DISASTER RISK AND VULNERABILITY CONFERENCE 2017

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DISASTER RISK AND VULNERABILITY CONFERENCE 2017 DRVC 2017

DRVC 2017

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29 - 31 March 2017

Proceedings of the 3rd Disaster Risk and Vulnerability Conference

Joice K Joseph, Karunakaran Akhil Dev, Asharose Naveen Babu and A.P. Pradeepkumar
Editors

Disaster, Risk and Vulnerability Conference 2017

Proceedings of the Third Disaster, Risk and Vulnerability Conference
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K. Joice Joseph, Karunakaran Akhildev, Asharose,
Naveen Babu and A. P. Pradeepkumar
(editors)

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Preface

The Disaster, Risk and Vulnerability Conference (DRVC) 2017 is an outcome of the interest that was generated and the requests for a repeat of the first DRVC, which was held in the School of Environmental Sciences (SES), MG University, Kottayam, in March 2011 and the second which was held in the Dept of Geology, University of Kerala in 2014. The world has witnessed a series of disasters over the intervening period and displacement, migration and humanitarian crises has evolved into the most devastating of disasters today. Each disaster brings upon us the onerous task of conducting a post-mortem, and inevitably the harsh reality of lessons not learned becomes evident. It is in this context that conferences like the DRVC gain importance as avenues where practitioners from diverse areas that touch upon disasters could come together and listen to each other, share ideas and experiences and discuss possible success stories that could be replicated elsewhere. The papers in this volume range from those utilizing technology to tackle disasters or mitigate their effects to those that look at post-disaster interventions, community-based adaptation strategies to GIS-based disaster management strategies. The University of Kerala is thanked for sponsoring the conference. The Kerala State Council for Science Technology and Environment (KSCSTE) has been very quick to approve the proposal for the DRVC2017, as also the Kerala State Disaster Management Authority (KSDMA). On behalf of the Organizing Committee I extend my sincere gratitude to all of them. The Institute of Land and Disaster Management of the Govt of Kerala (Dept of Revenue) is thanked for extending its support for the conduct of the conference. The School of Environmental Sciences, Mahatma Gandhi University is a partner in this conference as also the Advanced Centre of Environmental Studies and Sustainable Development (ACESSD) an Inter-University Centre of the MG University, and the NGO the 'Centre for Humanitarian Action and Emergency Response Training (CHAERT)'. Dr AP Thomas of ACESSD is specially thanked for planting the seed of the DRVC in the organizers in 2010. I thank all the staff, and the students of the Dept of Geology, University of Kerala and SES, MG University for their active involvement and cooperation which has helped in the planning and execution of this event. I thank all my former students at the SES, MG University who have always supported my in my academic endeavours. Finally, I thank all the delegates who have send in their papers and have gathered here from far and near, for their support and presence. I wish all of you a pleasant stay in Trivandrum and days of fruitful discussions in the conference, and hope to meet all of you again in the next DRVC.

Dr AP Pradeepkumar
29 March 2017

Specific disaster management system at district level: review of Sabarimala pilgrimage, Kerala, India in administrative perspective

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Introduction

The objective of administration and governance is to deliver the services effectively to the community. Disasters are one of the uneven phenomenons that cause lag in the fruitful delivery of products or services in such a system. The disaster management mechanism for the crisis free conduct of Sabarimala pilgrimage is being discussed and analyzed here. Though the relief centric approach in disaster management has changed to pre-disaster centric approach, it further requires fine tuning for its effective execution. India being a land of rituals and religions, there are number of institutional mechanisms that exist to serve the pilgrimage. Sabarimala is one of such destination in South India where millions of pilgrims visits the shrine every year, which is situated in dense forest in Pathanamthitta District, Kerala State. The major pilgrimage season here lasts for 60 days which is the *Mandala-Makaravilaku Pooja* that falls in middle of November to mid of January, receiving pilgrims from various states of India and from other countries as well. Though the temple welcomes pilgrims from all religions, most of them are Hindus. Women in the age group of 10–50 are not allowed in the temple.

Role of Administration

The Travancore Devaswom Board (TDB) is the government setup that caters all needs of the temple administration. It is the constitutional mechanism comprising of three board members including a Chairman. The general administration is carried out by the Devaswom Secretary as Government Official, Devaswom Commissioner and such other officers who looks after the day by day affairs of the board. The District Administration plays a key role in Sabarimala pilgrimage and alleged mechanisms like coordination among stakeholder departments, food, water, sanitation, waste management, crisis management etc. Police is the main agency in Sabarimala for maintaining safety and security, law and order, people and vehicle management etc. Fire and Rescue department, Health, Motor vehicle, Irrigation, Forest, Armed forces, Electricity Board, BSNL, Food Safety, The Ayyappa Seva Sangham are other key stakeholder agencies who perform the duties during the pilgrim season.

Updated Disaster Response Mechanism

The temple had witnessed many emergency situations in its past, including fire emergencies, explosion of gun powder, landslides, stampede, flood etc. The district administration inter alia the District Disaster Management Authority (DDMA) is taking key role in disaster response. The DDMA is the constitutional setup established through the Disaster Management Act 2005. The updated disaster management mechanism explains itself as the body of policies, administrative decisions and operational activities pertaining to all phases of a disaster. DDMA engages in the Disaster Preparedness, Disaster Mitigation and Disaster Response during the pilgrim season. DDMA conducts safety walk, an assessment for hazard identification, usually takes place two months before the season every year. It is a joint inspection which includes all the stake holder departments. On the basis of the report obtained from the safety walk, the DDMA proposes mitigation activities and assign responsibilities for risk reduction accordingly. Recovery mechanisms, crisis management plans etc are established during the period. As a result, crowd management mechanisms are established. A check list of resource inventory is identified before the season

and is made available to Emergency Operations Centers (EOCs). Weather and allied satellite inputs are being analyzed in EOC frequently along with hourly crowd flow data. EOCs are equipped with different types of communication systems. Warning for flood hazard and other natural phenomenon are disseminated to field staff from EOC. Technically sound staffs are deployed to operate these systems. Alerts are being communicated to stakeholder departments through SMS, E-mail, Whatsapp group, telephone – fax – hot line, wireless and live telecast systems. On receipt of message the stake holder department's nodal officers on disaster response assembles at EOC and reports to incident commander. If any emergency occurs, collective decisions are being taken and directions are issued accordingly.

The shortcomings and recommendations.

- The safety walk is carried out every year as a preparedness activity. All the recommendations are being presented to DDMA for taking steps. But the implementation of recommendations is not being carried out especially the long term proposals, though a few are getting addressed. The next year the same hazards are being reported for mitigation. Hence proper long term plans are required.
- Though the crisis management plans are prepared, the stakeholders are not thoroughly aware about it. Mechanism has to be established by the disaster management authority for awareness creation among the deployed human resources at various levels.
- The crowd management tethering is a manual process which need to be automated to minimize the errors and to increase the decision making speed.
- Updating of resource inventory is to be carried out prior to the pilgrim season involving disaster management professionals.
- The available weather predictions involve regional or district level forecast. It needs to be done available locally.
- The EOC functions efficiently during the season. The facilities provided to the staff of EOC are so pathetic that the unhygienic environment could tamper the health and allied issues may affect the functioning of EOC.
- A number of sophisticated communication equipments have been deployed in the EOC. To meet the special requirements for installation of equipments, a lack of staff and decision maker has been identified/can be seen in the existing mechanism. Utmost priority should be given to address the issue.

Conclusion

The implementation of disaster risk reduction activities requires extreme monochromatic attention and wisdom in Disaster Management. Hence, if qualified personals are appointed, the efficiency of the system will increase. Disaster Management Cell associated with DDMA at district level is proposed to carry out the aforesaid activities catering the needs of the millions of pilgrims visiting the shrine every year. The responsibility before six months can have implementation of plans, preparedness activities, preparing and updating resource inventory etc. During the season, the team can function as a specialized entity for coordination, warning, response and relief. After the pilgrim season, the team could produce an evaluation report on the basis of the challenges met by every officer of the field. Thus the activities enlisted (classic) disaster management cycle could easily be materialized.

Key Words: Disaster, Sabarimala, DDMA,Disaster Response Mechanism

Effectiveness of multimedia on achievement in disaster management of CBSE students at secondary level

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Introduction

Man learns something every day and every moment. His entire life is education. Hence education is a dynamic and continuous process. It is concerned with ever growing society. Hence it is still in the process of evaluation (Walia, 2003). Learning provides a key or structure to one's personality and behavior. An individual starts learning immediately after his birth or in a strict sense even earlier when in the womb of the mother (Sharma, 2002). Innovation pedagogy is "a learning approach focused on the development of innovation competences, defining how knowledge is assimilated, produced and used in a manner that can create innovations". The teachers often continuously talk for an hour without knowing students responses and feedbacks. The material presented is only based on lecture notes and textbooks. There may be insufficient interaction with students in the classroom. More emphasis has been given on theory without any practical and real life time situations. It is the learning from memorization but not understanding and gives more importance to marks rather than result oriented. Innovative methods of teaching are a goal of many educators.

Need and significance of the study

The investigator hopes that the present study will be helpful to the school students, college students, B. Ed. trainees, teachers, professors and educationalists. The result of the study will reveal the importance of the applications of multimedia in teaching and learning process. Today, most of the people depend upon the applications of multimedia for educational purposes. It is very helpful to transact knowledge in an effective manner. And also it is very helpful to develop skills in multimedia.

Statement of the Problem

The present study is entitled as "Effectiveness of Multimedia on Achievement in Disaster Management of CBSE Students at Secondary Level"

Operational definitions of key terms

Multi Media: Multimedia is the technology engaging a variety of media, including text, audio, video, graphics and animation, either separately or in combination with computers to communicate ideas or to disseminate information.

Disaster: Disaster is referred to as a sudden accident or a natural catastrophe that causes great damage or loss of life. Oxford Dictionary (2013)

Disaster Management: Disaster management means managing resources and various responsibilities to deal with all humanitarian aspects of emergencies. This may include preparedness, response and recovery. The purpose of disaster management is to lessen the impact of disasters.

In this present study the investigator refers Disaster management to how one can manage and implement the action of plan with reference to earthquake, landslide, flood and anthropogenic disasters.

Objectives of the study

The major objectives of the study are,

1. To compare the effectiveness of Multimedia on achievement in Disaster Management with that of Conventional Activity method of teaching.

2. To compare the effectiveness of Multimedia on achievement in disaster management with reference to the following objectives: Remembering, Understanding, Applying, Analysing, Evaluating, Creating.

Methodology in brief

Experimental method was applied in this study. The study was conducted on a final sample of 50 students of standard 1X of two divisions of Lisieux English School, Vaikom. Each division consist of 25 students. The tools used were Achievement test in Disaster Management and lesson transcripts based on Multimedia and Conventional method of teaching. The two divisions selected were compared on the basis of their previous achievement in Disaster Management and one division was considered as experimental group and the other was control group. The experimental group was taught with lesson transcripts prepared on the basis of Multimedia assistance and control group was taught in the conventional way. The same achievement test was given as post-test to both groups. The data collected were used for statistical analysis.

Tools used in the study

The tools employed here for collecting data are: Lesson Transcripts based on Multimedia, Lesson Transcripts based on Conventional Activity method, Achievement test in Disaster Management.

Table 1. Consolidated results of Adjusted Means of the Post –test Scores of pupils in control and experimental Groups

Categories of objectives	Groups	N	Mx	My	My.x	T value	Level of significance
All categories together	Experimental	40	3.62	20.07	15.75	4.18	significant at 0.01 level
	Control	40	3.55	12.90	9.66		
Remembering	Experimental	40	0.28	2.18	0.01	5.5	significant at 0.01 level
	Control	40	0.22	1.37	0.04		
Understanding	Experimental	40	1.82	9.72	9.72	9.53	significant at 0.01 level
	Control	40	1.86	6.86	6.86		
Applying	Experimental	40	0.63	3.35	3.35	5.83	significant at 0.01 level
	Control	40	0.65	2.3	2.30		
Analysing	Experimental	40	0.28	1.57	1.57	7.18	significant at 0.01 level
	Control	40	0.27	0.78	0.78		
Evaluating	Experimental	40	0.3	1.52	0.02	6.21	Not significant at 0.01 level
	Control	40	0.27	0.65	0.005		
Creating	Experimental	40	0.28	1.71	0.01	7.7	significant at 0.01 level
	Control	40	0.26	0.92	-0.78		

Major Findings

The findings that emerged from the analysis of Pre-test and Post-test scores using the Test of significance are: The mean post-test scores of experimental group that was taught through Multimedia assisted learning is found to be higher than that of the Control group which was taught through conventional method. This shows the effectiveness in teaching Disaster Management with Multimedia assisted learning over Conventional method. The critical ratio of the mean value of post test scores of experimental group and control group indicates that experimental group has significant improvement in their achievement after the experiment. This indicates the advantage of Multimedia assisted learning over Conventional method.

The gained scores of the experimental group and control group, when subjected to the analysis of Critical Ratio showed that there is significant difference between their achievements in the gained scores. This data testifies the advantage of Multimedia assisted learning over Conventional method of teaching. The analysis of variance of pre-test and post-test scores of pupils in experimental and control group showed that there is no significant difference between the two groups. This also testifies the effectiveness of Multimedia assisted learning. The analysis of covariance of pre-test score and post-test scores of pupils in experimental and control groups showed that there is significant difference between the two groups. This implies that the experimental group exceeds control group in their achievement.

The t-value for adjusted mean achievement of experimental group and control group were found to be significant at 0.01 level. This reflects that adjusted mean achievement scores of the group taught through Multimedia assisted learning differ significantly from the adjusted mean achievement scores of group thought through conventional method. The adjusted means achievement of the students taught through Multimedia assisted learning gained significantly higher scores than those taught through conventional method.

Educational Implications of the study

- Students can explore more about the materials related to that study.
- Knowledge in multimedia may lead to motivation for learning.
- Students can update their knowledge with the help of internet.
- Multimedia assisted teaching may enhance the education of disabled children.
- Awareness in multimedia may help to improve the teaching skills of teacher trainees.

Conclusion

When a teacher designs an instruction plan for teaching, it is necessary to include not only the target goal of the unit but also other related goals determined by types of teaching tools and teaching materials. The purpose of Multimedia assisted learning is to study the effectiveness of teaching. The investigator believes that the findings of the study are helpful in improving the usage of multimedia for educational purpose.

The major conclusions of the present study are noted below:

1. Multimedia assisted learning of investigation is more effective than Conventional method of teaching on achievement in Disaster Management of secondary school students.
2. Multimedia assisted learning of investigation is more effective than Conventional method of teaching on achievement in Disaster Management under the category of objectives – Remembering, Understanding, Applying, Analyzing, Evaluating and Creating

Vetiver system *(Chrysopogon zizanioides)* applications in natural disaster reduction and environmental sustainability – a feasibility study

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Abstract

This work examines the scope of vetiver system as a natural solution for various environmental risk reduction activities. The Vetiver System (VS), which is based on the application of vetiver grass- a perennial grass of Indian origin (Vetiveria zizanioides L Nash, now reclassified as Chrysopogon zizanioides L Roberty), was first developed by the World Bank for soil and water conservation in the mid 1980s. It is a very simple, practical, inexpensive, low maintenance and incredibly efficient means of natural disaster reduction. The two case works in the study reported here documents the success of VS application in Kerala, India.

Key Words: Eco-DRR, Vetiver System, Disaster Case Studies

Introduction

Ecosystem Based Disaster Risk Reduction (Eco-DRR) is a concept to reduce the risk of being exposed to natural hazards by avoiding development of disaster prone areas as well as by using healthy ecosystems as buffers, to protect people's life and properties (Sudmeier and Ash, 2009). A well managed ecosystem can reduce physical exposure to natural hazards by serving as natural protective barriers and provide protection against common natural hazards such as floods and landslides (Dolidon, 2009) and these are also viewed cost effective and is a no regret investment (UNEP, 2012). The lack of identification and development of suitable flora systems is the main crisis in the recent Eco-DRR advancements.

The vetiver grass (Chrysopogon zizanioides) belongs to the Poaceae family and is a unique tropical plant of Indian origin that has been proven and used in some countries as the source of vetiver essential oil and many other environmental applications (Gupta et al., 2012). The vetiver is a very tolerant plant to the extreme climatic conditions such as prolonged drought, flood, submergence and extreme temperatures from -15ºC to +55ºC, wide range of soil pH from 3.3 to 12.5 without soil amendment and is highly tolerant to hazardous metals (Truong et al., 2008). DRR practices and environmental administration are not well connected in our country and there are not many strategic entry points and platforms for integrating environment and risk reduction initiatives.

Materials and methods

For the case studies, special attention was placed on the analysis of efficient risk reduction management mechanisms, in order to highlight the effectiveness of vetiver system techniques for dealing with the particular vulnerability. Detailed field visits were made in the month of May 2016 to Punchavayalkattu region of Neendoor Panchayath in Kottayam district and Tyford tea estate region of Elappara Panchayath, Idukki district, both in Kerala. Seasonal floods and landslips, respectively, are the major environmental hazards in these regions. Self report measures such as personal interviews and focused group discussions with local people, agricultural officers, and elected representatives of local governments, engineers and environmental specialists were carried out.

Results and Discussion

Table 1. Vetriver system: case studies

	Case study I: VS technology for the control of seasonal flooding and bund erosion in the elevated road section of Neendoor area in Kottayam district.	**Case Study II**: Use of VS against various natural hazards in Tyford tea estate region in Idukki district.
Background	Location 8°40′46″N 76°30′24″E This case study gives an overview of natural hazards in the region and success of VS based solutions for risk reduction.	Location 9°37′0″N 76°58′0″E This case study features protection of highland landscapes from hazards such as heavy soil erosion and landslips using VS applications.
Problem statement in the region	The area is low elevation, (0-5m above MSL) and recurrent flooding happens here every year during monsoon and hence the road needed to be raised by 3-5m. Due to the clayey instable soil type, severe bund erosion reported as a major problem in the province.	Soil erosion and land slips are the major problem in tea plantations especially in the replantation stage. Hilly slopes of Western Ghats and heavy annual rainfall are the other causative factors for these natural hazards. Every year huge property loss and environmental degradation take place here.
Measures implemented	The local self government in the area implemented a project named *Punchavayalkattu* and they planted Vetiver hedges along the 750m stretch of a road in 2005.	Vetiver was introduced to the Tyford tea estate in 2010 and planted as a contour hedge along the boundary portions.
Implications for Ecosystem-based DRR	The VS implemented portion of the elevated road is well protected from bund erosion and associated hazards.	The vetiver system successively prevented the soil erosion and landslip problem in the observed portion of the tea plantation. Vetiver hedges are not developed as a weed; rather it prevents the entry of weeds.
Lessons learned	Vetiver system is very efficient in preventing mud slip and soil erosion in the low lying areas. And the local communities are well aware about the applications of VS and are planning to apply it in their own farmlands.	The vetiver system could be used to replace mechanical engineering works such as contour bunding and have multiple environmental applications against soil degradation, loss of soil fertility as well as regarding ground water recharging and water quality enhancement

The vetiver grass focused on the current study has excellent Eco-DRR efficiencies. Successful application of the VS can reduce or even eliminate many types of natural hazards such as landslides, mud slides, road bund instability, and erosion (Smyle, 2000).The application of vetiver grass along muddy roadside (case study I) and in the tea plantation (case study II) are found to be very effective in order to prevent bund erosion and land slips respectively. Vetiver hedges used for protecting road embankments is cost effective, requires less maintenance and is labor intensive. The vetiver system has some limitations also such as in the establishment phase the vetiver grass is intolerant to shading and the Vetiver System is effective only when the plants are well established and needs a continuous monitoring post implementation.

Conclusion

The vetiver grass technologies can provide cost-effective and sustainable solutions to reduce the impact of a large number of natural hazards and disasters. Today authorities are looking for new solutions in DRR activities because conventional engineering approaches are insufficient, especially in a densely populated

tropical country like India. The VS applications is a long-lasting, cost effective, community- based and environment friendly bio- engineering tool for natural disaster mitigation and infrastructure protection.

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Hydrogeology, spatial patterns of resistivity, salinity and water management in a small tropical coral atoll island in the Arabian sea, western India

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Abstract

Small coral atoll islands are prevalent in the humid tropical regions of the world. Most are part of developing countries and have scarce natural land-based resources. In particular, the water resources of small islands are often very limited. Many have no surface water resources and rely on limited groundwater resources in the form of thin freshwater lenses. The exposure of islands makes them particularly vulnerable to natural disasters such as cyclones, floods and droughts. Pollution from population centers and other activities are an increasing problem. Owing to factors such as limited size, geology and topography, water resources in small islands are extremely vulnerable to changes and variations in climate, especially in rainfall, and with the rapid growth of tourism and service industries in many small islands, there is a need for both augmentation of the existing water resources and more efficient management of those resources that already exist. The dependency on rainfall increases the vulnerability of small islands to future changes and distribution of rainfall. In small islands, a freshwater lens can develop due to the recharge induced by rain. Magnitude and spatial distribution of this recharge control the elevation of freshwater and the depth of its interface with salt water. This paper explores the results of resistivity tomography applied on a small coral island, Amini, the most densely populated island in the U.T of Lakshadweep, India giving relevant information on lens structure. Cross validation of geo-electrical results and hydrogeological conditions showed that recharge exceeds water uptake in the dunes with little population/vegetation allowing lens to develop. Conversely in the low lying and populated/vegetated sectors, where water uptake exceeds recharge, the lens cannot develop and sea water intrusion occurs. It also addresses water resource planning and management issues and suggests approaches for resolving some of the major water resources problems in the island.

Key words: Hydrogeology, ground water, salinity, resistivity survey, water quality, ground water management.

Introduction

The Union territory (U.T) of Lakshadweep in India consists of 10 inhabited islands, attached islets, 4 narrowly formed islets and 5 submerged reefs. The islands are scattered in the Arabian Sea between north latitudes 08^0 00’ and 12^0 13’ and east longitudes 71^0 00’ and 74^0 00 (Figure 1). Amini Island is the sixth largest of the inhabited islands of the U.T. of Lakshadwep, with an area of 2.50 Km^2 and is elliptical in shape. Amini island is located between Kadmat and Kavarathi (in the N-S direction) and between Agathi and Androth (in the E-W direction) in a NE-SW alignment, about 11 km south of Kadmat island. It is 324 km west of Kozhikode and 407 km west North West from Kochi. It is located between north latitudes 11^0 07’ 00” and $11^0$08’00” and east longitude 72^0 44’ 00” and 72^0 45’ 00”

Population

As per 2011 Census statistics, total population of the island is 7661, out of which male population is 3829 and female population is 3832. The population density of the island is 2958 having the highest population density among the islands of the U.T and a decennial growth rate of 10.34% (between 2001 and 2011). The literacy rate in Amini Island is 92%.

