUKUMAR
Chairman

Dear Colleague,

I write this regarding the preparation of the annual report of our activities for the year 2007-08 to be submitted to the Ministry of Environment and Forests.

I request you to adhere to the 4-page limit as previously.

It is highly desirable if the report is ready as early as possible, so that the monitoring committee meeting can also be held during April 2008, to make it easier for the MoEF to release the first installment for 2008-2009. Could you please hand in the report (one printout + msword files on CD ROM + by e-mail to office) by 31st March 2008?

Please also submit ONE copy of all your paper published during 2007 that are relevant to the work carried out at CES.

I look forward to your cooperation.

With best regards.

Yours Sincerely,

(R. SUKUMAR)

Encl: Annexure: 1 and 2

rl/CH

Telephone (O):91-80-23600382;22933102;
FAX: 91-80- 23601428; 23602280; E-Mail: chairman@ces.iisc.ernet.in

Annexure-1

LIST OF PROJECTS UNDERTAKEN BY CES DURING 2007-2008

Centre for Ecological Sciences
Indian Institute of Science, Bangalore

LIST OF PROPOSED PROJECTS TO BE UNDERTAKEN DURING THE XI FIVE YEAR PLAN PERIOD (2007-2012)		
Project No.	**Title of the Project to be undertaken**	**Faculty-in-charge**
	THEME I: BIODIVERSITY AND CONSERVATION	
Project 1	Tropical Forest Ecology and Conservation in the Nilgiri Biosphere Reserve	Sukumar, R.
Project 2	Assessment of Carbon Stock and Vegetation Dynamics in Tropical Forests in Uttara Kannada District of the Western Ghats	Ravindranath, N.H.
Project 3	The Ecology of Invasive Species and their impact on Native Plant and Animal Communities	Kavita Isvaran and Sukumar, R.
Project 4	Characterizing Biodiversity of Uttara Kannada District, Western Ghats through Landscape Ecology and Geoinformatics	Ramachandra, T.V. & Joshi, N.V.
Project 5	Inventorying and Monitoring of Lentic and Lotic Ecosystems	Ramachandra, T. V. & Joshi, N.V.
Project 6	Monitoring of sea turtles in the Andaman and Nicobar islands and Orissa coast.	Kartik Shanker
Project 7	Patterns of Genetic Divergence among different Herpetofaunal Ecological Guilds in Central Western Ghats and their Consequences on Species Delimitation	Kartik Shanker
Project 8	Marine and coastal biodiversity	Kartik Shanker
Project 9	Ecology and Conservation of Asian Elephants	Sukumar, R.
Project 10	Biogeography and Taxonomy of Ants	Gadagkar, R.
Project 11	Acoustic Sampling as a Non-Invasive Tool for Identifying, Monitoring and Discovering Species of Nocturnal Insects and Mammals in Tropical Evergreen Forests	Rohini Balakrishnan

Project 12	Habitat Structure and Composition and its Relation to Orthopteran Insect Diversity and Species Composition	Rohini Balakrishnan
Project 13	DNA Barcoding of Taxonomically important Groups from South India	Praveen Karanth, K.
Project 14	Establishing Museum for Diatom	Ramachandra, T. V. & Joshi, N. V.
	THEME II: BEHAVIOUR AND EVOLUTION	
Project 15	Biology And Behaviour of Queenless Ponerine Ants	Gadagkar, R.
Project 16	Origin and Elaboration of Social Life in Insects	Gadagkar, R.
Project 17	Molecular Ecology and Biogeography of Social Wasps	Gadagkar, R.
Project 18	The Chemical Ecology of Species Interactions: Plants, Insects, and other Invertebrates	Borges, R.M.
Project 19	The Visual Ecology of Species Interactions	Borges, R.M.
Project 20	Behavioural Flexibility in Large Mammals: Linking Ecology, Demography and Behaviour	Kavita Isvaran
Project 21	Mathematical and Statistical Ecology	Joshi, N.V.
	THEME III: CLIMATE CHANGE AND ITS IMPACT	
Project 22	Past Climate Change in Southern India	Sukumar, R.
Project 23	Impact of Climate Change on Tropical Forest Ecosystems	Ravindranath, N.H. and Sukumar, R.
	THEME IV: HUMAN ECOLOGY AND ECODEVELOPMENT	
Project 24	Management of Non-Timber Forest Products for Biodiversity Conservation and Peoples' Livelihoods	Ravindranath, N.H.
Project 25	Energy Policy Analysis and Prospects of Renewable Energy Resources	Ramachandra, T.V.
Project 26	Bee Keeping in Western Ghats, Karnataka	Gadagkar, R.
Project 27	Popularisation of the work of CES	Faculty

Annexure - 2

Format for Preparation of Reports

1. Title
2. Duration
3. Authors
4. Summary (½ page)
5. Objectives (½ page)
6. Methodology (½ page)
7. Results (½ page)
8. Discussion (½ page)
9. Tables and Charts (one page)
10. Recommendations }
10. Publications } ½ page
11. Degrees awarded }