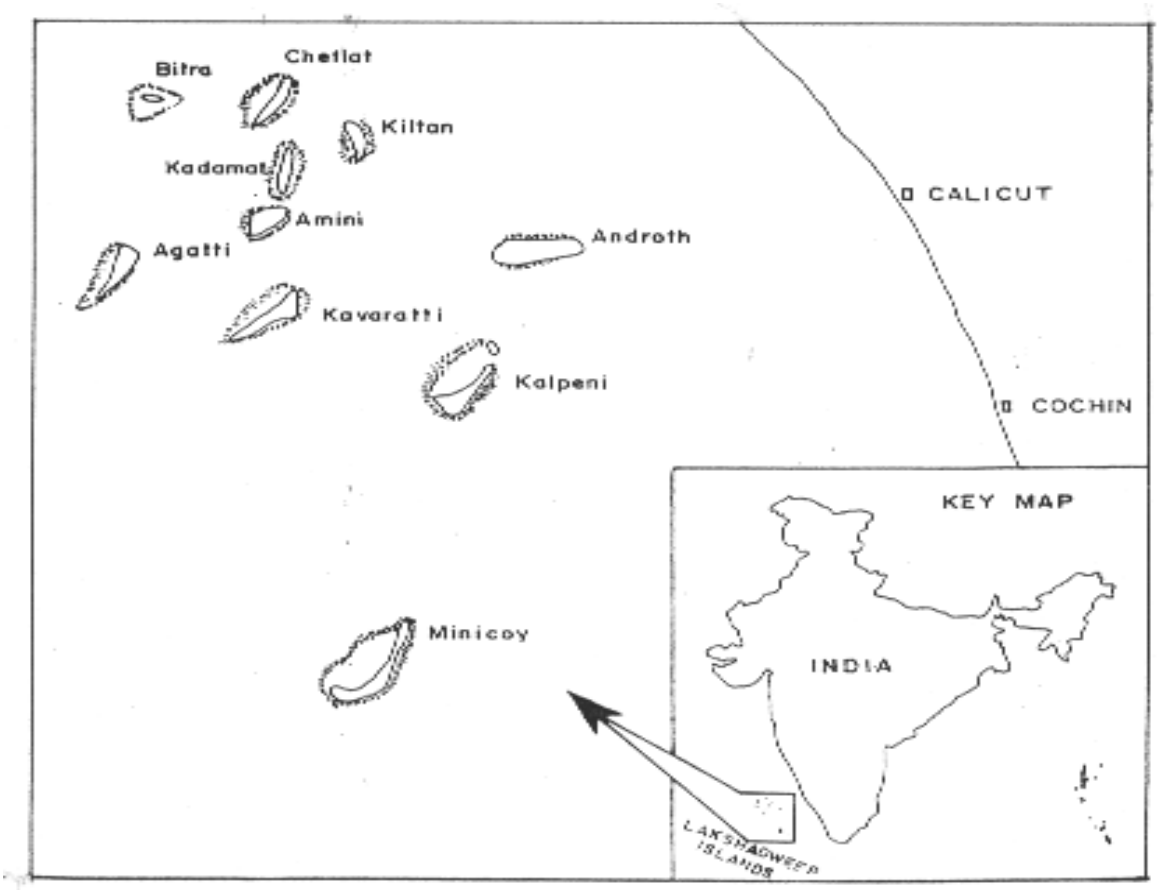

Fig.1. Location map of the islands

Physiography: The atoll has a northeast- southwest orientation with an island in the central part with well-developed reefs on the west and east sides with a narrow lagoon in between. Geomorphologically, the island has lagoon beach, storm beaches, beach ridges, sand dunes and hinterland. The island is generally flat with localized depressions and sand mounds, which are largely man-made. The island is situated on the eastern reef margin. The ground elevation of Amini Island is generally between 1 and 7 m amsl. The island is having a more or less flat topography with occasional sand dunes on the western side and storm beach on the eastern side. The storm beach consists of coral pebbles and boulders piled up above high tide level.

Climate: The island experiences a pleasant and equable climate throughout the year. The climate of the island can be described as tropical wet and dry as per Koppen climate classification. The various seasons in the island can be divided as

1	Winter:	*December* to *February*
2	Summer:	*March* to *May*
3	Monsoon:	1. Southwest monsoon - *June* to *September*
		2. Northeast monsoon - October to *November*

Temperature: The Amini Island has a humid climate with an oppressive hot season from March to the end of May. This is followed by the South-West monsoon which, continues till the end of September. October and November form the post-monsoon or retreating monsoon season. The North-East monsoon which follows extends up to the end of February, although the rain generally ceases after December. During the months of April and May, the mean minimum and maximum temperature are 26.8^0C and 33.1^0C

respectively. Temperature is low in the month of December and January and the mean minimum and maximum temperature are of 24.0^{0}C and 31.1^{0}C respectively.

Rainfall: The IMD maintains a weather station at Amini Island. The Amini Island has a normal annual rainfall of 1554.90 mm. A maximum of 70.6% percent of it occurs during the period of South -West monsoon, 17.8% is received during the North-East monsoon period and 11% is received during summer months. The annual variability of rainfall is 22.6%.

Soil: Most of the islands of Lakshadweep have a soil layer overlying coral limestone. The soils are mainly derived from coral limestone and include coral sands, lagoon sands and mud. From a ground water resource perspective, the relevant soil characteristics are: the rate of infiltration, the thickness and the moisture contents at both field capacity and wilting point. The soils over most of the island are highly permeable and allow rainfall to readily infiltrate, with the result that surface run-off does not occur except in local areas of compacted soils. In some areas of the islands of Lakshadweep, such as along the coast and around the lagoon, the soils are far less permeable and ponded water is often found after rainfall. These less permeable soils cover a small proportion only of the islands and it can reasonably be assumed from a water resources viewpoint that surface runoff into the sea or lagoon is nil.

Vegetation: From a water balance viewpoint, the vegetation in Amini Island can be classified as either shallow rooted or deep rooted. The shallow rooted vegetation which includes grasses, crops and shrubs obtain their moisture requirements from the soil moisture zone. The deep rooted vegetation consists of those trees whose roots can, where conditions are favorable, penetrate below the soil moisture zone and through the unsaturated zone to the water table. Coconut trees are a typical example of deep rooted vegetation in the islands of Lakshadweep. In relatively shallow areas, coconut trees typically have some roots within the soil moisture zone and some which penetrate to the water table. The significance of roots which can reach the water table is that transpiration can occur directly from the freshwater lens, even during drought periods. Vegetation of this type is referred to as phreatophytes and is common on coral atolls where the depth to the water table is typically 2 to 3 m. below ground level. Coconut trees have been reported to extend their roots to a depth of at least 5.5 m. There is no direct evidence to substantiate the rooting depth of coconut trees in island but it could reasonably be assumed that a proportion of the roots of coconut trees growing on areas of the islands where the depth to water table is 5 m or less can reach the water table.

Hydrogeological setting of Amini Island

Amini Island is located on the north-central part of the Lakshadweep archipelago. It is elliptical in shape and is oriented in a roughly NE-SW direction. Amini Island is quite unique by having a lagoon all around it unlike most of the other islands with a fringing reef on the eastern periphery and a lagoon on their west. The freshwater availability in this island is limited to central part, while it is brackish in the south western and north eastern parts (Fig. 2). The depth to water varies from 1.2 to 4.8 mbgl. and depth of wells range from 1.6 to 5.5 m bgl. There are 1050 domestic dug wells with a density of about 420 wells/ sq. km. The Amini Island is made up of coral reefs and materials derived from them, generally enclosing a lagoon (CGWB 1994). Hard coral limestone is exposed along the beaches of islands during low tides and also in well sections. Hard pebbles of coral limestone along with coral sand are generally seen. Beneath a thin layer of vegetal humus there is fine coral sand extending over the surface of all the islands. Below this is a compact crust of fine conglomerate looking like coarse oolitic limestone with embedded bits and shell, and beneath this crust there is another layer of sand. The coral sands and the coral limestone form the principal aquifer in all the islands. Ground water, existing under phreatic conditions can be found at a depth of less than 1 m to more than 4 m bgl. In the central part of the island, the DTW is generally less than 2 m bgl and the area is here and there marshy in nature. Majority of the area in the outer part of the Island, the DTW ranges from 2 to 4 m bgl and the north western part it is more than 4 m bgl .The ground water is seen as a thin lens floating over and in hydraulic continuity with the sea water. Large diameter wells are the most common and traditional ground water abstraction structures. In almost all the wells, hard coral limestone is exposed near the bottom. The sand below this hard layer has caved in most of the

wells. The hydrogeological map of Amini Island is presented in Fig. 3. The conceptual representation of fresh water lens and the vertical distribution of hydrogeological layers of a typical coral atoll island is presented in fig. 4 (Falklands,1993).

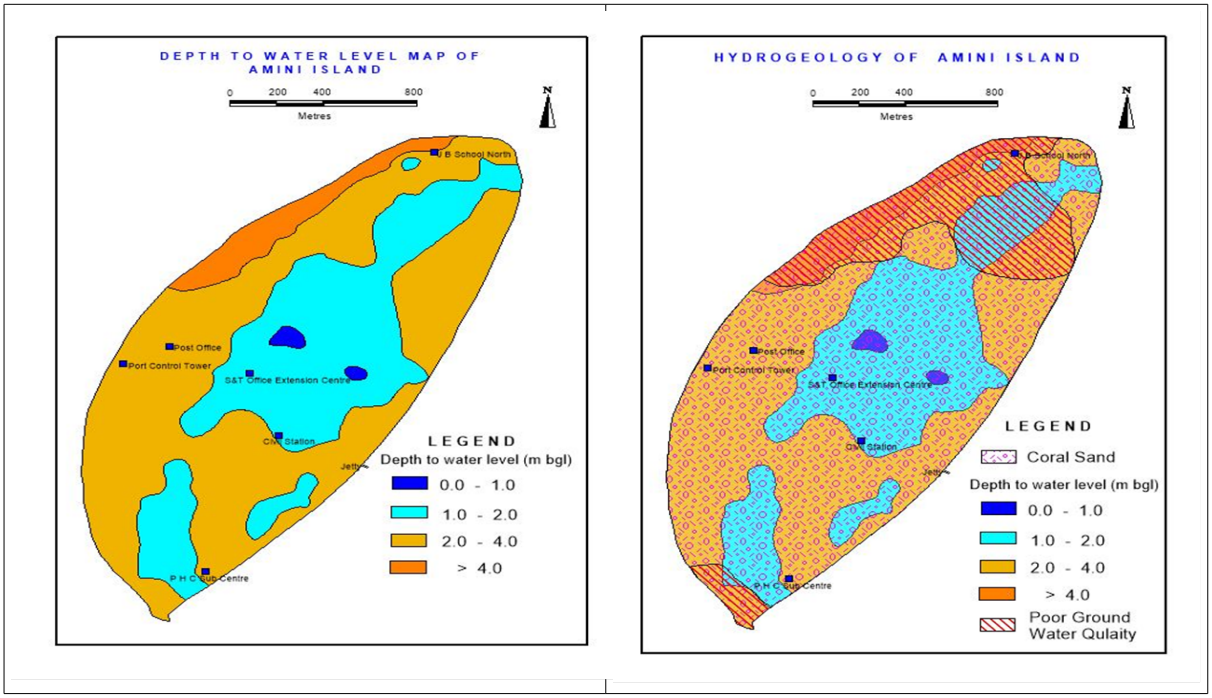

Fig. 2: Depth to Water level (mbgl) map of the Amini island **Fig. 3** Hydrogeological map of the island

The calcareous sands overlying these islands are highly porous and infiltrate bulk of the rainfall received. The infiltrating rainfall displaces the saline water to a freshwater lens due to density difference and the hydraulic continuity of ground water with seawater. There is no rejected recharge of ground water even during heavy rainfall. About 18 to 51 percent of the annual rainfall gets recharged into the ground water depending on the intensity, frequency and distribution of rainfall. However, the rise in water level due to recharge gets adjusted within the lens and hence appreciable increment in the water level is not observed. Rainfall received in the Lakshadweep Islands are fully recharged and adjusted in the fresh water lens, as a result of which significant rise in water levels are not discernible in the wells even after the monsoon rains. In most cases the thickest part of the freshwater lens is not in the center but is displaced towards the lagoon side. This is due to the lower permeability sediments on the lagoon side slowing down the mixing of the fresh water and sea-water, thus enabling a thicker fresh water zone to develop.

Coral atolls generally consist of a layer of recent (Holocene) sediments, comprising mainly coral sands and fragments or coral, on top of older limestone. An unconformity separates these two layers at typical depths of 10m to 20 m below mean sea level. Several deeper unconformities may exist due to fluctuations in sea level which results in alternate periods of emergence and submergence of the atoll. During periods of emergence, solution and erosion of the reef platform can occur, while further deposition of coral limestone can occur during periods of submergence. The upper sediments are of primary importance from a hydrogeological viewpoint as freshwater lenses occur solely or mainly within this layer. The occurrence of such lenses within this layer is due to its moderate permeability (Typically 5 to 10 m/day) compared with higher permeability of the older limestone (typically 50 to 100 m/day). Permeabilities greater than 1000 m/day occur in solution cavities within the limestone. These extremely high permeabilities allow almost unrestricted mixing of freshwater and sea water which is less likely to occur in the upper sediments. The upper unconformity, therefore, is one of the main controlling features of the depth of freshwater lens.

As the ground water is in hydraulic continuity with seawater, it is highly influenced by the diurnal tidal fluctuations of the sea. The magnitude of the tidal fluctuation is dependent on several factors amongst which the permeability of the aquifer material, the proximity of the site to the sea and the magnitude of tidal variation in

the sea play significant roles. There is a time lag between tidal fluctuation in the sea and in the ground water levels, which is also dependent on the above factors.

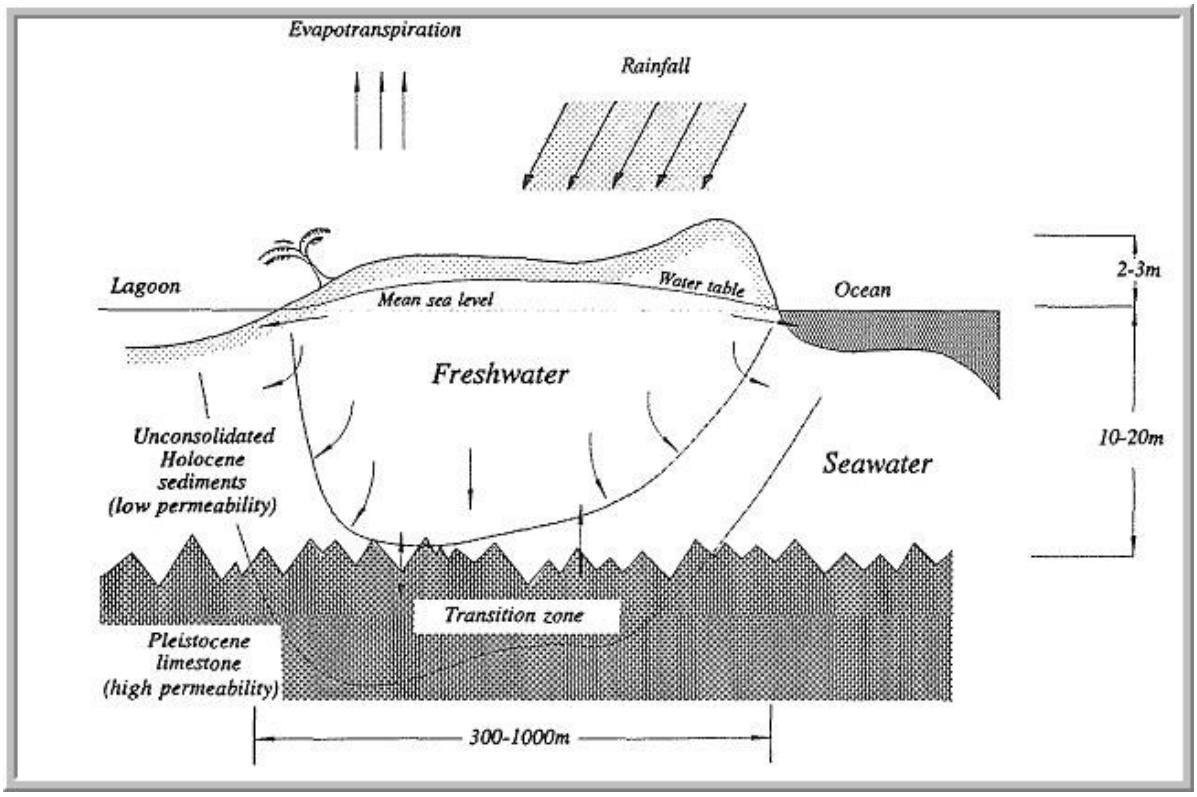

Fig.4. Freshwater lens in small Islands (Exaggerated vertical scale)

Sources of Water

The main source of freshwater in the island is ground water. Open, manually dug wells are the traditional method used by the islanders to obtain freshwater for their basic needs. As the depth from the surface to the groundwater table is generally just a few meters, and the soil is fairly easy to excavate by hand, open wells or pits, 1m to 2m in diameter, are excavated to depth of 30 to 90 cm below groundwater table. Almost every household is having a dug well which is mainly used for domestic purposes. Some are drawing water for coconut seedlings or for cattle breeding. The islanders have been conserving water by using step wells, ponds or tanks for washing and bathing purposes. But recent trend is to use small capacity centrifugal pumps mostly of 1/2 HP capacity for their domestic needs. The lack of surface and ground water storage capacity in this island, in spite of high rainfall, makes freshwater resources a dear commodity.

Quantitative Assessment of Water Resources

The dynamic ground water resources have been assessed by computing various components of recharge and draft. Rainfall is the only source of recharge in the Islands, whereas domestic draft, evapotranspiration losses and water loss due to outflow into the sea are the major components of draft. A part (20%) of the annual water surplus is reserved as buffer zone for reserve during delayed or deficit monsoon years. The computational details and island wise recharge figures are given in Table.1 (CGWB 2013).

Table 1. Computational details of groundwater in the islands

Total Resource (Water Surplus) (Ha.m))	**103**
Water loss due to outflow to sea (Ha.m)	**20.6**
ET loss from Trees for 6 non-monsoon months (Ha.m)	**27.8**
Balance available resource (Ha.m)	**34.1**
Buffer zone for reserve during delayed or lesser monsoon period (Ha.m)	**20.6**
Domestic draft @100 lpcd (Ha.m)	**27.9**
Gross Annual GW Draft (Ha.m)	**27.9**
Groundwater balance available (Ha.m)	**6.1**
Stage of ground water development	**82**
Category	**Semi critical**
Ha.m=Hectare meter Lpcd=Litre per capita per day	

Demand for water

The major demand for water in the village is to meet the domestic purposes. No major industries except few minor coconut based value added products manufacturing units in the northern part. The domestic need of water in the island is affected by increase in salinity during prolonged period of drought in the wells during summer seasons especially in the March-May months. The Island even faces difficulty in catering the domestic needs during these months and are managed by supplying water the in existing two infiltration galleries (radial collector wells) located in the central part of the island. The major cause of shortage is assessed to be the high rate of saline ingress in wells due to mechanized pumping and increase in demand for non-domestic purposes like construction activities and pollution due surface sources like septic tanks and waste disposal sites. The total population of the island is 5404 nos., and the total annual draft for domestic use is calculated as 27.9 ha m.

From the rough estimate of the ground water resources available in the island it is identified that the total groundwater resources available in the island is about 34.1 ha m. and the total draft is estimated to be 27.9 ha m. Hence the stage of development of the groundwater resource in the island is about 82%. The existing arrangement for drinking water supply is only partially meeting the requirement by combined source of ground water and rainwater sources. The total number of rainwater harvesting tanks in the island is 459 and the number of wells identified for water supply is 4. The number of overhead tanks are 2 and the number of ground water sumps is 1. Out of the total 1375 households in the island about 280 households in the poor groundwater quality area receives treated/non treated piped water supply through public taps. Village (Dweep) panchayath is responsible for supply and distribution of water. Grant and aid is provided by LPWD to Village (Dweep) Panchayath (VDP) for running and maintenance of the water supply scheme. LPWD water quality laboratory is available in the island for ensuring the quality of the distributed water. The domestic draft of the Island is found to be about 20 ha m. The major chunk of the total ground water draft is the island is contributed from domestic use.

Geophysical Investigations

The geophysical survey was conducted in February 2017 using an ABEM terrameter from ABEM Instruments AB, Sweden, with a 5 electrode spacing and a maximum AB spacing of 120 m. Measurements were taken with Wenner-Schlumberger array (a=5-30m; n=1-3) which has good signal-noise ratio (Dahlin & Zhou, 2004) and was sufficiently sensitive to the geometrical features of sea water intrusion in the coastal groundwater (Comte &Banton, 2007, Comte et al., 2010, Lambert Join et al., 2011). The maximum investigation depth achievable with this protocol was 40m below ground level. Measured resistivity was

spatially extrapolated using MAPINFO. The first geoelectric layer resistivity was varying in the range of 20-5483 ohm.m, and the thickness of this geoelectric layer is varying in the range of 0.4-3.4 m. The second geoelectric layer resistivity was varying in the range of 4-788 ohm.m, and the thickness of this geoelectric layer is varying in the range of 0.8-8.3 m., at about 1 VES (Amini10) the geoelectric layer was extending in nature. The third geoelectric layer resistivity was varying in the range of 1-122 ohm.m and the thickness of this geoelectric layer is varying in the range of 1.2-3.3 m., at about 11 VES the geoelectric layer was extending in nature. The fourth geoelectric layer resistivity was varying in the range of 3-5 ohm.m, at about 3 VES the geoelectric layer was extending in nature. The interpreted results were presented in Table 2. By considering the type of VES curves, resistivity, thickness of the geoelectric layers, Amini1, Amini6, Amini7, Amini8, Amini10, Amini14 & Amini 15 sites are represented that those are showing the Resistivity of <=22 ohm.m. up to a depth of 3m below ground level. The Location map of Vertical Electrical Soundings have been shown in the below Fig.5. Some of the examples of field curves at Amini-9 & Amini-13 has been shown in the below figures 6 & 7. The Resistivity of the curves in the entire area is showing that it is decreasing with increasing a-separation between adjacent Electrodes. The interpreted results of VES in Amini Island is presented in table-2

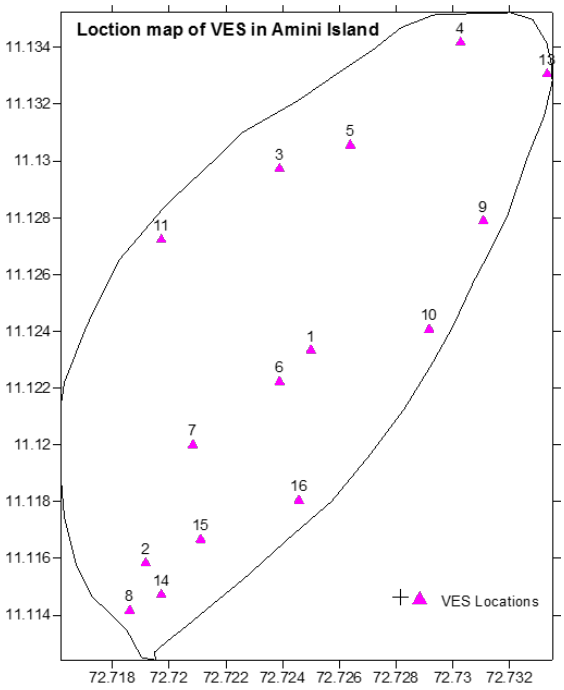

Fig.5. Location map of VES at Amini Island

Apparent resistivity distribution maps for different electrode separations (AB/2) have been prepared with the field data. The maps were prepared with AB/2 distance of 1, 2,4,6,8,10 and 20 m and are shown in fig. 8,9,10.11.12,13&14 respectively. Resistivity reduces with increasing current electrode separation. In fig 8, the variations in apparent resistivity obtained using half current electrode separation as 2 m, it was observed that the values were very high at almost all the locations, except locations 1, 6 and 15.The interpreted 1st layer thickness is less than 1 m in these locations and depth to water level is very shallow, less than 1 m bgl at location 6. The result indicates dry coral sand or rock present at the surface and the variations are due to the moisture content of the sand and also presence water table in different pockets. The apparent resistivity valve is low where water level is shallow and the formation is sandy and loose soil. The resistance will be more where hard stratum is available at the depth, even though the water is available. The resistivity reduces considerably when there is sea water mixing which is observed about 8 to 10 meters depth. In the western part of Island since the strata is hard shows more resistance even at 10 meters depth.

Structural characteristics of the aquifer

The geo-electrical imaging yielded resistance ranging from <5 ohm m to >300 ohm m. Resistance >50 ohm m corresponds to unsaturated coral sand above the aquifer water table. Two zones of brackish water with resistance ranging from 2-50 ohm m appear on each side of the island. In the middle part of the island the unsaturated zone contains brackish water. Resistane Pleistocene limestone was also identified at ~35 m below ground level. These resistance values are consistent with previous studies on similar atolls (Lloyd et al., 1981; Ajaykumar and Ramachandran, 1996; Comte et al., 2010; Narasimha Prasad 2011)

Spatial pattern of groundwater table

Groundwater levels were measured in the open dug wells. The measurements taken during February 2017 were used for the spatial interpolation studies by contouring the water level at 2 m intervals.

Spatial pattern of groundwater salinity

The ground water in the island is generally alkaline with a few exceptions. The Electrical Conductivity (EC) ranges from 500 to 15,000 µS /cm at 25 C. Higher concentrations of dissolved solids are generally seen along the periphery of the island and also close to pumping centres. The quality variation is vertical, temporal and also lateral. The quality is highly variable and reversible. It is also observed that the quality improves with rainfall. Other factors affecting the quality are tides, ground water recharge and draft. There is a vertical variation of quality due to the zone of interface and underlying sea water. Perforation created due to drilling or otherwise also affects the quality as it acts as a conduit for flow of sea water.

Table 2. Interpreted results of VES in Amini island, UT of Lakshadweep

Sl No.	Village Name.	Ves no.	Interpreted Results.								AB in m.	Depth to Water level below ground level,(m)
			Resistivity (Ohm.m.)				Thickness (m.)					
			r_1	r_2	r_3	r_4	h_1	h_2	h_3	Total(H)		
1	Amini	1	29	9	4	-	0.8	3.3	Ext.	4.1	60	1.60
2		2	3866	788	122	3	0.8	1.9	1.2	4.0	60	1.87
3		3	5483	574	74	4	1.6	1.3	3.3	6.1	60	3.31
4		4	982	250	23	5	1.7	0.8	1.7	4.2	60	2.56
5		5	2075	62	5	-	2.1	1.8	Ext.	3.9	60	2.90
6		6	20	8	3	-	0.9	5.7	Ext.	6.7	60	0.64
7		7	1035	22	5	-	1.5	8.3	Ext.	9.9	60	1.88
8		8	953	10	2	-	1.6	1.5	Ext.	3.1	80	2.75
9		9	1588	94	4	-	1.8	4.8	Ext.	6.6	90	2.28
10		10	1212	4	-	-	2.3		Ext.	2.3	90	2.55
11		11	920	75	4	-	3.4	4.5	Ext.	7.9	90	3.05
12		12	Not Interpretable								90	
13		13	1961	33	2	-	1.5	4.9	Ext.	6.4	90	2.10
14		14	532	13	1	-	1.1	4.9	Ext.	6.0	60	1.86
15		15	146	19	2	-	0.4	3.2	Ext.	3.5	60	1.74
16		16	1354	40	3	-	1.2	2.9	Ext.	4.1	60	2.10

$r_{1\ -\ First}$ layer resistivity in ohm.m. h_1 - First layer thickness in m.

Ext. - Extending with depth. VH - Very High.

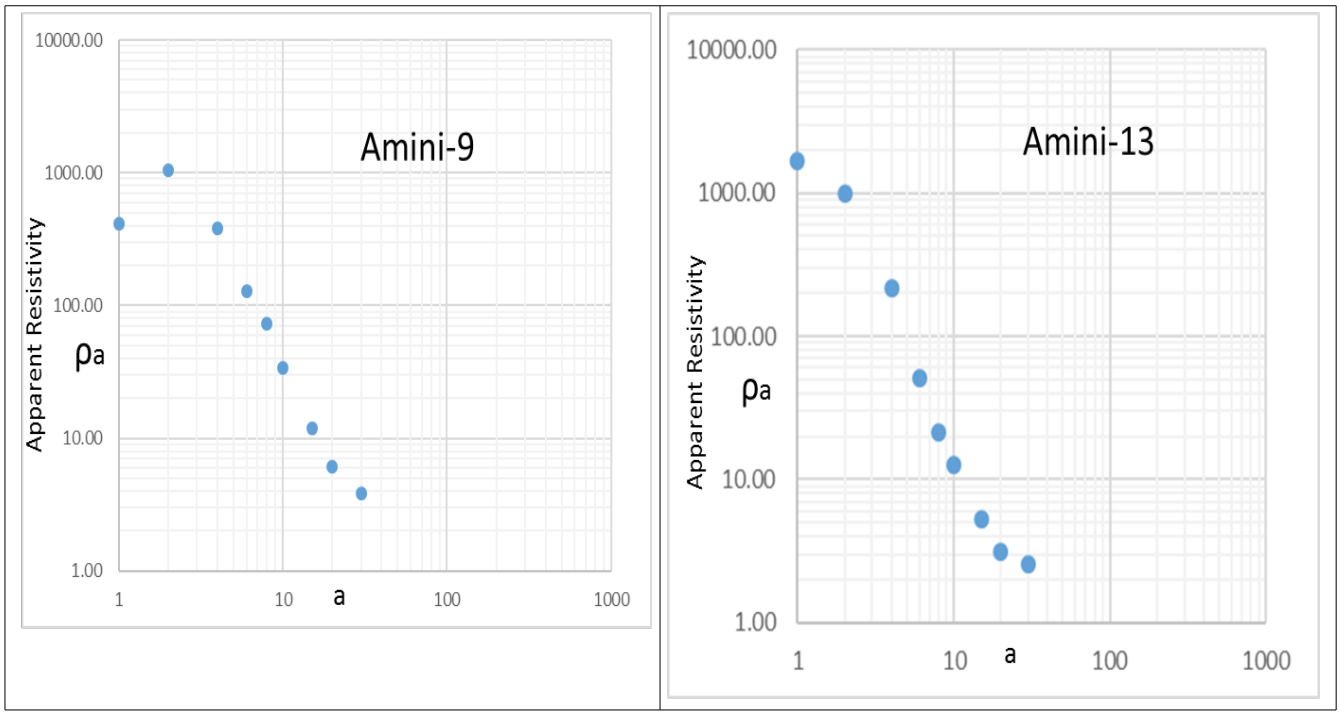

Fig.6, 7 Representation of field curve at location Amini-9 and Amini-13

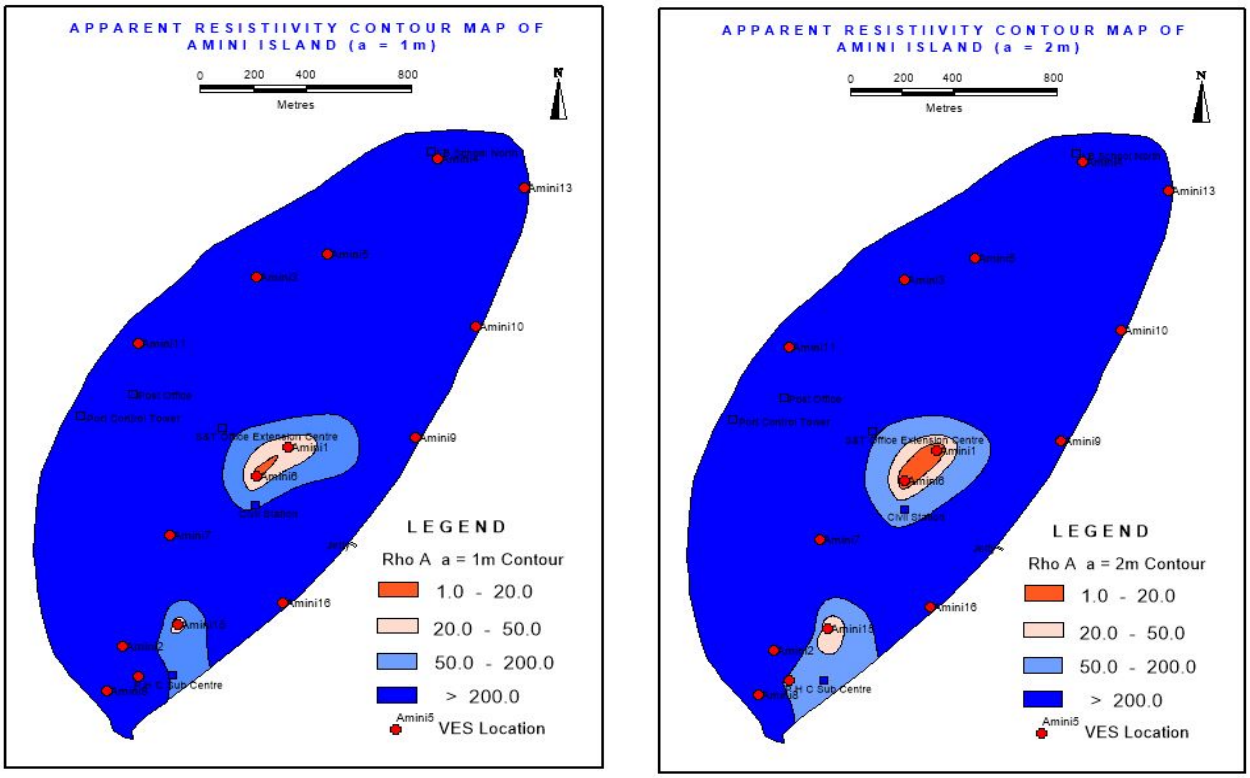

Figure 8, 9. Distribution of apparent resistivity at depth of 1 m below ground level and 2 m below ground level

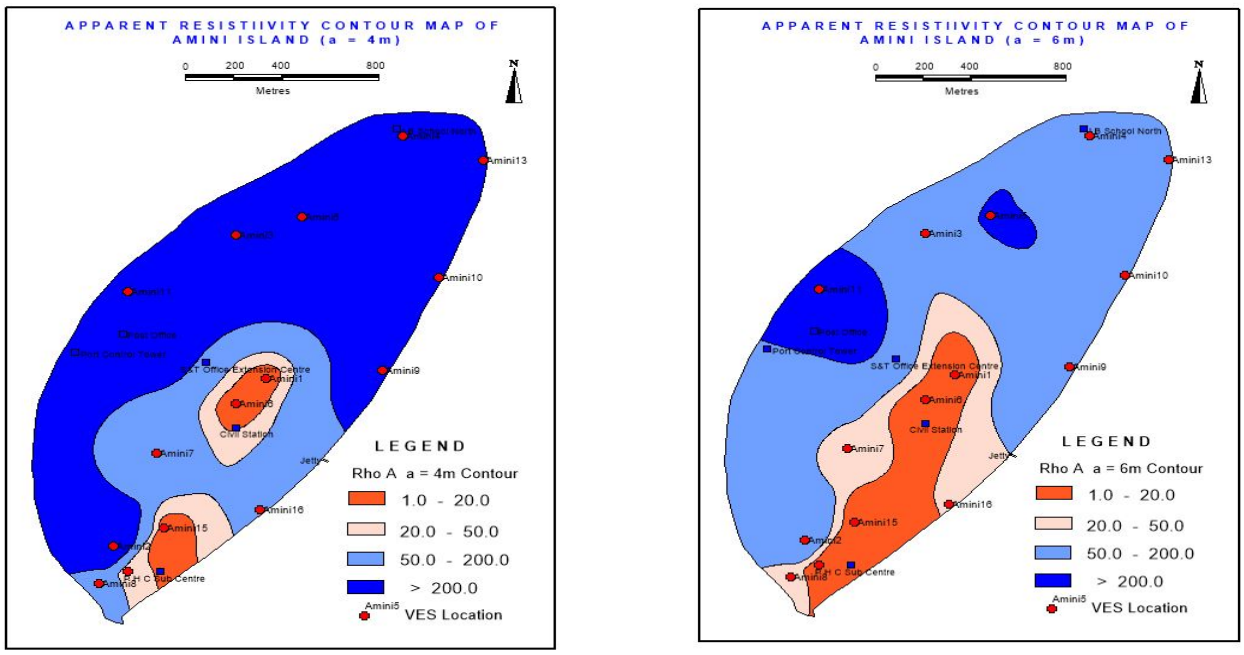

Figure 10, 11. Distribution of apparent resistivity at depth of 4 m below ground level and at depth of 6 m below ground level

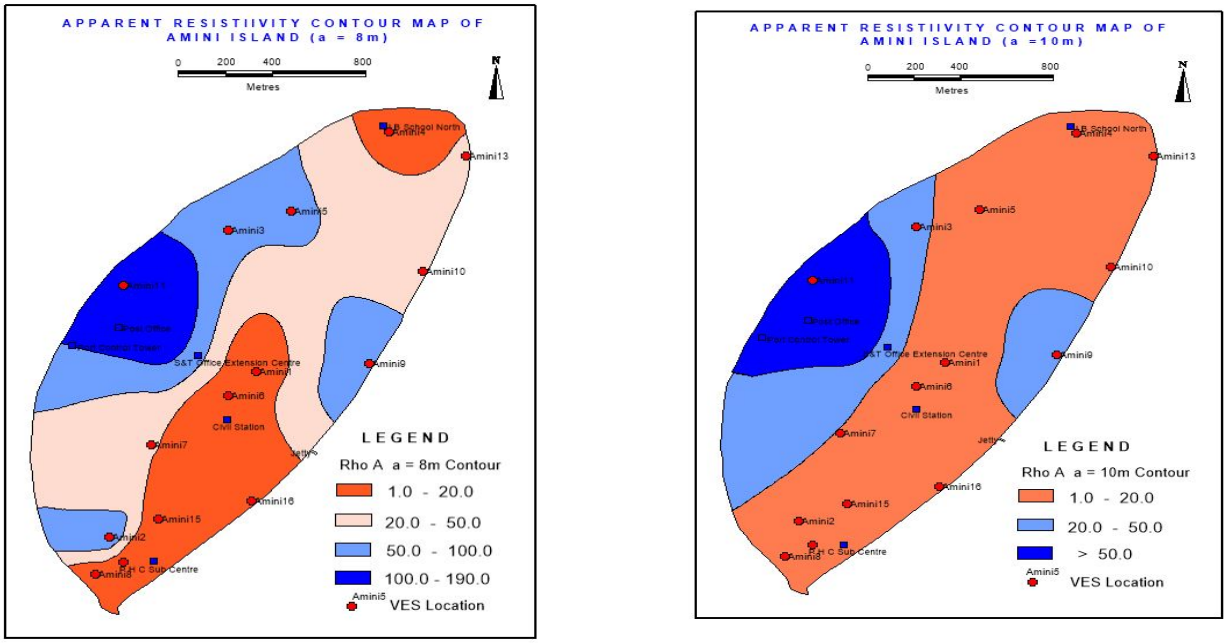

Figure 12, 13. Distribution of apparent resistivity at depth of 8 m below ground level and at depth of 10 m below ground level

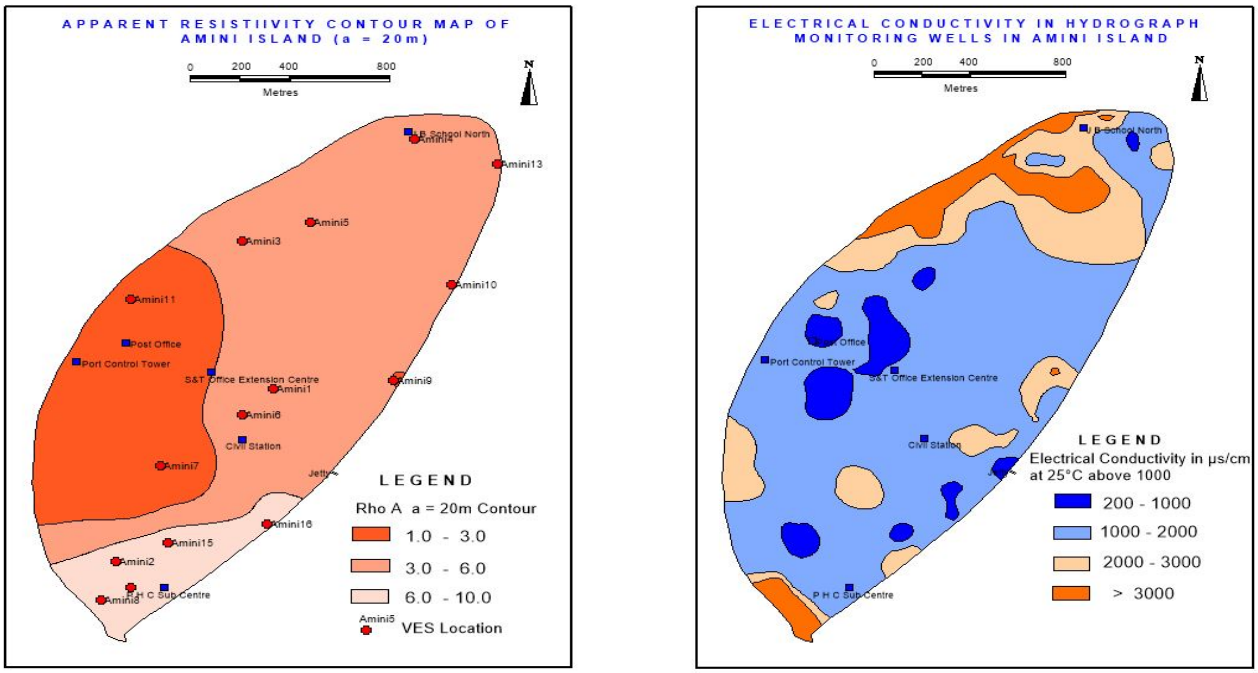

Figure 14, 15. Distribution of apparent resistivity at depth of 20 m below ground level. **15.** Distribution of electrical conductivity in Amini Island.

Figure 16, 17 Photograph showing hard coral limestone substratum existing at shallow depth and **17.** well tapping ground water below the sub stratum at shallow depth.

Wells manually operated retain more or less the same quality of ground water over longer time periods as compared to mechanized wells where, quality deterioration is observed in the form of increasing EC. Brackish water is present along topographic lows and in places where coarse pebbles and corals are present. Another major threat to ground water in the islands is the pollution. The human and livestock wastes, oil spills are the main polluting agents with sewerage and other biological wastes contributing most. The electric conductivity of groundwater samples was indicative of the presence of brackish water throughout the island, with values higher than standards for safe drinking water. The iso-conductivity contours clearly pointed to a decrease in salinity towards the center of the island (Fig.15). However this map manifested major difference from what would be expected in a Ghyben-Herzberg model. For example the northeast area showed a large inward saltwater intrusion and in the southern part there was a marked anomaly relative to depth to water level. In these sectors no correlation was evident between depth to water level and salinity of water**.**

Discussion

The complexity of the spatial distribution of the groundwater was confirmed by geoelectric imaging of the substratum. Despite the apparent homogeneity of this island geophyisical prospecting revealed stratified structuring of the aquifer. This is related to the presence of limestone bedrock reef encountered in dug wells in shallow depths in the south. The specific conditions of groundwater flow in these karstic terrains can locally modify the presence of salt wedge intrusion. The geo-electric spatial pattern shown in fig 14 & 15 confirms this substratum uplift in the south sector of the island. Geo-electric spatial distribution shows resistances ranging from <0.1 ohm m to >800ohm m. Resistances >50 ohm m appears at the top and bottom of water table. On the surface they corresponds to unsaturated coral sands, whereas at the bottom high resistances are interpreted as originating from limestone bedrock. Despite the presence of salt water, the low porosity of the carbonates increases resistance. Between these two layers the low resitances are associated with brackish waters with resistance ranging from 0.1-50 ohm m. The hydrogeological interpretation of the spatial pattern of the geo-electrical values is consistent with the salinity values measured in the dug wells. In accordance with the iso-salinity map, the spatial pattern reveals a very wide brackish coastal area in the northern part. To the south the less salty groundwater is related to the apparent upraise of the bedrock (Reef rock). The geo-electrical pattern also suggests new elements in terms of the island's geological structure. Vertical distribution of salinity shows much localized intrusions of salt water. The salt water interface is therefore far more complex than assumed in the theoretical model that is based on the assumption of a distinct interface between two immiscible liquids, freshwater of density 1 and sea water of density 1.25.

Management solutions

Estimation of the groundwater resources shows that a total available groundwater resource of the village is 34.1 ha m, and the demand is 27.9 ha m. This figure demands for further development of the source available in this island through rainwater harvesting and improving the quality of water in the poor groundwater quality area through suitable groundwater management practices. The inability to utilize the water available from rainfall and the lack of judicious management of available water resources are mainly responsible for the present water status of the village. The main thrust areas are the, rain water harvesting and creating awareness to the public which can bring a spectacular improvement in the quality of ground water and drinking water supply status of this island. For the development of the Island to water sustainable, the participation or involvement of every single islander is necessary. Participatory water management programs are to be strengthened and the following activities were identified suitable for the island.

Repair, renovation and restoration of existing and abandoned water bodies like well, ponds especially north western part of Island where hard strata existing at the shallow depth where normal rain fall infiltration is hindered due to the impervious nature of the stratum.

- Judicious use of ground water
- Construction of rainwater harvesting tanks
- Artificial recharge to ground water especially in poor ground water quality area/pockets and also in areas where hard substratum exists at shallow depth (Fig. 16 and 17).

- Control on pumping of dug wells with high power motors especially for construction purposes.
- Mass awareness programs
- Community based water monitoring
- Proper water budgeting (if possible on a daily time step)
- Proper plan for water allocation for different sectors as per priority

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Drying up of the hard rock aquifers of Trivandrum district, Kerala: A hydrogeological threat

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Abstract
Groundwater in the hard rock aquifers of Trivandrum district has been studied to characterize the groundwater potential and prospects. The study area is occupied by four watersheds (Ayirur, Vamanapuram, Karamana and Neyyar) and groundwater is one of the main sources of water for drinking and agricultural purpose. The groundwater scenario has been assessed by using the water table contour maps and groundwater level fluctuation maps based on the data obtained from 93 observation wells. The average water level in the region is 9 to 13 and 8 to 10 mbgl during pre and post monsoon seasons respectively. The deepest water level (20.21 mbgl to 26.67 mbgl) is recorded from places such as Chovvarapotta, Pazhayaucchakkada and Ozhukupara and shallowest water level (0.85 mbgl to 1.61 mbgl) is in places like Irumba, Punnamkarikkakam, Kathipara and Erattachira. The groundwater levels at Mangalapuram, Varkala and Kallambalam show declining trend at an alarming rate. Most of the dug wells go dry during summer months, though these wells show good water level fluctuation during rainy season. Detailed investigation during March 2016 and 2017 reveals that the depth of the vadose zone has increased considerably vis-à-vis with the lowering of water table and the district is now under the threat of severe drought. It is also observed that substantial quantity of groundwater is being lost as base flow. This base flow of groundwater makes the rivers and river lets, perennial in the area. The long term trend analysis shows that (ten years data), majority of the wells are showing declining trend (1.99 m/year) and this decline is attributed to the change in land use pattern in the area and less recharge from the rainfall. The rainfall analysis shows that there is not much variation in the rainfall pattern over the last few years. On the basis of mathematical projection the water level trends for the next ten years has been predicted. The data shows that the groundwater level in the district will decline further and most of the wells become dry during summer months by 2020. The analysis shows that the groundwater potential in the hard rock aquifer is depleting hence an immediate recharge measures have to be implemented in this region to arrest the declining trend of water table.
Key words: Hard rock aquifer, Groundwater potential.

Introduction

Groundwater has become immensely important and dependable source of water supplies in all climatic regions including both urban and rural areas of developed and developing countries (Todd and Mays, 2005). In general groundwater occurs beneath the surface under semi confined, confined or unconfined state. The groundwater availability varies from place to place and its distribution is not uniform. This is due to the variation of rainfall in different regions at different time and differences in geology and geomorphology of the terrain. The irregular distribution of groundwater and its over exploitation in certain areas are the main reason which leads to the scarcity of drinking water in many parts of the country (Jagannathan, et al., 2000). This study focuses on the status and groundwater potential of the hard rock aquifers of Trivandrum district, southern India.

Hydrogeology of the area

The study area lies between North latitudes 8^0 16′ 59″ to 8^0 46′ 59″ and East longitude 76^0 40′ 59″ to 77^0 15′ 59″ (Fig 1). The area falls in survey of India Toposheets 58 D & H and the area covered by hard rock is 1970 sq.km. As shown in the figure 1 the study area consists of four watersheds namely Ayirur (part),

Vamanapuram, Karamana and Neyyar (part) river basins. In which Vamanapuram and Karamana river basins falls completely within the study area and the other two river basins are partly within it. The study

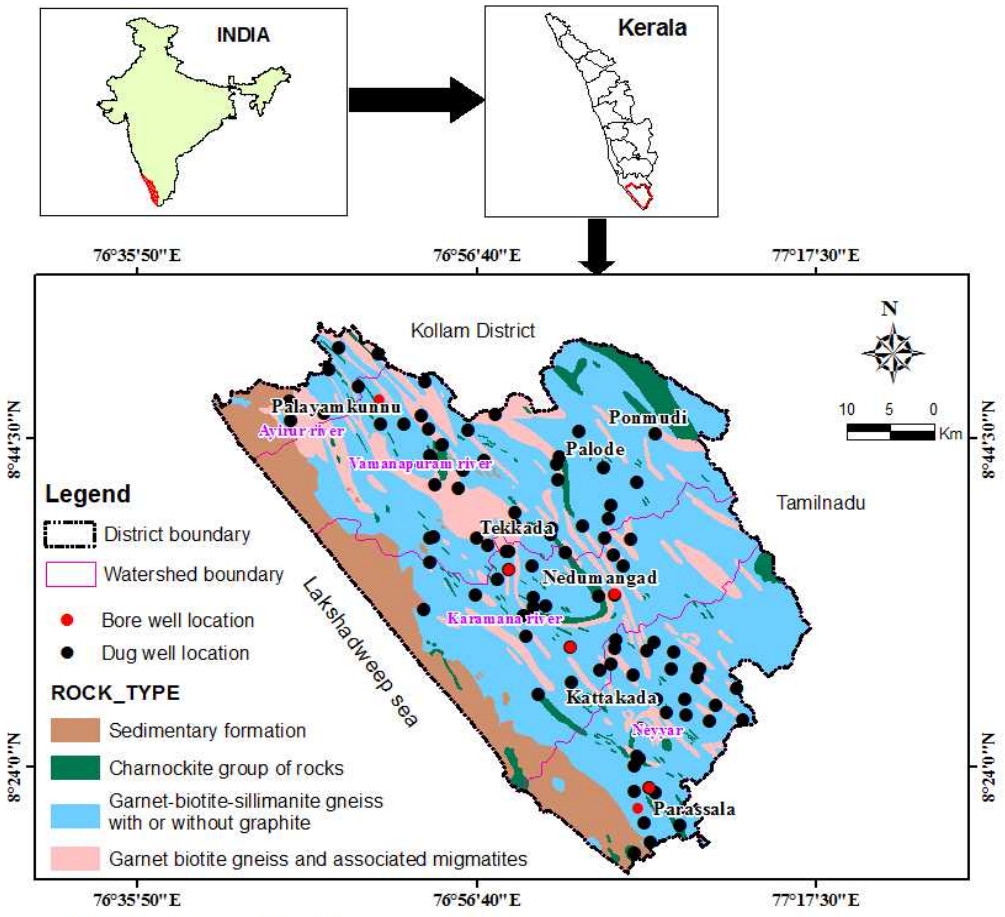

Fig. 1: Location map of the study area

area falls in the tropical climatic zone with a mean temperature ranges from 22°C to 34°C. The average annual rainfall is about 1643 to 3449 mm (CGWB, 2013). The occurrence and movement of groundwater is controlled by various factors like physiography, climate, geology and fracture patterns (Yousef, et al., 2015). The major aquifers in the study area are the weathered, fissured and fractured crystalline rocks. The formations of the area are grouped into the Precambrian crystalline rocks includes the charnockites, the khondalites, the intrussives and the granitoids and related rocks, the Tertiaries, laterite and the Quaternaries (GSI, 2005). The groundwater in these crystalline formations is found in unconfined and semi to confined conditions. The occurrence and movement of groundwater in this region is controlled by the secondary porosity in the crystalline rocks. Due to the variation in lithology and fracture patterns these aquifers are highly heterogeneous in nature. Groundwater occurs in phreatic as well as deeper zones in the weathered crystalline rocks and the fractured crystalline rocks respectively. The shallow aquifers generally occur within a depth of 25m. The yield of wells in these formations ranges from 6 to 12 m^3/day. The deeper fractures (between 50 and 80 m depth) in hard rock form major potential aquifers at places. The yield of wells tapped in deeper fractures ranged from 30 to 1200 lpm (CGWB, 2013).

Groundwater levels – present scenario

The groundwater occurs in unconfined condition in shallow aquifers, weathered crystallines and semi to confined condition in the deeper hard rock aquifers. The water level is monitored (pre and post-monsoon)

during the 2014, 2015 and 2016. For monitoring the water level, 93 observation wells (Fig. 1) were established. The deepest water level (20.21 mbgl to 26.67 mbgl) is recorded from places such as Chovvarapotta, Pazhayaucchakkada and Ozhukupara and shallowest water level (0.85 mbgl to 1.61 mbgl) is in places like Irumba, Punnamkarikkakam, Kathipara and Erattachira. Deepest water level between 17 and 26.67 mbgl is recorded in the Vamanapuram and Neyyar (part) river basins. The midland portion of the

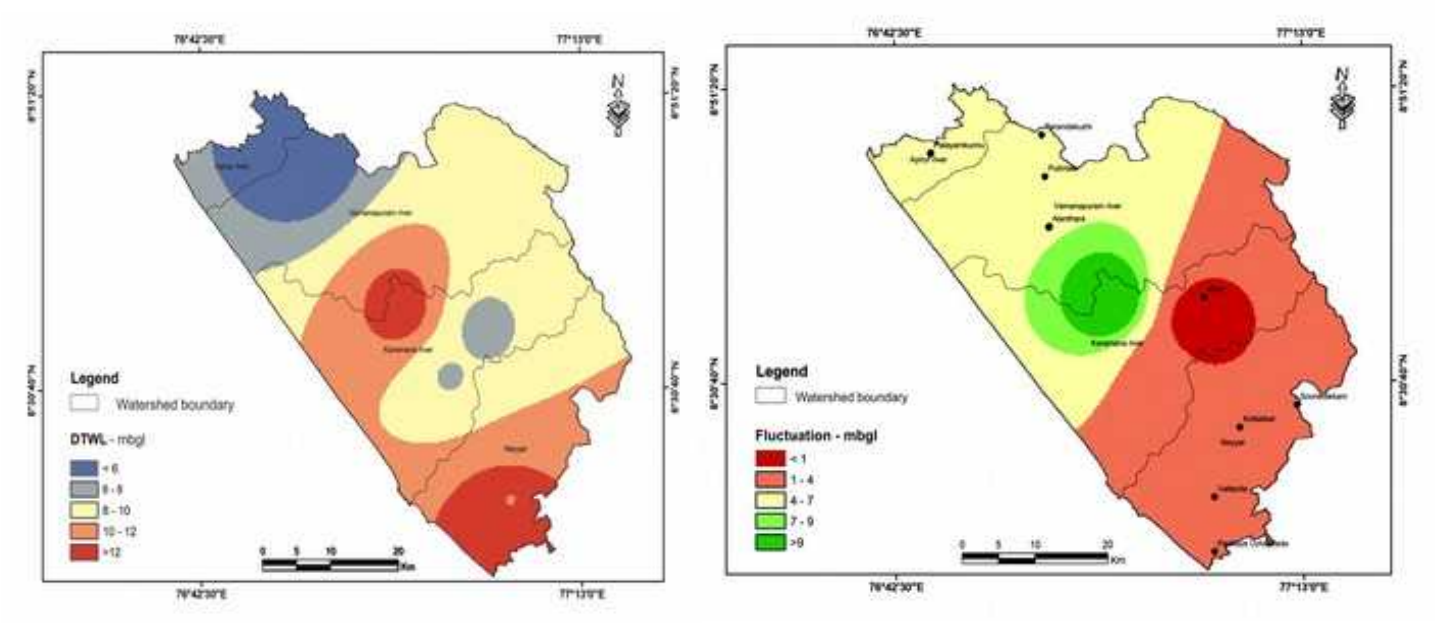

Fig 2a: Depth to water level during pre-monsoon season. **2b:** Depth to water level during post-monsoon season.

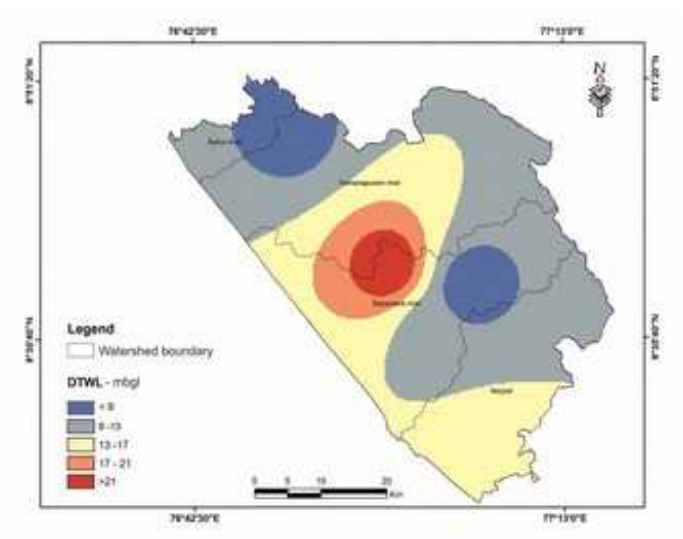

Fig 3: Fluctuation map

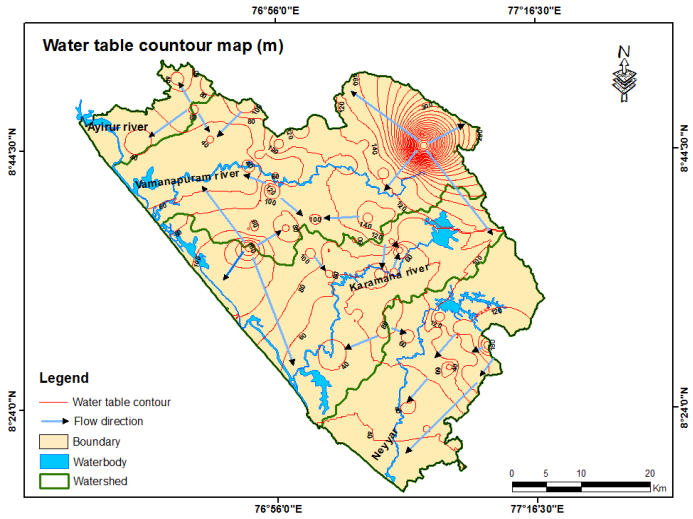

Fig.4 Water table contour map

basins record deepest water level compared to the highland regions. During post-monsoon the total scenario changes (Fig 2a & b). Figure 3 shows the fluctuation map. Fluctuation is maximum in Vamanapuram and Karamana river basins (4.47 and 4.39 mbgl)whereas the minimum fluctuation is recorded in the Neyyar river basin (-2.04 mbgl). The midland portions of Vamanapuram and Karamana river basins have maximum fluctuation, which indicates good recharge during rainy season in these areas.

Minimum fluctuation is observed from Kottakkal and maximum fluctuation is from Parandakuzhi. The northern part covering the watersheds of Karamana (part), Vamanapuram and Ayirur rivers shows better water level fluctuation, which indicates good recharge from rainfall than the southern part of the area. This may be due to the change in land use pattern in different watersheds of the area. The land use analyses show that the area is covered under rubber plantation, built-up areas, mixed plantations, double crops like kharif and rabi etc. Water table contour map (Fig 4) shows that the groundwater varies with the topography of the basins and is trans-boundary. The groundwater flow occurs across the watershed divides. The groundwater is flowing towards the major stream and there is a subsurface flow towards the ocean. The groundwater is lost as a base flow during summer season. Hence there is a decline in water level every part of the study area. The water levels monitored from the bore wells indicate that deeper aquifer water level ranges from 5.28 to 26 mbgl during pre-monsoon and 3.25 to 13.82 mbgl during post-monsoon. From the seasonal groundwater level, deepest water level recorded from Pazhayauchakkada and shallow water levels from Kathipara. About 7% of the locations show negative seasonal fluctuation, ie., the post-monsoon seasonal water level is lower than that of the pre-monsoon water level. This indicates the groundwater is not sufficiently recharged from the precipitation. Detailed investigation during March 2016 and 2017 reveals that the depth of the vadose zone has increased considerably and the district is under the threat of severe drought. The groundwater levels at Mangalapuram, Varkala and Kallambalam show declining trend at an alarming rate.

Groundwater level- long-term trends (past)

Long-term trend of the groundwater levels in the hard rock aquifers of the study area is studied using historical (ten years) data collected from Central Groundwater Board, Regional Office, Trivandrum. For analysing the long-term trend, water level data (10 years) of 15 dug wells were used. Hydrographs for pre-monsoon and post-monsoon water level were prepared. Figure 5 shows pre and post-monsoon water levels of different locations in the study area for ten years. The figure shows that there is continuous decline of

Table 1: The water level for the years 2004, 2014 and 2020.

Locations	Premonsoon 2004	Postmonsoon 2004	Premonsoon 2010	Postmonsoon 2010	Premonsoon 2020	Postmonsoon 2020
Kattakkada	5.66	2.48	4.84	2.77	5.73	3.76
Palode	3.8	8.28	6.19	2.96	4.27	1.14
Pangod	7.28	3.78	7.14	2.17	11.88	5.45
Vamanapuram	2.80	1.50	4.03	1.68	1.31	1.52
Ponmudi	4.17	3.67	4.14	4.00	3.8	3.89
Aruvikkara	4.72	1.62	4.30	2.40	14	2.73
Vithura	8.78	7.75	10.10	7.92	2.69	10.24
Maruthamala	8.65	6.15	8.12	6.02	7.43	7.06
Kallar	4.50	3.53	4.49	3.40	5.7	3.92
Nedumangad	9.56	7.77	10.57	7.83	9.89	11.71
Pothencode	12.32	8.83	10.34	7.48	6.56	11.53
Perunkadavila	10.78	9.97	13.51	12.45	17.54	13.57
Amboori	9.85	8.04	8.86	6.89	9.31	5.64
Kallikkad	3.30	0.75	1.90	0.75	2.76	2.65
Madavur	13.01	9.68	11.55	9.04	15.96	9.72

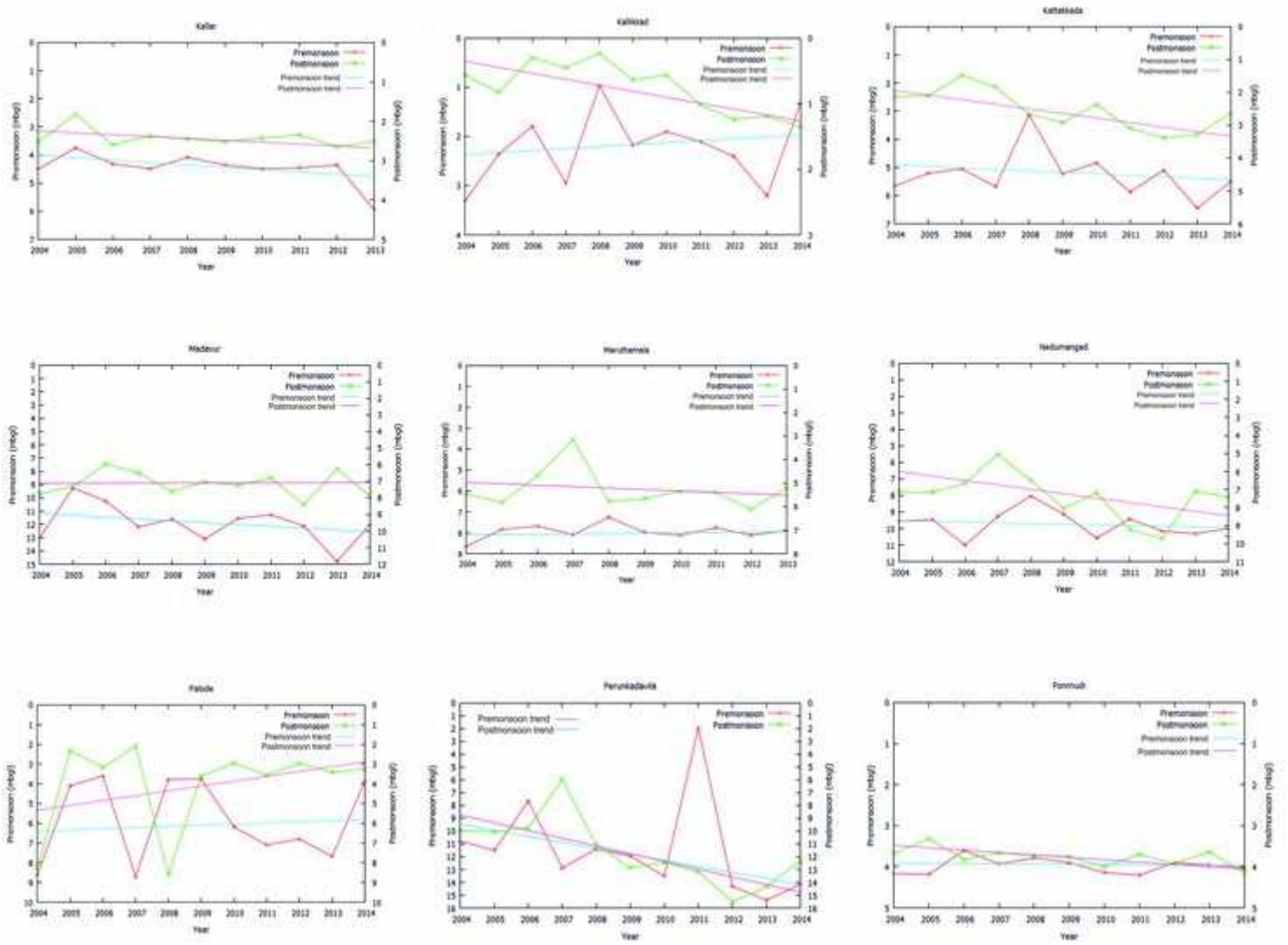

Fig 5: Pre and post-monsoon water levels of different locations in the study area for ten years

water levels in both pre and post monsoon seasons. Long-term trend of the water level depicts that the locations such as Vamanapuram, Perunkadavila, Pangod, Nedumangad, Kattakkada, Kallar and Aruvikkara show a rate of decline of pre-monsoon water level ranges from 0.5 to 6 mbgl and the rate of decline of post-monsoon season ranges from 0.4 to 4.9 mbgl. This shows that groundwater level has a decline trend in all river basins during pre-monsoon season. Water level in Palode shows rising trend with a rate of 0.6 and 2.3 mbgl during pre-monsoon and post-monsoon respectively. The long term trend analysis shows that (ten years data), majority of the wells are showing declining trend (1.99 m/year) and this decline is attributed to the change in land use pattern in the area and less recharge from the rainfall. The long-term trend of the water level shows a declining trend during post-monsoon season in most of the area indicates that there is no sufficient recharge occurs from the rainfall. This may be due to insufficient fracture patterns to enter the rainwater into the aquifer. Palode and Amboori are the locations with sufficient recharge occur where the post-monsoon water level shows a rising trend.

Groundwater future trends

This study has made an attempt to predict the future water levels and trend based on mathematical simulations. The future water level is determined using the software Eureqa. Eureqa is a mathematical software tool which uses symbolic regression to determine mathematical equations that describe sets of

data in their simplest form. Using symbolic regression this program can create accurate predictions (www.formulize.nutonian.com). The future prediction made by this software shows that the post-monsoon water level in the Vamanapuram and Karamana river basins (places Vithura, Nedumangad, Pothencode) will continue to decline further by the year 2020. The pre-monsoon water levels in all watersheds (areas include Pangod, Aruvikkara, Perunkadavila and Madavur) show a declining trend by the year 2020. The future water level and the water level of 2004, 2014 and 2020 are tabulated in Table 1. The maximum pre monsoon water level decline is expected in the areas around Aruvikkara (Karamana basin) and Perunkadavila (Neyyar basin) and post monsoon it is in Nedumangadu and Perunkadavila. The prediction shows that the water levels in the hard rock aquifers will continue to decline irrespective of the good rainfall received in the area. This may be due to the change in land use pattern, construction activities, paddy field reclamation and reduction in groundwater recharge due to clay filling in the fracture zones.

Conclusions

1. Hydrogeology of the hard rock aquifers of Ayirur (part), Vamanapuram, Karamana and Neyyar (part) river basins has been investigated.
2. The groundwater potentials and recharge characteristics are not uniform in all the basins. Groundwater is the primary source of water for domestic and agricultural use in all the basins. The present water level trends show that the midlands of Vamanapuram and Neyyar river basins record the deepest water level (up to 26.67 mbgl). The groundwater level fluctuation is more in the northern part of the area than that of the southern part. However the areas with deepest water levels in parts of Vamanapuram and Karamana river basins record highest fluctuation.
3. The water table contour map shows that the groundwater varies with the topography of the basins and is trans-boundary. The groundwater flow occurs across the watershed divides. The groundwater is flowing towards the major streams and there is substantial subsurface flow (base flow) towards the major rivers. The groundwater is lost as a base flow during summer season. Hence there is a decline in water level in most part of the study area.
4. The long-term trend shows that groundwater levels decline during post-monsoon season in Vamanapuram and Neyyar river basins. Whereas during pre-monsoon season groundwater level in the entire river basins show falling trend.
5. The future trend of the groundwater level is predicted using mathematical prediction software Eurequa. The future prediction shows that the post-monsoon water level in the Vamanapuram and Karamana basins (places Vithura, Nedumangad, Pothencode) will continue to decline further by the year 2020. The pre-monsoon water levels in all watersheds (areas include Pangod, Aruvikkara, Perunkadavila and Madavur) show a declining trend by the year 2020. The prediction shows that the water levels in the hard rock aquifers will continue to decline irrespective of the good rainfall received in the area.
6. The present study shows that the groundwater resources of the hard rock aquifers are depleting and lack proper recharge from the rainfall. This may be due to the change in land use pattern, construction activities, paddy field reclamation and reduction in groundwater recharge due to the blockage of fractures with clay minerals.
7. Intense artificial recharge schemes are necessary in the area.

Acknowledgements. We extend our sincere thanks to University of Kerala for the financial support for this work. We are thankful to Dr. Nandakumaran, and V Kunhambu, Regional Directors, and Dr N Vinayachandran, Scientist ‘D’ CGWB, Kerala Region for providing data and guidance. We also thank Dr. Satheesh Kumar, Department of Futures studies for his help in this work.

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Groundwater quality evaluation in and around Vembayam, south Kerala, India

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Abstract
Quality of groundwater in Vembayam and adjoining areas which is situated in the Trivandrum district, Kerala has been studied to assess its suitability for domestic use. Thirty three groundwater samples were collected and were analyzed for various physico-chemical attributes like pH, EC, TDS, salinity, TH, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-}, NO_3^{-}, SO_4^{2-} , PO_4^{3-} and HCO_3^{-}. Suitability of water for agricultural utility was also studied with the help of U.S.S.L and Wilcox diagrams. Values of most of these parameters except pH fall within the permissible limit recommended by BIS. Mean pH of water sample is 5.38. This observed low pH value might be due to the presence of laterite aquifer system, open waste dumping and extensive rubber plantation in the study area. The alarming observation is that the water available in the shallow aquifers in the study area is acidic in nature. Low pH can cause gastro intestinal disorders like hyper acidity, ulcers, stomach pain, burning sensation, etc in the users. In addition to this pH below 6.5 can cause corrosion in pipes, thereby releasing toxic metals such as Zn, Pb, Cd, Cu, etc. Proper water treatment mechanism is essential to neutralize the impact of acidic pH. It could be possible by alkali neutralization method by diluting groundwater with fresh rain water by adopting different rain harvesting method.

Key words: Groundwater, Vembayam , laterite, Acidic water

Introduction

Water said the eminent Greek philosopher Pindar, “is the best of all things”. Throughout history water has been considered a natural resource critical to human survival. More than two-thirds of Earth’s surface is covered with water. But most of the water is salty and most of the freshwater remain frozen in the Antarctic and Green land ice caps. Groundwater is stored in aquifer that can be confined or unconfined and represent about 96% of earth unfrozen fresh water. Any change in atmospheric precipitation inevitably influences the groundwater regime, resources and quality. Water is a natural resource and an absolute necessity for the survival of living beings. Groundwater is an important source of water for domestic and agricultural purposes. There has been tremendous increase in the demand for fresh water due to the growth of population. Quality of groundwater varies from place to place. Therefore, groundwater quality assessment studies, is equally important as its quantity. Increasing population, rapid industrial developments and excessive and continuous use of fertilizers and pesticides in agriculture has damaged the quality of groundwater. In addition to this as groundwater is a powerful solvent that dissolves minerals in rocks with which it draw closer contact. For ample provision of good quality water, regular monitoring of groundwater quality is essential.

In this work an attempt was made to assess the groundwater quality in and around Vembayam area with the aid of geospatial tool. The present study has been undertaken with a view to understand the geology of the area, to embark on hydrogeological analysis of groundwater to comprehend the quality of water in the area and also to study the spatial variation of groundwater quality. The proposed study area lies in and around Vembayam and Mannanthala in Thiruvananthapuram district. The area under study is mainly composed of Precambrian crystalline rocks. The major rock type observed in and around the study area is garnet biotite gneiss. Laterite is found as cap rock above the crystallines. Most of the open well water is confined to this shallow laterite aquifer system.

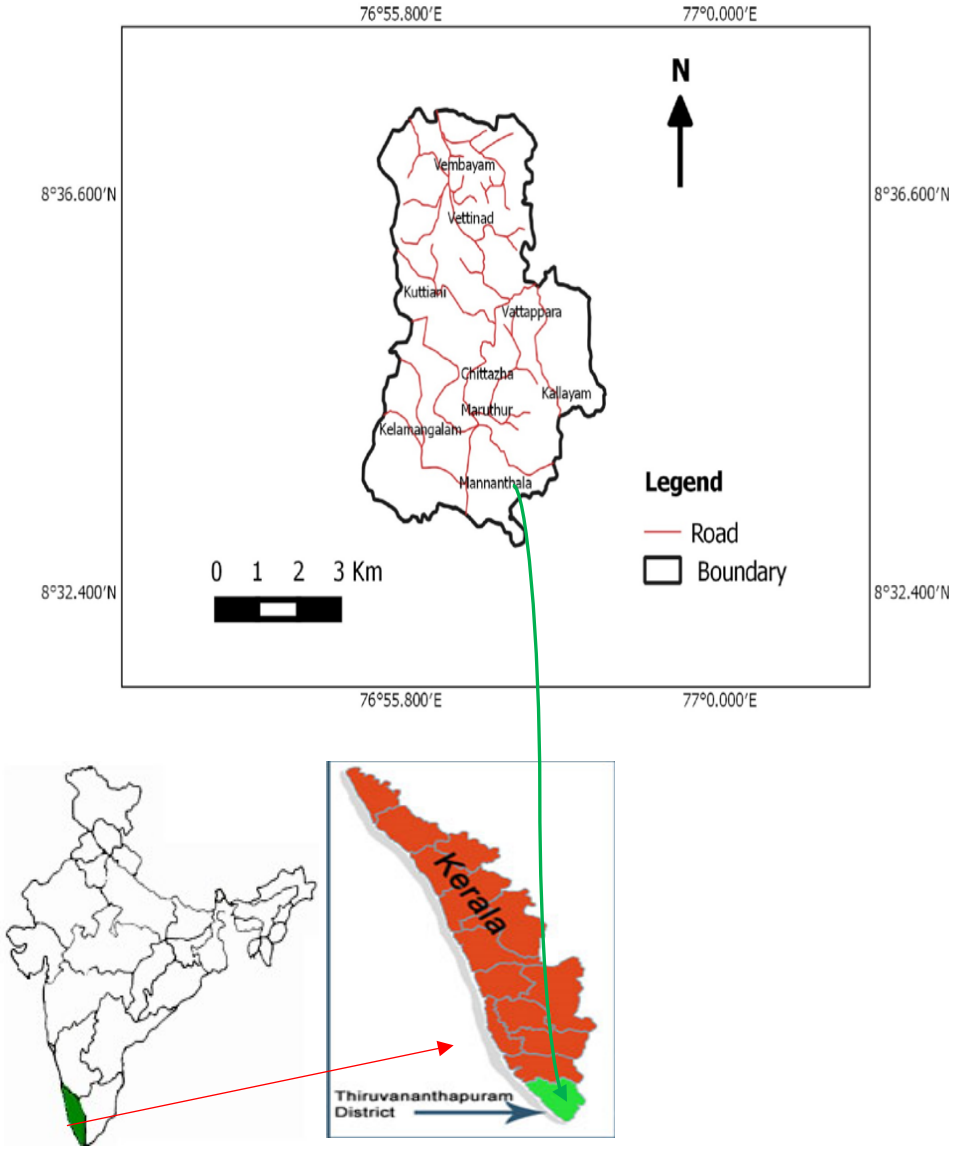

Fig.1. Location map of the study area

Study area

The study area is located in the north-eastern part of the Thiruvananthapuram district. The study area belongs to the 76^0 55' 0" E-76^0 57'30''E longitude and 8^0 37'00''N - 8^0 32'00''N latitude delineated from the top sheet number 58D/14 SE in 1:25,000. The samples were taken from areas between Vembayam and Mannanthala with an aerial extent of 65km^2 (Fig 1). Garnet biotite gneiss is the major lithounits in the study area. In addition to that Laterite cuttings are observed along road sides and well cuttings in different parts of the study area.

Methodology

Water samples were systematically collected from 33 open wells in and around Vembayam ara and the sampling locations are shown in the Fig: 1. The wells from which water samples were collected are extensively used for drinking and other domestic purposes. Physico chemical parameters like pH, EC,TDS, salinity, total hardness, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+} (cations), Chloride, NO_3^-, SO_4^{2-} , PO_4^{3-} and HCO_3^- (anions) were

Table 1: Mean and range values of water samples

Parameter		Open well water	BIS standard	
			Highest desirable	Maximum permissible
pH	Range	4.4-6.5		
	Mean	5.38	6.5-8.5	No relaxation
EC	Range	45-798		
	Mean	241.18		100
TDS	Range	32.6-472		
	Mean	153.27	500	2000
Hardness	Range	10-68		
	Mean	35.68	300	600
Bicarbonate	Range	5-55		
	Mean	21.72	300	600
Na (ppm)	Range	8-61		
	Mean	26.77	50	200
K (ppm)	Range	1-36		
	Mean	4.76		
Ca(ppm)	Range	2-28.01	75	200
	Mean	6.95		
Mg(ppm)	Range	1.10-33.28		
	Mean	7.10	30	60
Cl (ppm)	Range	31.95-106.5		
	Mean	57.75	250	1000
NO_3(ppm)	Range	0.064-0.148		
	Mean	0.117	45	100
SO_4	Range	1.6-21.5		
	Mean	10.14	200	400

measured. The analysis were carriedout following the standard procedures (APHA, 1995 and Trivedy and Goel 1986). The pH of water has been assessed in the field itself by using portable digital pH meter. EC, TDS and salinity were measured by water quality analyzer. Ca^{2+} and Mg^{2+} were determined titrimetrically using standard EDTA and Chloride was determined by silver nitrate titration. Carbonate and bicarbonate were estimated with standard sulfuric acid. Na^{+} and K^{+} were analyzed by flame photometer. NO_3^{-}, SO_4^{2-} and PO_4^{3-} values were obtained by spectrophotometer. Mean and range values of groundwater samples comparing with BIS standards are presented in Table: 1. The base map was prepared on 1:25,000 scale and

their attributes are added using Arc GIS software. Groundwater chemical data was integrated to prepare thematic maps. Since the striking parameter which shown anomaly is pH the thematic maps for the pH value is prepared and presented in Fig 2.

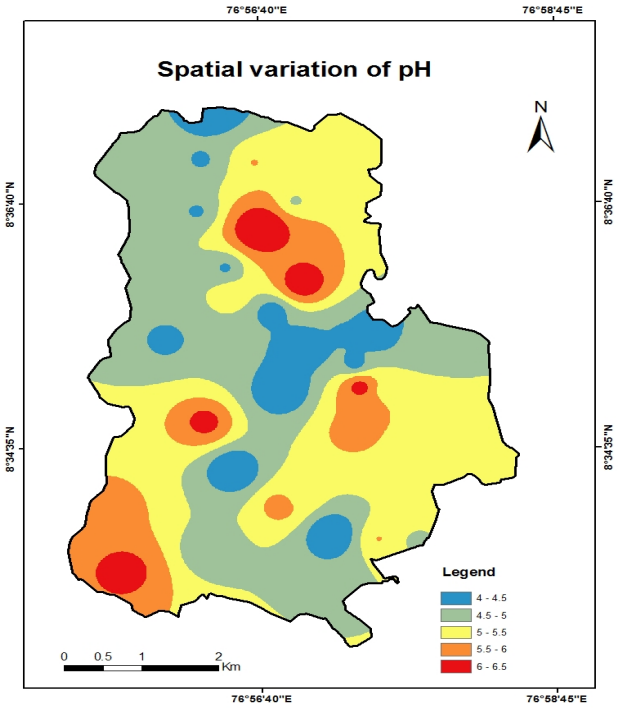

Fig 2. Spatial variation of pH.

Results and discussion

The present study area possesses unconfined aquifers beneath the zone of aeration. In the present investigations, the dug wells penetrating through unconfined aquifers are taken into account. Water samples collected from the study area were analysed systematically to determine various parameters such as pH, EC, TDS, total hardness and all major cations and anions. Most part of the study area shows pH values less than 6.5 (BIS, 1991) and this indicate an acidic trend for groundwater in the study area. The lowest pH is encountered at Pallivila and the highest pH value is reported from Perumkoor. The pH value of majority of the study area falls in between 4.4 to 6.5. The pH value of groundwater in lateritic terrains is generally below 7 (CGWB 2003). Besides the low pH can also result from anthropogenic activities wherein application of fertilizers like ammonium phosphate and superphosphate can lower water pH (Ward. C, 2008) in the present study area (Narendra Babu et, al. 2003). The common fertilizers used in the study area are NPK (Nitrogen, Phosphorous and Potassium). Excess application of NPK will contribute more nitrogen and phosphorous dissolving in to groundwater and this in turn will react with water to form nitric acid and phosphoric acid, which also gives acidic nature to the groundwater. In lateritic aquifer, iron content in laterite react with chloride of percolating rain water, easily dissolving ferric chloride and forming acidic compounds this will also contribute the acidity to groundwater. In addition to this, pH below 6.5 can cause corrosion in pipes, thereby releasing toxic metals such as Zn, Pb, Cd, Cu, etc. (Trivedy and Goel, 1986). The concentration of EC, TDS, and all the major cations and anions of groundwater in the study area are within the permissible limits of BIS. The chemical analysis indicates that the quality of groundwater in the study area is fit for domestic consumption. Only exception is in the terms of the pH thereby induced acidity. Suitability of water for agricultural utility was studied with the help of U.S.S.L and Wilcox diagram (Wilcox, L.V 1995). The plotting values over the U.S.S.L diagram indicates that most of the samples fall in C1S1 field and a few in C2S1 field, indicating low salinity/low alkali hazard (USEPA

1971). Wilcox diagram also shows that most of the water in the area under study is suitable for agricultural purpose. All the samples belong to excellent to good category. The parameters such as residual sodium carbonate (RSC), sodium adsorption ratio (SAR) and percentage sodium etc. were studied and results show that the groundwater in the study area is good for irrigation purpose. Groundwater is being used in the area for many domestic and irrigation purpose, this reason makes the study significant, pH can be controlled by reducing the use of fertilizers. Proper water treatment mechanism is essential to neutralize the impact of acidic pH. It could be possible by alkali neutralization method by diluting groundwater with fresh rain water by adopting different rain harvesting method. In addition it's also possible to have soda ash/soda hydroxide injection method. This treatment method is used if water is acidic. Soda ash (Sodium carbonate) and sodium hydroxide raise the pH of water to near neutral (7) when injected into water system. Unlike neutralizing filters they do not cause hardness problems in treated water. If the water needs to be disinfected (removal of microbial contamination) as well as neutralized, dual treatment is possible with the injection system by adding a chlorine solution (sodium hypochlorite) along with sodium carbonate and sodium hydroxide.

Conclusion

Groundwater is being used in the area for many domestic and irrigation purpose, this reason makes the study significant, pH can be controlled by reducing the use of fertilizers. Proper water treatment mechanism is essential to neutralize the impact of acidic pH. It could be possible by alkali neutralization method by diluting groundwater with fresh rain water by adopting different rain harvesting method. In addition it's also possible to have soda ash/soda hydroxide injection method. This treatment method is used if water is acidic. Soda ash (Sodium carbonate) and sodium hydroxide raise the pH of water to near neutral (7) when injected into water system. Unlike neutralizing filters they do not cause hardness problems in treated water. If the water needs to be disinfected (removal of microbial contamination) as well as neutralized, dual treatment is possible with the injection system by adding a chlorine solution (sodium hypochlorite) along with sodium carbonate and sodium hydroxide. Hence in total a comprehensive water management strategy need to be in force to ensure safe drinking water to people in the study area.

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Application of analytical hierarchy process (AHP) for Landslide Susceptibility Mapping: A study from southern Western Ghats, Kerala, India

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Abstract
Western Ghats, the bold westerly escarpment of India, that traverses though the entire length of the Kerala State, from north to south, witnesses landslides very frequently during the monsoon season and causes widespread damage to life and property. The present work is carried out in parts of Western Ghats covering a geographical extent of 480km^2 and spread over Thiruvananthapuram district. This research integrates the analytical hierarchy process (AHP) and Remote sensing & GIS for landslide susceptibility mapping. To map the landslide susceptibility, nine potential independent variables were selected as effectual factors, including geomorphology, slope curvature, slope of the terrain, proximity to roads, drainage density, relative relief, soil texture, land use and annual rainfall. AHP based normalized weights are assigned to these factors and final Landslide susceptibility map is prepared using GIS. The Landslide susceptibility map is classified into five hazard zones: least hazard zone (9.67%), low hazard zone (35.65%), moderate hazard zone (38.43%), high hazard zone (15.13%) and very high hazard zone (1.13%).The results reveal that the predicted susceptibility levels are found to be in good agreement with the past landslide occurrences, and, hence, the map is trustworthy for future land-use planning.

Keywords: Remote sensing & GIS. Analytical Hierarchy Process (AHP). Landslide Susceptibility Mapping. Western Ghats, Kerala, India.

Introduction

Landslides are one of the most wide spread natural hazard that can damage both property and life. Landslide refers to the downslope movement of Earth materials such as mass of rock and debris under the influence of gravity. These events are associated with earthquakes, intensive soil erosion, heavy precipitation and anthropogenic factors. Increased urbanization and continuous deforestation in landslide prone areas leading to the increase of landslide susceptible zones. Landslide susceptibility can be defined as probability of spatial occurrence of landslides on the basis various geo-environments of the particular area (Brabb et al., 1984). Presently all researches about landslide susceptibility mapping make use of advanced tools such as Geographic Information System (GIS) and Earth Observation for handling spatial data (Van Westen et al., 2008). Remote Sensing with its advantages of spatial, spectral and temporal availability of data, high resolution digital elevation models and powerful application of Geographic information systems (GIS) together made great advancement in mapping and assessment of landslide susceptibility of an area (Krishnan et al.,2015). Integrated remote sensing and GIS techniques for landslide susceptibility mapping are presented by many scholars (Ayalew et al., 2005; Fell et al., 2008; Jawan Singh Rawat & Ramesh CHANDRA Joshi., 2011; Sujit Mondal & Ramkrishna Maiti, 2012; Conforti, et.al, 2014).

GIS aided landslide susceptibility mapping involves several methods that can conclude either qualitatively or quantitatively. Earlier approaches especially qualitative techniques are depended on expert opinions (Aleotti and Chowdhury., 1999). In order to remove the subjectivity of qualitative approaches, more sophisticated statistical techniques such as AHP, bivariate, multivariate, logistic regression, fuzzy logic, or artificial neural network (ANN) have been used in LSZ studies (Rahamana.,et al 2014). Many scholars integrated GIS based data and remote sensing data with AHP for landslide susceptibility mapping (Marko Komac,2006; Park, et al 2013; Pourghasemi, et al., 2012; Ying, et al., 2007).

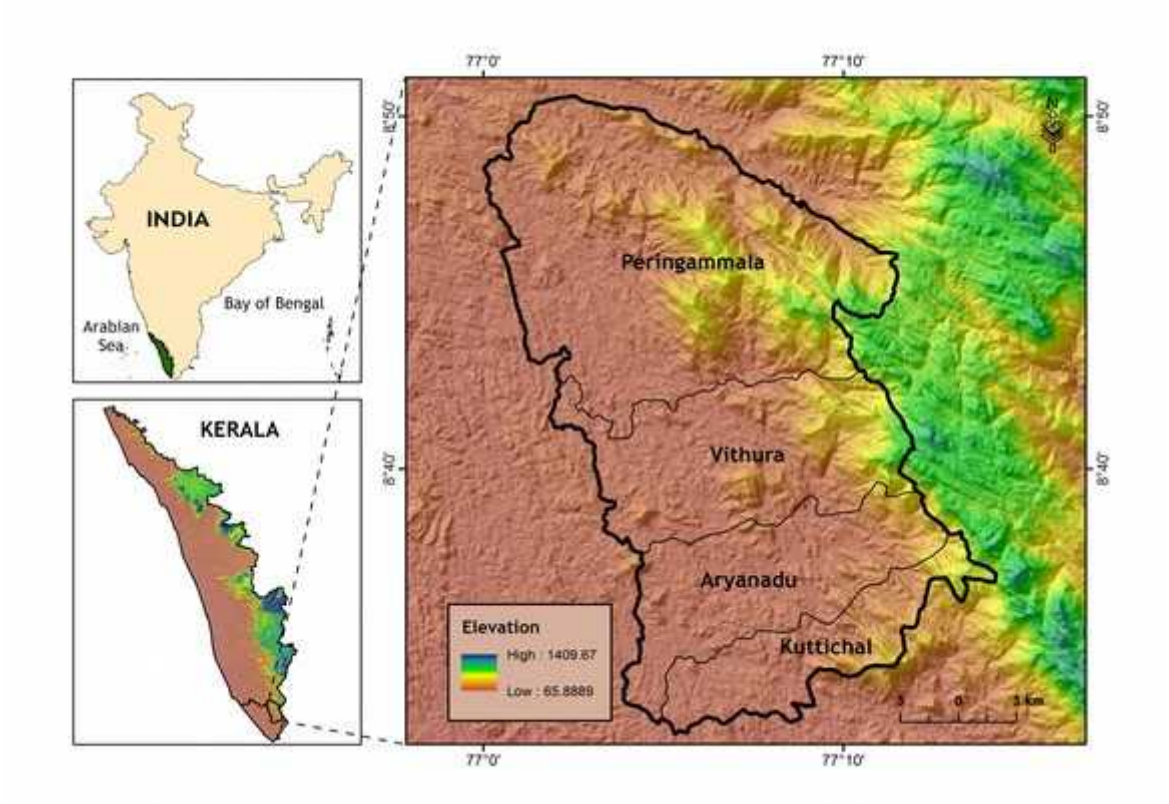

Figure. 1 Location map of the study area.

Landslide affects large part of the Hilly terrain in India especially the Himalayas, the Eastern Ghats, the Vindhyans and the Western Ghats (Prasannakumar and Vijith, 2012). Because of its specific morphological, climatic and terrains settings, Kerala is one of the landslide prone area in the country. The present study aims to assess the usability of GIS assisted AHP in landslide susceptibility zoning in a data deficient hilly terrain in the Western Ghats of Kerala, India, which witnessed severe land degradation due to landslides (debris flows) during the monsoon periods in the past. Landslides in the Western Ghats, which comes second to the Himalayan region, can be categorized as a monsoon related phenomenon.

Study area

The study area lies between latitude 8°32' 27.91" and 8°50' 26.39"N and longitude 77°3' 53.70" and 77°14' 16.89"E on the western slopes of Western Ghats, upland catchments of the three major rivers namely Kallada, Vamanapuram and Karamana (Fig.1). Study covers an area about 480 km^2 and spread along four panchayats (smallest unit of administration in India) including Peringamala, Vithura, Aryanadu and Kuttichal. Peringamala is the second largest panchayat in Kerala. The important tourist spots of the southern Kerala such as Ponmudi, Kurishadi, Kallar, Braemore, etc are located in the present study area. The areas are highly undulating and majority of the area fall under highland category (>75 m AMSL), and the maximum elevation in the terrain exceeds 1400m above the Mean Sea Level (MSL). The study area has complex geological settings. Khondalite Group of rocks contribute 78% of the total area and is followed by Migmatite Complex (12.05%) and Charnockite group of rocks (9.95%). Study area enjoys a tropical humid climate. Principal rainy seasons are southwest (June to September) and northeast (October to December) monsoons. The average annual rainfall of the study area is 1700mm. Average monthly temperature varies from 24°c to 35°c. The tropical monsoon climate with clear, alternating and distinct wet and dry seasons, has driven the upper portions of most of the crystalline rocks to laterite. The study area experienced several major and minor landslides. The major landslide occurred at 1992, in the periphery of the Peppara Reservoir and lesser ones at Thennur and Peringammala. However many debris flows are recoded near to road side viz., Vithura, Vellanadu, Parandode and Bonacaud.

Materials and Methodology

The geo-environmental variables which can predict the probability of landslide occurrence are derived and integrated using ArcGIS software. Thematic layers of Geomorphology, Slope gradient, Relative relief, Land use land cover, Rainfall, Drainage Density, Soil texture, Road proximity and Slope curvature are integrated and the susceptibility map is prepared from the integrated data base.

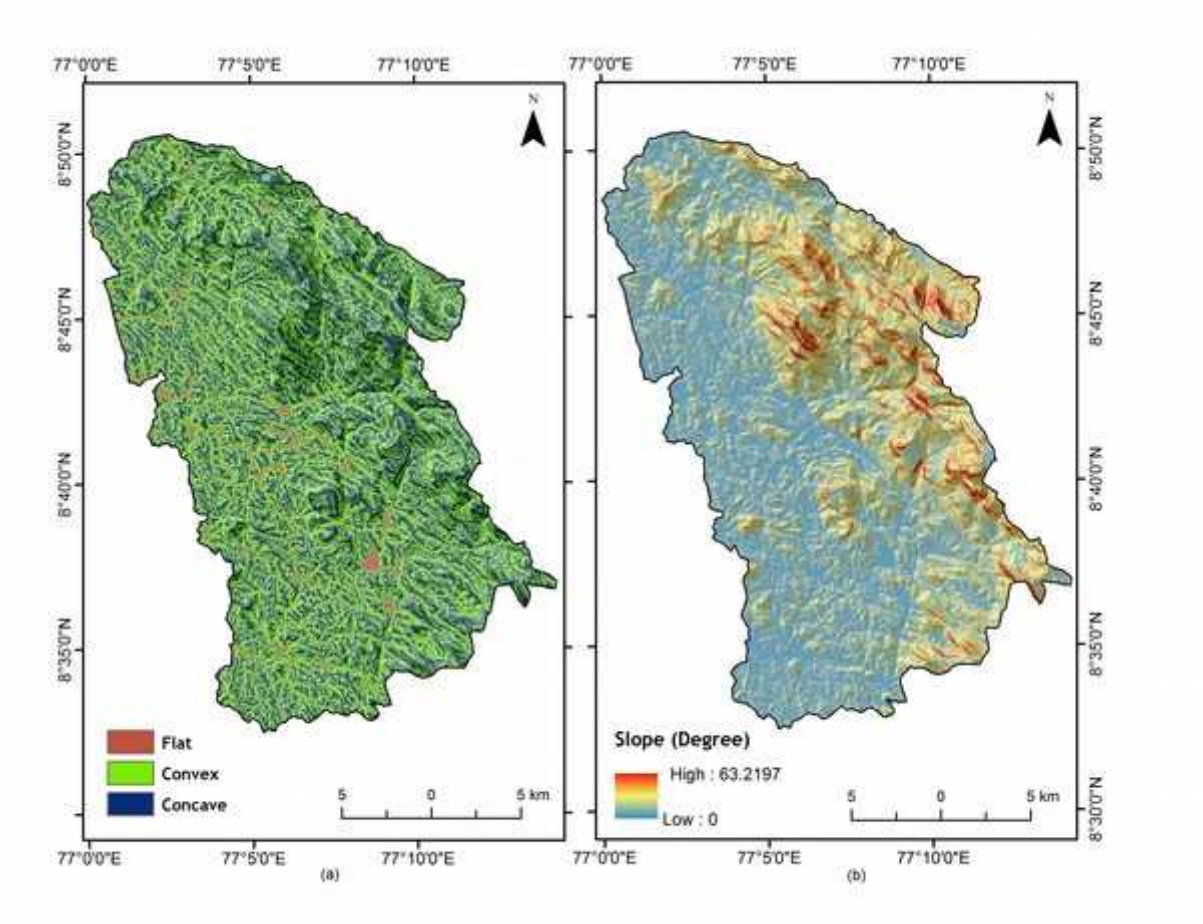

Figure. 2a Slope Curvature of the study area

Figure. 2b Slope map of the study area

Topographic factors: SRTM Digital Elevation Model (DEM) with a spatial resolution of 30×30m has been downloaded from USGS Earth explorer website and extracted by study area boundary. From this DEM, thematic data layers such as slope angle, slope shape (curvature) and relative relief were prepared.

Slope angle: The probability of landslide occurrence in a terrain is largely depended on its slope. The slope map is generated from the DEM and reclassified into seven different classes: flat slope (<5°), flat to very gentle (5-10°), very gentle to gentle slope (10-15°) gentle to moderate slope (15-20°), moderate to high (20-30°), high to steep slope (30-40°) and very slope (>40°)(Fig.2 b).

Slope shape (curvature): The morphology is represented by slope curvature (Kayastha et.al; 2012). The study area is classified according to curvature values: convex, concave and planar (Fig.2 a). Generally convex slopes are more stable as they disperse runoff equally down the slope while concave slope considered as potentially unstable as they concentrate the water at lowest point leading to adverse hydraulic pressure (Stocking, 1972).

Relative relief: Relative relief is defined as the maximum height difference of a terrain normalized by its length or area. In this study, the relative relief is computed as the range between minimum and maximum elevation per km^2 area (Fig.3 a). Relative relief is reclassified into five major classes :<75 m/ km^2, 75-150 m/ km^2, 150-300 m/ km^2, 300-600 m/ km^2 and >600 m/ km^2.

Rainfall: Rainfall is an important factor in predicting landslide susceptibility mainly because the previous slides in the study area are associated with heavy rainfalls. Annual average precipitation data of 1950-2016 were downloaded from Worldclim geo database as girded data and analyzed for the present study (Fig.3 b).

Geomorphology: Landforms plays a vital role in slope stability. The study area have complex geomorphological settings, ranging from weathered Pediplain to Denudational structural hills (Fig.4 a).

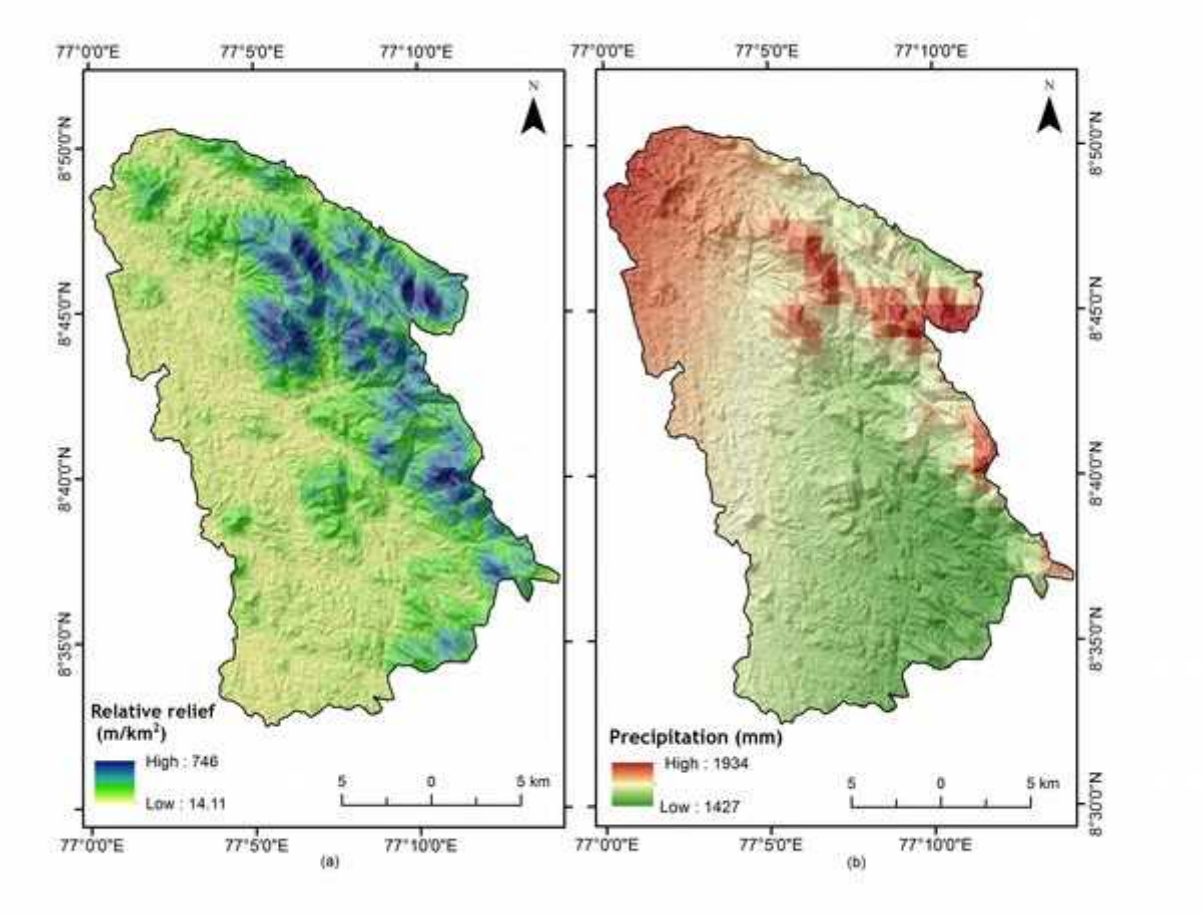

Figure. 3a Relative relief of the study area

Figure. 3b Annual precipitation map of the study area

The dominant geomorphological feature found in the present study area is Denudational structural hills (59% of the total area). Other major landforms identified are Piedmont Zone, Lower Plateau (Lateritic), Pediplain - Weathered and Residual Hill.

Drainage density: Runoff is the important factor in slope stability. Drainage density defines total length of stream lines per unit area. In this study, the total length of streams per km^2 has been calculated using ArcGIS software (Fig.4 b) and regrouped into four classes: Low (<1km/km^2), Moderate (1-2km/km^2), High (2-3km/km^2) and Very High (>3km/km^2).

Soil Texture: Soil data of the study area has been collected from Soil Survey & Soil Conservation Directorate, Government of Kerala. Study area exhibits three major soil textures (Fig.5 a). The dominant soil texture is gravelly sandy clay loam (81%) followed by gravelly sandy clay (16%) and gravelly clay (3%). Generally Gravelly sandy clay loam is considered as more unstable compared to other textures.

Road Proximity: Roads are considered as slope instability regions in highland areas. Several segments of the road network are found in the study area, especially in the midland and highland regions. These road networks steeply cut across or along the toe of the hills, destabilizing the area and may fail in the event of heavy precipitation. Many debris slides occurred in the past in the study area are near to roads so that proximity from the road is calculated as: near (<100m), moderate (100-300m), far (300-500m) and very far (>500m) (Fig.5 b).

Land use and land cover: Land use land cover is an important factor for landslide susceptibility mapping. Thirteen land use land cover classes are identified from Landsat 8 OLI image. More than 60 percent of the area is covered by forest. Agricultural plantations (Rubber, banana, Coconut, Tea and Mixed) is next the major land use identified in the study area (Fig.6). They together contribute 33.89% of the total area. Other

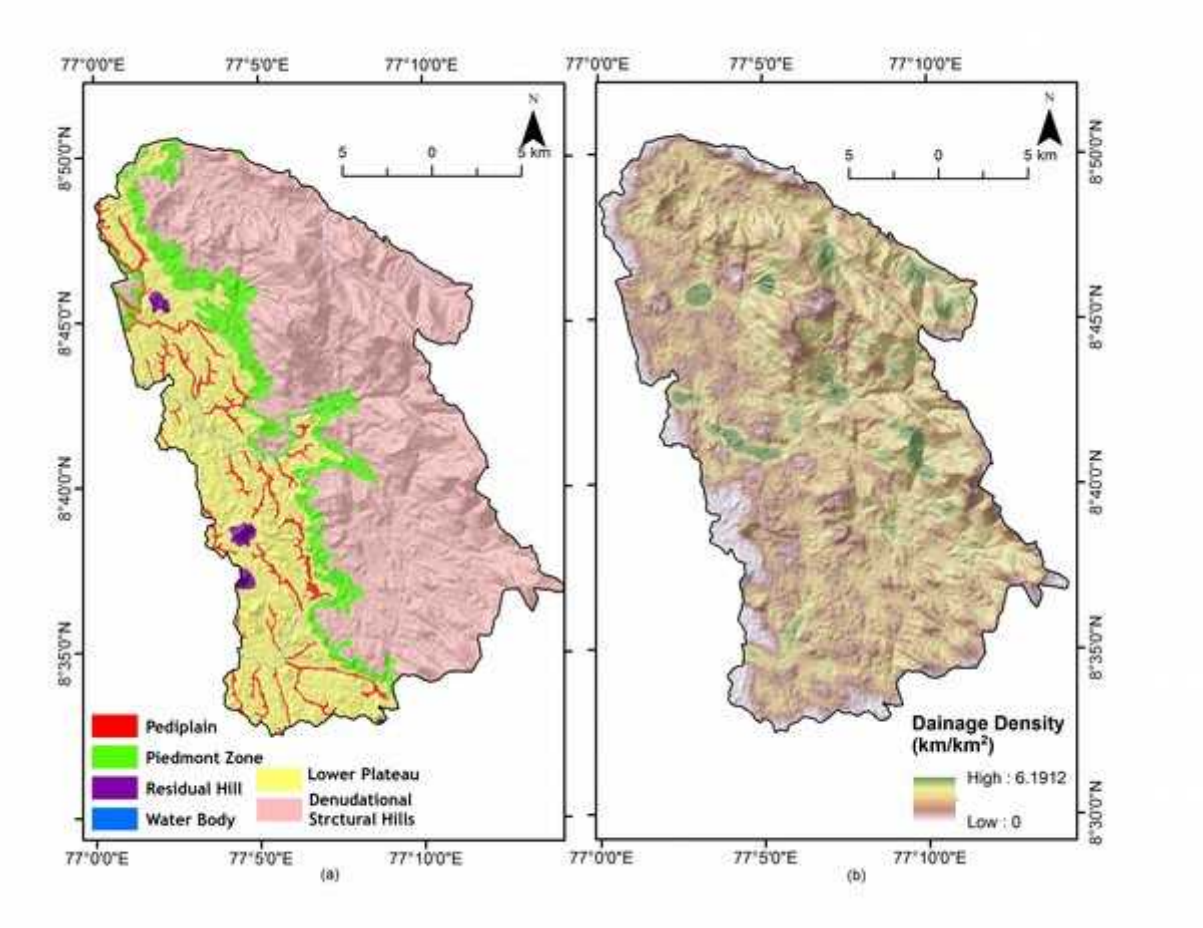

Figure. 4a Geomorphology map of the study area **Figure. 4b** Drainage density map of the study area

land uses present in the study area are built-up, forest plantations, grass land, land with scrub, double crop (Kharif+Rabi) and barren rock.

Analytical hierarchy process

The analytical hierarchy process (AHP) is a semi-quantitative approach in which decisions are taken using weights through pair- wise relative comparisons without inconsistencies in the decision process (Saaty, 1980). The advantages of using AHP as an expert based method in landslide susceptibility analysis are (Thanh, et al.,2012): (i) all types of information related to landslides can be included in the discussion process; (ii) judgment is structured so that all information is taken into account; (iii) discussion rules are based on expert's knowledge and experiences; (iv) when a consensus is reached, weights for each relevant factor are obtained automatically by eigenvector calculation of the comparison matrix; and (v) inconsistencies in the decision process can be detected using consistency index developed by Saaty (1980, 2000) and, hence, corrected if needed.

Landslide susceptibility map

In AHP, the comparison of factors are done using a scale from1-9. If the factors have an inverse relationship then scale of 1/2 -1/9 is used. In this study corresponding ranks were assigned to each factors

from the above said scale. While ranking factors, previous slide location and their relation to corresponding factor is also accounted. There after the weights of the each factor are calculated using Eigen vector techniques in R studio software (Table.1). The consistency ratios are found out to check the consistency of the judgments made. Hence CR is an index of inconsistency is given by Eq.1

$$CR = \frac{CI}{RI}$$

where CI is the consistency index and RI is the consistency index of a random square matrix. Consistency ratio (CR) should be lower than or equal to 0.1. Commission and omission of a variable is fully depended on the value of CR. The CI is calculated as Eq.2

$$CI = \frac{\lambda max - n}{n - 1}$$

where λmax is the largest Eigen value and N is the order of the comparison matrix.

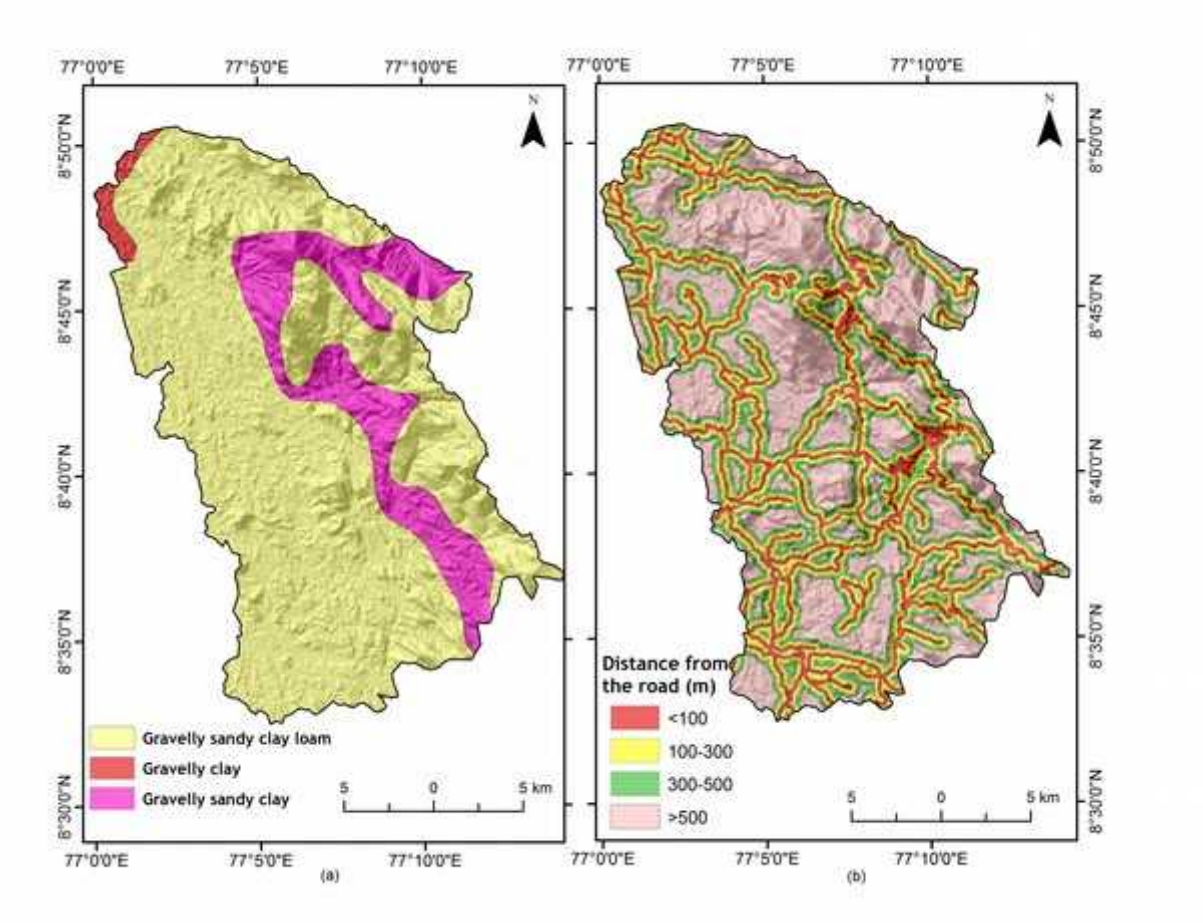

Figure. 5a Soil Texture of the study area

Figure. 5b Road proximity map of the study area

Saaty (1980) developed an average random consistency index (RI) for different matrix orders and defined the consistency ratio (CR) as the ratio of the consistency index (CI) and the random consistency index (RI). If CR is greater than 0.1, the comparison matrix is inconsistent and should be revised. In the present study all CR values are less than 0.1. Finally, the integration of the various causative factors and classes in a single landslide susceptibility index (LSI) is given by a procedure based on the weighted linear sum. The resulting Landslide susceptibility map of the study area is shown as Fig.7. The derived Landslide susceptibility map has been reclassified into five major classes: least hazard zone, low hazard zone,

moderate hazard zone, high hazard zone and very high hazard zone. Moderate hazard zone covers 183.86km^2 which is about 38.43 percent of the total area followed by low hazard zone covering 35.65% of the study area (170.57 km^2).High hazard zone accounts 72.38km^2 (15.13%). Very high hazard zone covers only 1.13 percent of the total area while least hazard zone accounts 9.67 percent of the area. The final landslide susceptibility map is validated with previous slide locations. All previous slide locations fall in the high hazard zone.

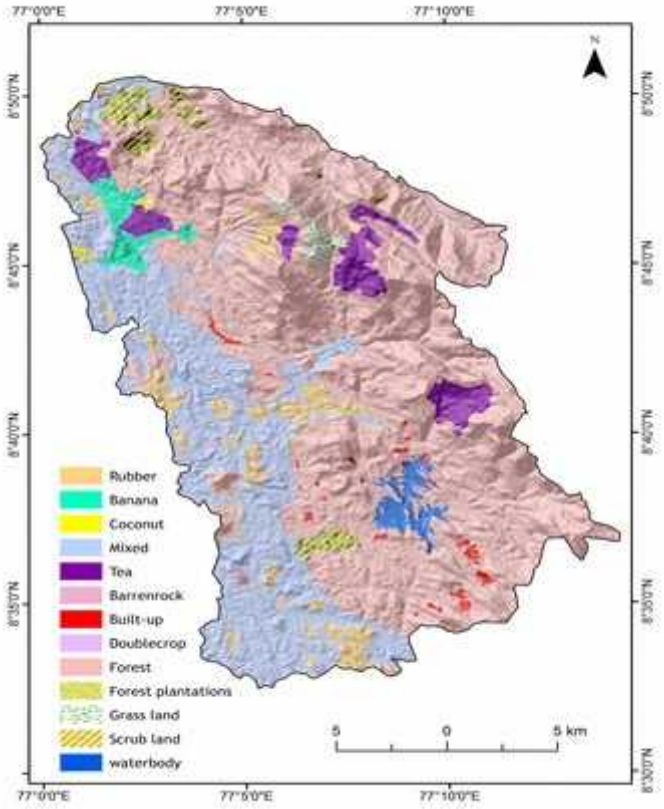

Figure. 6 Land use and land cover map of the study area

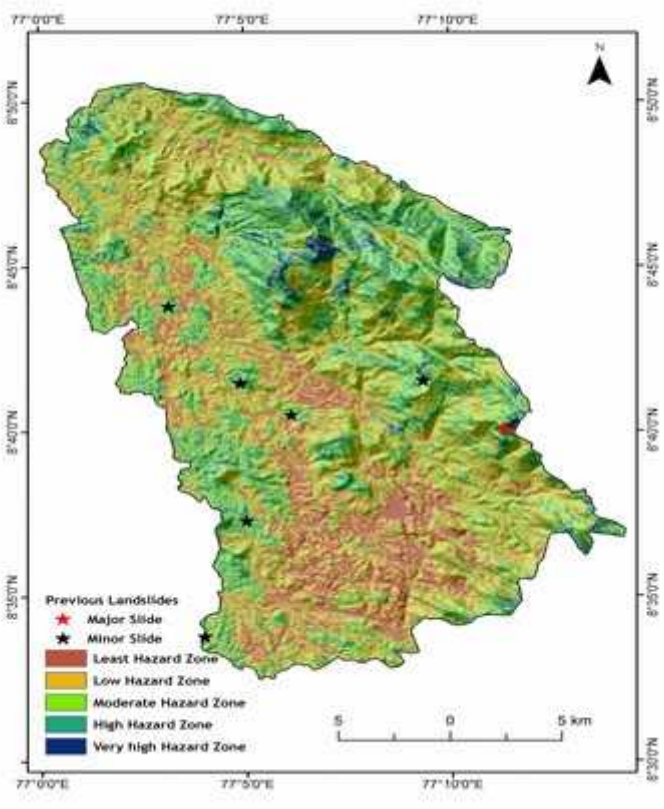

Figure. 7 Landslide susceptibility map of the study area

Conclusion: The analytical hierarchy process is an expert-judgment method with its advantage of checking consistency of the rating provided by the expert. The methodology is applicable for Landslide susceptibility mapping with higher accuracy because of the pair-wise relative comparisons of the parameters without inconsistencies in the decision process. In this study, nine causative factors were considered, i.e. slope angle, slope curvature, relative relief, land use, geomorphology, road proximity, drainage density and annual rainfall. The selection of these nine factors is based on the availability of data for the study area and the relevance with respect to landslide occurrences. However, more factors can be considered on the basis of availability of data for further study. The results show that the very high susceptible zone, which covers only 1.13% of the study area, predicts about 29% of the observed landslides, and the high susceptible zone, which covers only 15.13% of the study area predicts about 57% of the observed landslides. Moreover, large observed landslides are clearly marked in the areas of high and very high susceptible zones. These results show that the predicted susceptibility levels are found to be in good agreement with the past landslides. The landslide susceptibility map presented in this study can be a good source for policy makers, planners and engineers. This map provides valuable information so that due attention can be paid to the high and very high susceptible zones for any kind of developmental works. Possibly, this map can be used by the concerned authorities in disaster management planning to prepare rescue routes, service centers and shelters.

Causative factors and classes within each factors	Pair-wise comparison matrix													Normalized Weights
Land use	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	
[1]Scrub Land	1													0.2300
[2]Rubber	1/2	1												0.1150
[3]Banana	1/3	2/3	1											0.0767
[4]Coconut	1/4	1/2	3/4	1										0.0575
[5]Tea	1/2	1	1 1/2	2	1									0.1150
[6]Mixed	1/3	2/3	1	1 1/3	2/3	1								0.0767
[7]Double Crop	1/5	2/5	3/5	4/5	2/5	3/5	1							0.0460
[8]Forest	1/6	1/3	1/2	2/3	1/3	1/2	5/6	1						0.0383
[9]Forest plantations	1/5	2/5	3/5	4/5	2/5	3/5	1	1 1/5	1					0.0460
[10]Grass land	1/7	2/7	3/7	4/7	2/7	3/7	5/7	6/7	5/7	1				0.0329
[11]Barren Rock	1/9	2/9	1/3	4/9	2/9	1/3	5/9	2/3	5/9	7/9	1			0.0256
[12]Built-up	1/2	1	1 1/2	2	1	1 1/2	2 1/2	3	2 1/2	3 1/2	4 1/2	1		0.1150
[13]Water body	1/9	2/9	1/3	4/9	2/9	1/3	5/9	2/3	5/9	7/9	1	2/9	1	0.0256
Geomorphology	**[1]**	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**								
[1]Denudational Structural Hills	1													0.3896
[2]Lower Plateau	1/3	1												0.1299
[3]Piedmont Zone	1/5	3/5	1											0.0779
[4]Residual Hill	1/3	1	1 2/3	1										0.1299
[5]Pedi Plain	1/2	1 1/2	2 1/2	1 1/2	1									0.1948
[6]Water body	1/5	3/5	1	3/5	2/5	1								0.0779
Soil texture	**[1]**	**[2]**	**[3]**											
[1]Gravelly clay	1													0.1111
[2]Gravelly sandy clay	5	1												0.5556
[3]Gravelly sandy clay loam	3	3/5	1											0.3333
Drainage density (km km-2)	**[1]**	**[2]**	**[3]**	**[4]**										
[1]>1	1													0.4918
[2]1-2	1/5	1												0.0984
[3]2-3	1/3	1 2/3	1											0.1639
[4]>3	1/2	2 1/2	1 1/2	1										0.2459
Relative Relief (km km-^{2})	**[1]**	**[2]**	**[3]**	**[4]**	**[5]**									
[1]< 75	1													0.0455
[2]150	3	1												0.1364
[3]150-300	5	1 2/3	1											0.2273
[4]300-600	6	2	1 1/5	1										0.2727
[5]>600	7	2 1/3	1 2/5	1 1/6	1									0.3182
Proximity to Road (m)	**[1]**	**[2]**	**[3]**	**[4]**										
[1]>100	1													0.5607
[2]100-300	1/3	1												0.1869
[3]300-500	1/4	3/4	1											0.1402
[4]>500	1/5	3/5	4/5	1										0.1121
Slope (°)	**[1]**	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**	**[7]**							
[1]<5	1													0.0278
[2]5-10	3	1												0.0833
[3]10-15	4	1 1/3	1											0.1111
15-20[4]	5	1 2/3	1 1/4	1										0.1389
[5]20-30	6	2	1 1/2	1 1/5	1									0.1667
[6]30-40	8	2 2/3	2	1 3/5	1 1/3	1								0.2222
[7]>40	9	3	2 1/4	1 4/5	1 1/2	1 1/8	1							0.2500
Slope Curvature	**[1]**	**[2]**	**[3]**											
[1]Flat	1													0.1111
[2]Concave	6	1												0.6667
[3]Convex	2	1/3	1											0.2222
Rainfall (mm)	**[1]**	**[2]**	**[3]**	**[4]**										
[1]< 1500	1													0.0625
[2]1501 – 1600	3	1												0.1875
[3]1601-1800	5	1 2/3	1											0.3125
[4]>1800	7	2 1/3	1 2/5	1										0.4375
Data layers	**[1]**	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**	**[7]**	**[8]**	**[9]**					
[1]Land use	1													0.0187
[2]Geomorphology	5	1												0.1461
[3]Road Proximity	9	5/9	1											0.0925
[4]Soil	6	5/6	1 1/2	1										0.1268
[5]Drainage density	7	5/7	1 2/7	6/7	1									0.1125
[6]Rainfall	8	5/8	1 1/8	3/4	7/8	1								0.1014
[7]Slope	4	1 1/4	2 1/4	1 1/2	1 3/4	2	1							0.1738
[8]Slope Curvature	8	5/8	1 1/8	3/4	7/8	1	1/2	1						0.1014
[9]Relative relief	6	5/6	1 1/2	1	1 1/6	1 1/3	2/3	1 1/3	1					0.1268

Table.1 Pair-wise comparison matrix and normalized weight for landslide susceptibility mapping.

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Shrawani Mela Deoghar, 2016 – Crowd Management System

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Introduction

Shrawani Mela at Baidyanath Dham Deoghar is an ancient, traditional and important month long festival for Jharkhand wherein devotees turn up in large number from India and abroad. More than 8 million devotees visit Babadham during a year but the bulk of devotees more than 3 million throng the Holy shrine in the month of Shrawan during the month long Shrawani Mela . It is the longest Mela of 105 Kilometres where in Kanwariyas (devotees) pick up Holy water from the Ganges at Sultanganj in Bhagalpur, Bihar, walk 105 kilometres upto Babadham and offer it to Sparsh Jyotirlinga at Babadham-the holy shrine. The smooth conduct of the Shrawani Mela and the crowd management is a challenge for the district administration of Deoghar and Government of Jharkhand.

Description

The Babadham temple is old small structure located in old city of Deoghar with limited infrastructures like small streets, amenities and communication. However, the number of devotees is increasing every year posing administrative challenges to the district as well as state. The orderly regulation of crowd duly supported with facilities and technology is the essence of Crowd Management at Shrawani Mela. There are comprehensive arrangements made by Government of Jharkhand for smooth and disaster free conduct of the mela.

Crowd Management Technology and Systems

The major components of the Crowd Management System adopted are as follows:-

Detailed Hazard Risk Vulnerability and Capacity analysis of the Mela

Detailed planning, coordination and crowd management plans with respect to the assessment of crowd holding and handling capacity of the district including anticipated strength and nature of the crowd

Division of the Mela area in various Zones, subzones and sectors for administrative control.

Employment of modern Information technology and gadgets including Mega Server based automated Command Operation Centers (Main Control rooms with 34 Regional Control Rooms) CCTV cameras, Automatic crowd Counting system, Surveillance and management through Drones, GPS Based Ambulance, Queue Monitor system, modern communication devices etc. in an integrated method.

Capacity Building- The existing road from Dumma(Bihar) to Babadham temple is 9 km with crowd holding capacity of 80000 devotees was enhanced to total 16 km along with provision of 27 holding points crowd upto 3.5 lakhs per day.

Proper registration and regulation of each devote from entry to safe exit.

Argha system was introduced so that maximum number of devotees to perform darshan in shortest possible time frame.

Creation of proper barricading and facilities like shelters, drinking water, food, communication, entertainment and all amenities with special emphasis on hygiene and sanitation.

Adequate deployment of Police, specialized forces like NDRF, RAF, ATS and Civil Defence with people friendly policing.

Exhaustive training and awareness of all officials and forces before mela including Mock Drills and exercises.

During Shrawani Mela in 2016, approximately 34 lakh devotees visited the Holy city. Deputy Commissioner and Superintendent of Police of Deoghar along with their team duly supported by various agencies worked rigorously to ensure smooth conduct and disaster free mela.

Conclusion

A proactive planning along with IT enabled services can be great asset in managing huge crowd and regulating them smoothly and avoid unexpected incidents. This added with facilities and communication can be great event management for administration and devotees.

Unscientific land modification in Kerala: an invitation to disaster in near future

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Kerala is a small strip of land, is flourished with a good network of streams. Geomorphology of Kerala plays a major role in movement of water in both surface and subsurface conditions. The transformation of land cover in Kerala due to various anthropogenic activities causes serious impact on surface- and subsurface water movement. Major transformations are due to (i) modification of land for cultivation and for extraction of soil (ii) urbanization. Cultivation and urbanization are essential and unavoidable requirements in the human civilization. But proper scientific approach in these aspects is lacking, and hence it affects the hydrological cycle. Natural gradient of the terrain is a very unique feature, which pools the precipitated water into a first-order stream; and is related with the geomorphology & geology of the terrain. Movement of surface water during precipitation is taking place as per the gradient of the terrain. Any unscientific modification of natural gradient of the terrain will directly affect the movement of surface water as well as loss of first order streams that originates from that area. It is very easy to transform or destroy first-order streams as because they are not prominent as higher orders. Many first order streams in Kerala including highland areas, especially in urbanized areas are vanished due to either one of these anthropogenic activities. Dying of first-order streams in a fluvial network will negatively affect the quantity of water in that basin and subsequently the recharge of groundwater in a large area. The present pace of urbanization is not at all considering the fluvial component of the terrain and even not giving enough weightage to that.

Another major issue is the transformation of first-order streams as drainage channels due to unscientific way of urbanisation. Opening up of drainage from the settlement area into the fluvial channel is the primary cause of contamination of surface- and subsurface water. Necessary precautions should be taken to save the first order streams from the land modifications as well as from the contamination. Integrated geomorphologic cum fluvial-network map of the area (Panchayat-wise) in 1:100 m scale must be prepared to scientifically monitor the anthropogenic changes of land and fluvial system. A clearance certificate from the local body government has to be made mandatory to modify the land for any sort of purpose. State Groundwater Department can assess the area and can give advices to whether permission can/cannot be given for modification of land or can be given with certain conditions which can preserve the land-slope/streams and its contamination due to transformation. Considering the importance of water, a close monitoring in every inch of land is essential and to be done with the help of hydrogeological mapping and remote sensing & GIS in at least 1: 100 m scale. For that, an integrated map with geo-referenced and digitized fluvial system and land cover (with elevation and slope direction) of the area is a must to monitor the changes periodically.

An assessment of coastal region vulnerability using risk matrix method - a case study of Kanyakumari district, Tamil Nadu

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Abstract
Kanyakumari district is the southernmost part of Tamil Nadu which is prone to disaster and escalating disaster losses. An effective way of disaster mitigation is the foundation for proficient disaster response and rescues which results in reducing the degree of hazardous impacts on the population. Vulnerability is the term to which the populations capacity to anticipate and recover the impact of hazardous event. Vulnerability systematically estimates the damage that could be caused by a potential disaster. The main aim of this paper is to assess the vulnerability of coastal region using risk matrix method. It highlights the identification of elements and stakeholders potentially at risk, identification of factors influencing on vulnerability and the mitigation measures to reduce the hazards.

Keywords: Vulnerability assessment, Matrix method, Mitigation measures, Environmental components, Risk reduction

Introduction

Asia is the one of the most disaster prone region in the world. Above millions of population is at risk to natural hazards such as typhoon, flood, landslides and fires. According to NIDM, the disaster is defined as a “catastrophic situation in which the normal pattern of life or ecosystem has been disrupted and extra-ordinary emergency interventions are required to save and preserve lives and/ or the environment. Disaster risk reduction is the concept and practice of reducing disaster risks through systematic efforts, to analyze and manage the causal factors of disasters that include reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events. The communities along the coastal region can be easily affected by disastrous event and safe zones are difficult to reach by the people. Tsunami, cyclone and sea level rising involve vulnerable risk and have the potential to cause massive damage to the coastal communities[1]. The study highlighted that 44 coastal fishing villages are partly located below the 2m contour line in Kanyakumari district and hence it is highly vulnerable to sea level rise[2]. The study of natural disaster and its socio-economic and environmental impact of Kanyakumari district highlighted that of the overall damages 75% of damage and losses were on the coastal region[3]. Coastal landform configurations are dependent on the pre-existing coastal settings, geological structures and a variety of coastal processes[4].

Most of the landforms along southern coast of Tamil Nadu particularly on the south west coast of Kanyakumari district have undergone morphological deformation due to the effect of Tsunami occurred on December 26, 2004[5]. Coastal zones are dynamic areas that are constantly undergoing change in response to a multitude of factors including sea level rise, wave and current patterns, hurricanes and human influences[6]. In the coastal region the higher is the loss of property, the lower is the tendency among the dwellers to invest which has a long-lasting effect on capital formation and social development[7]. The assessment on coastal vulnerability recognizes that whether in pre-disaster or post disaster the vulnerability gets transformed (either reduced or increased) with the nature of development performance and design inputs. The main aim of this paper is to assess the vulnerability of coastal region using risk matrix method. Remote sensing and GIS can be used as an effective tool to identify the areas that are vulnerable to coastal erosion along the coast.

Study Area

The study area is located at AgastheeswaramTaluk of Kanyakumari, the southernmost district of Tamil Nadu. The district lies between 77º 15' and 77º 36' of the Eastern longitudes and 8º 03' and 8º 35' of the Northern Latitudes (Figure 1). The Southeastern boundary is the Gulf of Mannar. On the South and the Southwest, the boundaries are the Indian Ocean and the Arabian Sea. The total area of Kanyakumari district is 1,684 sq.km where Agastheeswaram comprises of 133.12 sq.km. The population of the district according to the Census 2011 is 1,870,374 and the population density is 1,111persons/sq.km where the Agastheeswaram taluk comprises of 1,61,080 persons of which 79,923 are male, and 81,157 are female. Rainfall varies from 103 cm to 310 cm and elevation from sea level is 1829 m. From the historical data, it is found that during the North-East monsoon, between October and December, a precipitation of 549 mm is received in 24 rainy days and during the South-West Monsoon 537 mm is received from June to September in 27 rainy days. In summer, 332 mm of rainfall is received in 11 rainy days between March and May. The annual average rainfall in the district is 1465 mm with a maximum of around 247 mm in October and a minimum of 21 mm in February.

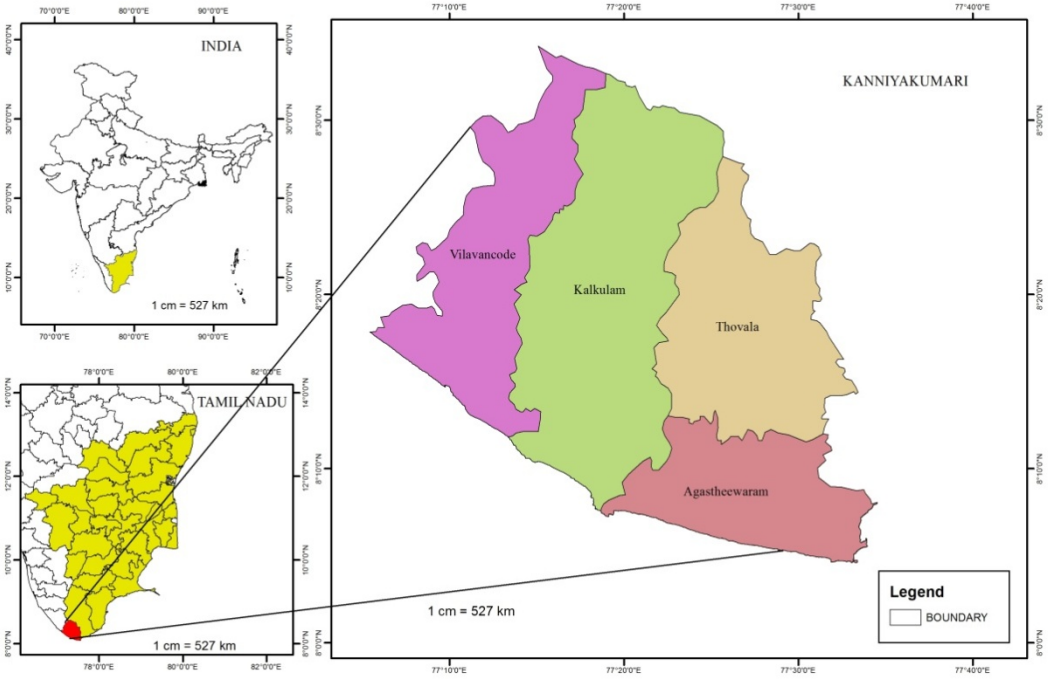


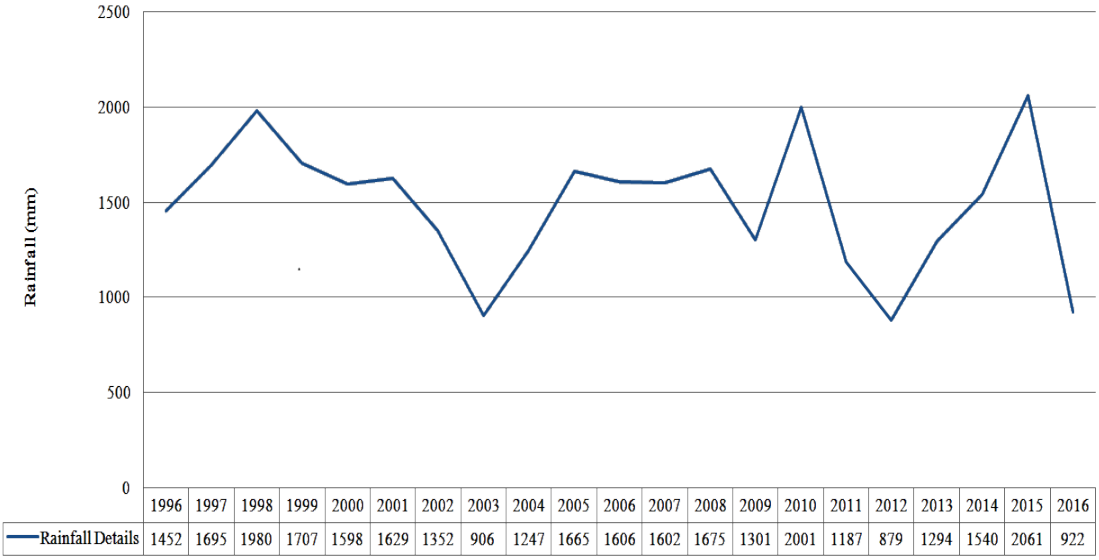
Figure 1. Map showing the study region

Vulnerability Assessment

Vulnerability indicates the population's capacity to anticipate and recover from the impact of hazardous event. Vulnerable populations usually include those with low incomes, individuals who may be chronically or terminally ill, physically or mentally disabled, homeless, or uninsured or underinsured; and the elderly, children, and pregnant women. One ongoing area of vulnerability is the surge capacity for large-scale events. During the response phase, (96 hours after the disaster occurs), the affected communities are coupled with stress that need immediate and specialized first aid services[10]. A Vulnerability assessment is the significant step in the emergency response to a disaster. It shall methodologically evaluate the degree of impact and provide background information to create a targeted disaster mitigation plan.

Social Vulnerability: Social vulnerability refers to the resilience of communities when affected by external stresses on human health, such as natural or human-caused disasters, or disease outbreaks. When there is disastrous event, some citizens such as children, elderly people and other physically challenged people may be unable to protect them or evacuate if necessary. The concept of vulnerability also involves socio-economic factors that affect community resilience[11].

Physical Vulnerability: According to UNISDR, the physical vulnerability may be determined by aspects such as population density levels, remoteness of a settlement, the site, design and materials used for critical infrastructure and for housing. The physical vulnerability of a region also depends on its geographic proximity to the source, meteorological parameters and origin of the disasters e.g. if region lies near the coast it makes the area more vulnerable to disasters as compared to an area that is far away from the origin of the disaster. The present study analyzed the rainfall pattern of the study area for two decades (Figure 2).



	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Rainfall Details	1452	1695	1980	1707	1598	1629	1352	906	1247	1665	1606	1602	1675	1301	2001	1187	879	1294	1540	2061	922

Figure 2. Rainfall pattern of the study area (Source: IMD).

Risk Assessment

Risk assessment is a key parameter for disaster strategy planning. There are many non-completeness perpetual problems in disaster risk analysis and research. The implementation of risk assessment in the study area is usually limited due to the constraints of obtaining data in real applications. The quantum of flood area affected along the coastal region is analyzed statistically in Table 1 and vulnerability profile is depicted in Figure3. This region is manifested with marine terrace, sand dunes, beach ridges, estuaries, floodplains, beaches, mangroves, uplands, sea cliff, etc.

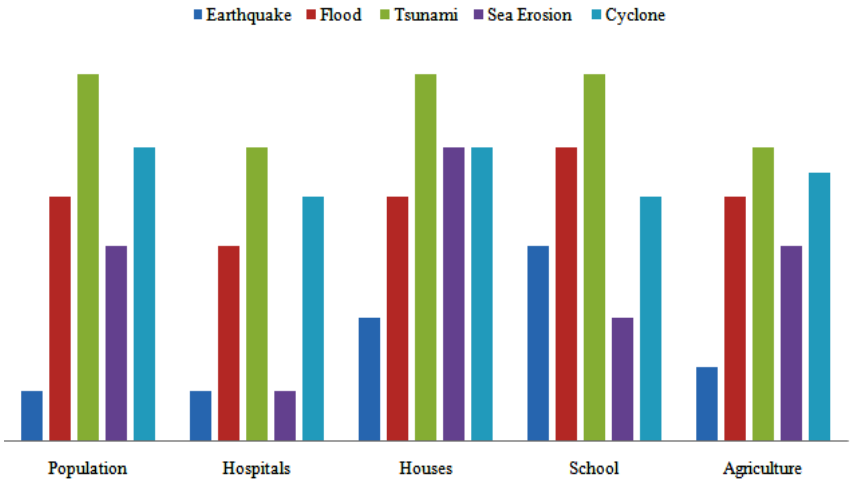


Figure 3. Vulnerability profile of Agastheeswaram region

Table 1. Flood hazard profile

Sl. No.	Areas affected by flood	1992	2010	2016
1	Kanniyakumari	NA	√	√
2	Azhagappapuram	√	√	√
3	Agsteeswaram	NA	√	√
4	Kottaram	NA	√	√
5	Thamaraikulam	√	NA	√
6	Nagercoil	√	√	√
7	Vadiveeswaram	√	√	√
8	Vadaseri	√	√	√
9	Neenadakarai (Block - A)	NA	√	√
10	Vembanoor	NA	√	√
11	Suchindrum	√	√	√
12	Theroor	√	√	√
13	Kulasekarapuram	NA	√	√
14	Marungoor	√	√	√
15	Eraviputhoor	√	√	√
16	Parakkai	NA	√	√
17	Thengamputhoor	NA	√	√
18	Mathusoothanapuram	NA	√	√
19	Neendakarai (Block - B)	NA	√	√
20	Dharmapuram	NA	√	√

Capacity

The term ‘capacity’ is the combination of all the strengths, attributes and resources available within a community, society or organization that can be used to achieve agreed goals (NIDM).The proper disaster planning could motivate people, organizations and society systematically and develop their capacities over time to achieve social and economic goals. In Kanniyakumari district primary health care delivery system to the rural has been provided by nine block primary health centers, twenty seven additional primary health centers, six urban primary health center and two hundred and sixty seven health sub-centers. From these health centers, curative and preventive services are being extended to the rural community. There are four primary health centers located in Agastheeswaram taluk. Additionally, twenty seven numbers of sub primary health centers. The emergency ambulance service for the district is nine regular ambulances and one neonatal ambulance of which totally nine hundred and fifty nine trips per month.

		Severity				
Probability		Low	Medium	High	Very High	Catastrophic
		1	2	3	4	5
Frequent	A	1A	2A	3A	4A	5A
Probable	B	1B	2B	3B	4B	5B
Occasional	C	1C	2C	3C	4C	5C
Remote	D	1D	2D	3D	4D	5D
Improbable	E	1E	2E	3E	4E	5E

Low Vulnerable
Medium Vulnerable
Highly Vulnerable

Risk Matrix

The risk is the amount of hazard that occurred to the vulnerability level at the existing capacity over a specific time period. The combination of probability of an event and its negative consequences.

Risk = (Hazard x Vulnerability) / Capacity

In fact, the amount of risk is usually categorized into a small number of levels because neither the probability nor harm severity can typically be estimated with accuracy and precision. In this case, there is need of quantitative assessment to evaluate the level of risk for any hazard events.

Conclusions

The study of quantitative risk assessments of vulnerability along the coastal region has been conducted. It is noted that the proportion of population density and literacy rate is relatively high and hence, the communities and stakeholders along the coastal region are prone to moderate vulnerability. The rainfall pattern analysis helps to interpolate the physical vulnerability of the region which tends to be a flood severe zone. Finally, the methodology adopted for the risk matrix indicates that the study region falls under the category 4C. Therefore, the result concludes that the region under the study have very high severity if the probability of occurrence is occasional.

Acknowledgments

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Process safety management systems in accident prevention

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Abstract
Unexpected releases of toxic, reactive, or flammable liquids and gases in processes involving highly hazardous chemicals have been reported for many years. Incidents continue to occur in various industries that use highly hazardous chemicals which may be toxic, reactive, flammable, or explosive, or may exhibit a combination of these properties. Regardless of the industry that uses these highly hazardous chemicals, there is a potential for an accidental release any time they are not properly controlled. This, in turn, creates the possibility of disaster. In this review, a detailed study is made on how the standard works, and the procedure to implement the various standards are analyzed for the eradication of unsafe acts and unsafe conditions in an industrial environment to prevent disasters.

Key words: process, hazards, information, OSHA

Introduction

Major disasters can be seen as being process failures and human-made, the reason being that human actions before the strike of the hazard can prevent it developing into a disaster. Although these major disasters involving highly hazardous chemicals drew national attention to the potential for major catastrophes, the public record is replete with information concerning many other less notable releases of highly hazardous chemicals. Hazardous chemical releases continue to pose a significant threat to employees and provide impetus, internationally and nationally, for authorities to develop or consider developing legislation and regulations to eliminate or minimize the potential for such events.

OSHA is part of the United States Department of Labor. With the Occupational Safety and Health Act of 1970, Congress created the Occupational Safety and Health Administration (OSHA) to assure safe and healthful working conditions for working men and women by setting and enforcing standards and by providing training, outreach, education and assistance. On July 17, 1990, OSHA published in the Federal Register (55 FR 29150) a proposed standard,-"Process Safety Management of Highly Hazardous Chemicals"-containing requirements for the management of hazards associated with processes using highly hazardous chemicals to help assure safe and healthful workplaces.

Elements of Process Safety Management (PSM)

OSHA's proposed standard emphasized the management of hazards associated with highly hazardous chemicals and established a comprehensive management program that integrated technologies, procedures, and management practices. The process safety management program is divided into 14 elements. The U.S. Occupational Safety and Health Administration (OSHA) 1910.119 define all 14 elements of process safety management plan.

- Process Safety Information
- Process Hazard Analysis
- Operating Procedures
- Training
- Contractors
- Mechanical Integrity
- Hot Work
- Management of Change

- Incident Investigation
- Compliance Audits
- Trade Secrets
- Employee Participation
- Pre-start up Safety Review
- Emergency Planning and Response

All of those elements mentioned above are interlinked and interdependent. There is a tremendous interdependency of the various elements of PSM. All elements are related and are necessary to make up the entire PSM picture. Every element either contributes information to other elements for the completion or utilizes information from other elements in order to be completed.

How the Standard Works

The standard mainly applies to manufacturing industries-particularly, those pertaining to chemicals, transportation equipment, and fabricated metal products. Other affected sectors include natural gas liquids; farm product warehousing; electric, gas, and sanitary services; and wholesale trade. It also applies to pyrotechnics and explosives manufacturers covered under other OSHA rules and has special provisions for contractors working in covered facilities. In each industry, PSM applies to those companies that deal with any of more than 130 specific toxic and reactive chemicals in listed quantities; it also includes flammable liquids and gases in quantities of 10,000 pounds (4,535.9 Kg) or more. To understand PSM and its requirements, employers and employees need to understand how OSHA uses the term "process" in PSM. Process means any activity involving a highly hazardous chemical including using, storing, manufacturing, handling, or moving such chemicals at the site, or any combination of these activities.

Process Safety Information: Employers must complete a compilation of written process safety information before conducting any process hazard analysis required by the standard. The compilation of written process safety information, completed under the same schedule required for process hazard analyses, will help the employer and the employees involved in operating the process to identify and understand the hazards posed by those processes involving highly hazardous chemicals. Process safety information must include information on the hazards of the highly hazardous chemicals used or produced by the process, information on the technology of the process, and information on the equipment in the process. Information on the hazards of the highly hazardous chemicals in the process shall consist of at least the Toxicity, Permissible exposure limits, Physical data, Reactivity data, Corrosivity data, and Thermal and chemical stability data, and hazardous effects of inadvertent mixing of different materials. Information on the technology of the process must include a block flow diagram or simplified process flow diagram, Process chemistry, Process conditions, etc. Where the original technical information no longer exists, such information may be developed in conjunction with the process hazard analysis in sufficient detail to support the analysis. Information on the equipment in the process must include Materials of construction, Piping and instrument diagrams (P&IDs), Relief system design and design basis, etc. The compilation of the above described process safety information provides the basis for identifying and understanding the hazards of a process and is necessary in developing the process hazard analysis and may be necessary for complying with other provisions of PSM such as management of change and incident investigations.

Process Hazard Analysis: The process hazard analysis is a thorough, orderly, systematic approach for identifying, evaluating, and controlling the hazards of processes involving highly hazardous chemicals. The employer must use one or more of the following methods, as appropriate, to determine and evaluate the hazards of the process being analyzed:

- What-if,
- Checklist,
- What-if/checklist,

- Hazard and operability study (HAZOP),
- Failure mode and effects analysis (FMEA),
- Fault tree analysis, or
- An appropriate equivalent methodology.

A discussion of these methods of analysis is contained in the companion publication, OSHA 3133, *Process Safety Management - Guidelines for Compliance*. The employer must establish a team for findings and recommendations and ensure that the recommendations are resolved in a timely manner and that the resolutions are documented.

Operating Procedures

The employer must develop and implement written operating procedures, consistent with the process safety information, that provide clear instructions for safely conducting activities involved in each covered process. OSHA believes that tasks and procedures related to the covered process must be appropriate, clear, consistent, and most importantly, well communicated to employees. The procedures must address the steps for each operating phase include Initial start-up; Normal operations; Temporary operations; Emergency shutdown, including the conditions under which emergency shutdown is required, and the assignment of shut down responsibility to qualified operators to ensure that emergency shutdown is executed in a safe and timely manner. Operating limits should consider the Consequences of deviation, and steps required to correct or avoid deviation. The employer must develop and implement safe work practices to provide for the control of hazards during work activities such as lockout/tag out, confined space entry, etc., and these safe work practices must apply both to employees and to contractor employees.

Employee Participation

Employers must develop a written plan of action to implement the employee participation required by PSM. Under PSM, employers must consult with employees and their representatives on the conduct and development of process hazard analyses and on the development of the other elements of process management, and they must provide to employees and their representatives access to process hazard analyses and to all other information required to be developed by the standard.

Training

OSHA believes that the implementation of an effective training program is one of the most important steps that an employer can take to enhance employee safety. Accordingly, PSM requires that each employee presently involved in operating a process or a newly assigned process must be trained in an overview of the process and in its operating procedures. Refresher training must be provided at least every three years, or more often if necessary, to each employee involved in operating a process to ensure that the employee understands and adheres to the current operating procedures of the process.

Contractors

Application - Many categories of contract labor may be present at a jobsite; such workers may actually operate the facility or do only a particular aspect of a job because they have specialized knowledge or skill. Others work only for short periods when there is need for increased staff quickly, such as in turnaround operations. PSM includes special provisions for contractors and their employees to emphasize the importance of everyone taking care that they do nothing to endanger those working nearby who may work for another employer. PSM, therefore, applies to contractors performing maintenance or repair, turnaround, major renovation, or specialty work on or adjacent to a covered process. It does not apply, however, to contractors providing incidental services that do not influence process safety, such as janitorial, food and drink, laundry, delivery, or other supply services.

Employer Responsibilities: When selecting a contractor, the employer must obtain and evaluate information regarding the contract employer's safety performance and programs. The employer also must inform contract employers of the known potential fire, explosion, or toxic release hazards related to the contractor's work and the process; explain to contract employers the applicable provisions of the emergency action plan; develop and implement safe work practices to control the presence, entrance, and exit of contract employers and contract employees in covered process areas; evaluate periodically the performance of contract employers in fulfilling their obligations; and maintain a contract employee injury and illness log related to the contractor's work in the process areas.

Pre-Start-up Safety Review

It is important that a safety review takes place before any highly hazardous chemical is introduced into a process. PSM, therefore, requires the employer to perform a pre-startup safety review for new facilities and for modified facilities when the modification is significant enough to require a change in the process safety information. Prior to the introduction of a highly hazardous chemical to a process, the pre-startup safety review must confirm that the following:

- Construction and equipment are in accordance with design specifications;
- Safety, operating, maintenance, and emergency procedures are in place and are adequate;
- A process hazard analysis has been performed for new facilities and recommendations have been resolved or implemented before start-up, and modified facilities meet the management of change requirements; and
- Training of each employee involved in operating a process has been completed.

Mechanical Integrity

OSHA believes it is important to maintain the mechanical integrity of critical process equipment to ensure it is designed and installed correctly and operates properly. PSM mechanical integrity requirements apply to the following equipment:

- Pressure vessels and storage tanks;
- Piping systems (including piping components such as valves);
- Relief and vent systems and devices;
- Emergency shutdown systems;
- Controls (including monitoring devices and sensors, alarms, and interlocks); and
- Pumps.

Hot Work Permit

A permit must be issued for hot work operations conducted on or near a covered process. The permit must document that the fire prevention and protection requirements in OSHA regulations (1910.252(a)) have been implemented prior to beginning the hot work operations; it must indicate the date(s) authorized for hot work; and identify the object on which hot work is to be performed. The permit must be kept on file until completion of the hot work.

Management of Change

OSHA believes that contemplated changes to a process must be thoroughly evaluated to fully assess their impact on employee safety and health and to determine needed changes to operating procedures. To this end, the standard contains a section on procedures for managing changes to processes. Written procedures to manage changes (except for “replacements in kind”) to process chemicals, technology, equipment, and procedures, and change to facilities that affect a covered process, must be established and implemented. These written procedures must ensure that the following considerations are addressed prior to any change:

- The technical basis for the proposed change,
- Impact of the change on employee safety and health,

- Modifications to operating procedures,
- Necessary time period for the change, and
- Authorization requirements for the proposed change.

Incident Investigation

A crucial part of the process safety management program is a thorough investigation of incidents to identify the chain of events and causes so that corrective measures can be developed and implemented. Such an incident investigation must be initiated as promptly as possible, but not later than 48 hours following the incident. The investigation must be by a team consisting of at least one person knowledgeable in the process involved, including a contract employee if the incident involved the work of a contractor, and other persons with appropriate knowledge and experience to investigate and analyze the incident thoroughly. An investigation report must be prepared and must keep these incident investigation reports for 5 years.

Emergency Planning and Response

If, despite the best planning, an incident occurs, it is essential that emergency pre-planning and training make employees aware of, and able to execute, proper actions. For this reason, an emergency action plan for the entire plant must be developed and implemented in accordance with the provisions of other OSHA rules (29 CFR 1910.38(a)).

Compliance Audits

To be certain process safety management is effective, employers must certify that they have evaluated compliance with the provisions of PSM at least every three years. This will verify that the procedures and practices developed under the standard are adequate and are being followed. The compliance audit must be conducted by at least one person knowledgeable in the process and a report of the findings of the audit must be developed and documented noting deficiencies that have been corrected. The two most recent compliance audit reports must be kept on file.

Trade Secrets

Employers must make available all information necessary to comply with PSM to those persons responsible for compiling the process safety information, those developing the process hazard analysis, those responsible for developing the operating procedures, and those performing incident investigations, emergency planning and response, and compliance audits, without regard to the possible trade secret status of such information. Nothing in PSM, however, precludes the employer from requiring those persons to enter into confidentiality agreements not to disclose the information.

Conclusions

Any facility that stores or uses a defined "highly hazardous chemical" must comply with OSHA's process safety management (PSM) regulations would be an inherently safe work place.

References

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Mainstreaming a tributary into DRR: status of transgenders and need of identification as vulnerable in the view point of inclusive operations of Disaster Risk Reduction

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An effective resilient community should have projected social integrity and inclusion with entire sections of it. At the same time the inclusive development of the nation in the way of DRR should have addressed vulnerable minority groups in an effective manner. Here is the relevance of transgender policy. In Kerala, being as the first state which produced policy for LGBT persons, it has been addressed the vulnerability of them in their normal life. The concerned programmes for gender issues and the issues of many 'defined vulnerable groups' achieved a best result in DRR with participatory approach. But these concerns in this way remarkably /notably touched not the TGs. It has several reasons like, no reported issues /case studies are available, mainly; but it does not mean that there is no issue. In this scenario the mode of development which followed by a disaster is exclusive of this minority group. The vulnerability definition does not consider TG's because the physical capability for survival is normal or above than other vulnerable groups such as women, aged, children and differently abled persons. It is only the advantage of response /rescue phase; by the next stages the life is same as before to the TG's - disastrous. There is no damage assessment and mitigation criteria's do identify them as victims. Being a potential resourceful person who can contribute much to the nation like anyone else here the exclusion will harmfully impact the concepts and reality of resilience.

Focus: *to find out the ways forward for TG's can ensure their 'rights' in disaster management process and LGBT policy.*

Objectives: 1) To rectify the vulnerability gradient of TG's 2) to promote TG inclusive DRR. The current status of TGs in Kerala: according to the state LGBT policy here are more than 25,000 TG persons identified in Kerala. Apart from this, an average of 200 identified persons are belonging to each district, and the number may be ascend when it could cover the unidentified persons in current situation, which is realized by some authorized organizations. These persons are leading a life by struggling to several social injustices and exclusion. Discarded/displaced by own families, without proper education, job accessibility and permanency, more over the dignity and identity are the crucial challenges to maintain a normal life here. The basic needs are obstructed. Being in unorganized, denied, unidentified conditions the occurrence of complete exclusion put challenges against strengthening them towards risk reduction. Notably the vulnerability is visible in the reach of education in disasters and mitigation are not yet directed towards them anyway. Adding one thing, the quality less cheap rate rental dwellings at high risk areas, they using as displaced persons also a major threat which identified in other states. In Kerala also the displacement is the major challenge in organizing them.

Legal Protection and provisions

The DM act (2005 India), and LGBT Policy (2015, Kerala) promotes the social integrity of nation focusing on the reduction of risks and achievements of dignity of life. In DM Act (2005, India) Chapter XI-Miscellaneous-61: *while providing compensation and relief to the victims of disaster, there shall be no discrimination on the ground of* ***sex****, caste, community, descent or religion.* In the objectives of Kerala DM policy it has put forwarded the *capacity strengthening of vulnerable communities with special emphasize on empowerment of women*. The vision of Kerala policy for DM constitutes: *a safer community and better quality of life in the state through holistic and comprehensive disaster management services*. It is very important to rethink and redefine the vulnerability criteria based on the above mentioned citations and ground realities according to the universal human rights article 3 as right to life, liberty and personnel

security. Later the special emphasizes touched the differently abled people with a scientific rectifications and started implementation in Kerala.

Situation analysis between normal and disaster situations to TGs

Usually the disasters are defined as the most critical circumstances of so many people's life, but in the case of TGs it has a life time dominancy. On this rationale, the situation analysis should be based on listed natural and man-made disasters. The aftermaths of the social exclusion and denial had made them lead an uncertain nomadic life. Based on the case studies and interactions the self-survival capacity is sufficient, but they lack the common communications and awareness about disasters and management. In the case of already defined groups to vulnerability, they are getting proper trainings, awareness, strengthening, involvement at several levels with the support of entire system and may have proper shelters. In this background being as unorganized and isolated person/group from the society, the vulnerability of TGs are very high. The vulnerability status has been derived from the study of issues at different stages of disasters management. *During disasters: don't know how to act due to the exclusion of preparedness activities. The common human imprints towards survival are accelerating the actions. In rehabilitation: the gender based issues in temporary shelters and sanitation facilities. No consideration as a victim who need to rehabilitate properly as others. During reconstruction: no consideration in resilience, including infrastructure and further life with a reliable source of income. And lack of proper community based rehabilitation programmes.* The main barrier could be listed as ignorance/lack of education about the nature of disasters and response skills and strategies. Important thing is how the entire machinery is working, is totally unaware to them. If the fortune could save them from any hazard, they may not be considered as victims to the particular disaster, as they don't have proper identity or proofs /documents that stand for them. The trend of similar people getting /gathering at an isolated place and leading their life in their own styles has history of long back, and unfortunately they are continuing the same.

Social hurdles

The communities in Kerala are still stuck under certain communal and cultural concepts against gender. They have the attention of government, that has been paid in the form of the policy and certain agencies/ NGO's are working for this. And at the same time, to make adequate interventions to society is under process. In that situation, the social acceptance to TGs has to be happening at first stage, then only the confidence to face the world will create in those persons. The social considerations through several areas can mainstream them. The collective results can further contribute to the participation level. Here the CBDRM can take an outstanding place with the inclusion of transgender persons effectively, which can also lead to an effective social integrity and inclusive of TG concerns, and which can also lead to an effective social engineering. In the meaningful shades of LGBT policy, the opportunities such as education, employment, other income generation activates direct accessibility to services, when promoted, the social hurdles shall be vanished.

Mainstreaming TGs in DRR

When comparing the population status of TGs, it is a fact that it is very low. There is no specific citation in defined vulnerable groups in the DM policy and acts, which can be justified as just due to the negligible number of them. And the physical vulnerability is also negligible. As per the LGBT policy identifies, they are multi potentials in so many levels, and it strongly stands for their accessibility towards all kinds of supports and assistance. In the view point of DRR, just because of the uncertainty of gender, how a community can isolate persons? If they are stranded out of the society into their own communication comforts, how they can become resilient from disasters? The TGs is also a part of community. The disaster and management education though available unions at different levels of community is the best way out of this struggle. In the case of TGs there are no reliable sources of income or they are not skilled in such a way just like what women empowerment programmes have done so far. Livelihood promotion among them, should make the well-being as a priority. Capacity building through community based rehabilitation is what the inclusion process should focus. After an effective period of interventions, it can be optimized based on the available legal protection and policies, the social engineering will occur towards resilience.

Conclusion

In Kerala among TGs there are married persons and persons having their own houses. Though the major portion of them are displaced persons without any documents which prove they belong to the nation. The importance of mainstreaming TGs in DRR aspect is that, the disasters are good trigger for the development, but when a hazard strikes only the realization and identification of vulnerabilities and future risks is getting its proper attention. And the people are getting prior consideration, though unfortunately we are losing the weaker sections of the society in every disaster. Apart from death toll, the forthcoming development followed by this is building up the resilience. And the resilience must ensure participation of every weaker section especially treating TGs a vulnerable persons towards disasters.

Lightning detection, alert, capacity building, protection and safe grid management system

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Introduction

Jharkhand accounts for an average 200 deaths per year due to lightning, against national average of 400 deaths per year. The deaths due to lightning are frequently reported in Odisha, West Bengal and Bihar too. Rather Lightning is a national disaster. Due to the prevalent geographical conditions that are undulating hilly topography, deciduous monsoon jungles, low altitude clouds, rich mineral content etc., during the monsoon from June to September, especially in initial and terminal phase of monsoon, lightning causes huge loss to life and property. The reported loss of life has been highest 247 in 2007 and the death toll during the last three years and the compensation paid out of State budget for the same is as under:

Ser	Year	Deaths due to lightning (in Number)	Amount of compensation paid (in Rupees)
1.1	2011-12	139	1,47,22000
1.2	2012-13	160	2,22,24000
1.3	2013-2014	183	2,90,20550
1.4	2014-15	204	4,67,00000
1.5	2015-2016	148	3,10,00000
	Total	632	14,36,66,550

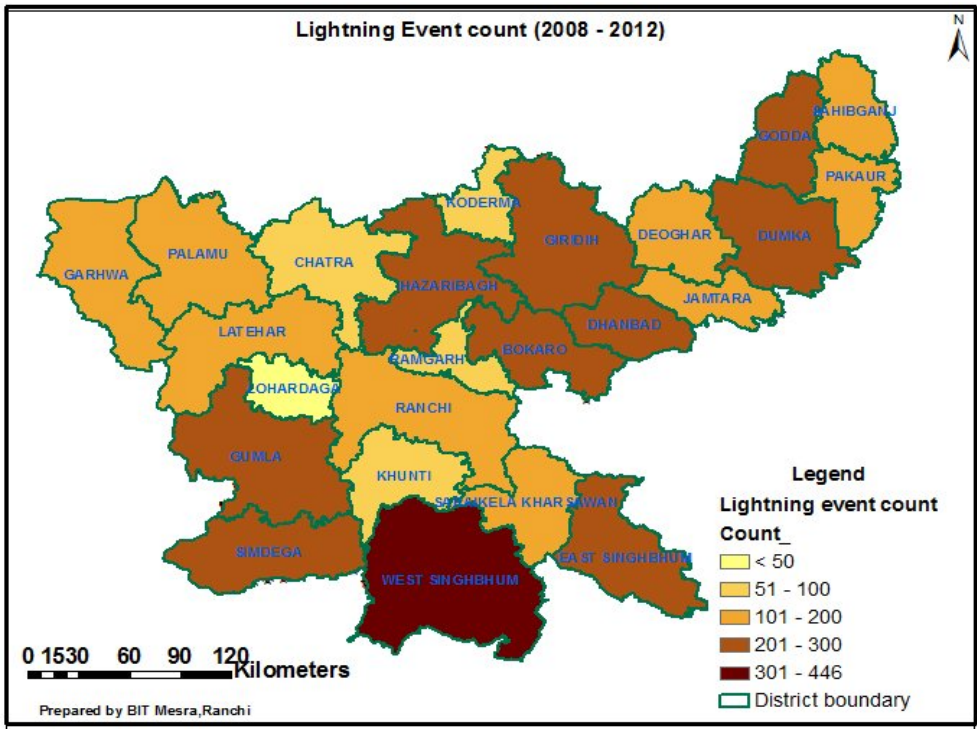
Lightning Action Plan

Government of Jharkhand carried out detailed analysis of the root cause of frequent lightning in Jharkhand in coordination with international and national agencies and a Lightning Action plan has been made to minimize the losses as well as to mitigate, prevent lightning impacts the salient aspects of which are as follows:-

HRVC Mapping of Lightning prone zones in Jharkhand.
- Detection of Lightning/storm
- Alert /warning system
- Enhance preparedness
- Prevention and Mitigation
- Capacity Building
  - Training
  - Awareness
- Safe Grid- Creation of safe grid
- Monitoring, evaluation and Review.

Implementation

Zone Mapping. The lightning has varied intensity and frequency. The Zonation of lightning undertaken by Birla Institute of Technology (BIT), Mesra, Ranchi in collaboration with NASA, U.S.A., has identified level of lightning as Level I in fifteen districts and Level II in rest of nine districts which is given below:-



Lightning Detection System

The lightning detection system is multi tiered system and the state gets inputs from mainly sensor set up by Earth Networks, USA, Boltek Weather Alert system and Met Center, Indian Meteorological Department, Ranchi. This is an App based system and the same is disseminated through various medium to effected masses.

Alert/ Warning System

Based on the alert received through warnings on Mobile App and other means, the same is re-communicated to masses. There is a field hooter system also, which can be installed to alert masses and direct them to safe grids/ shelters.

Lightning Warning System

Lightning Safe Grid at Deoghar

Lightning Safe Grid.

Based on expected intensity of lightning, Lightning arresters are installed in series to make the lightning safe. The lightning arresters are devices which arrest the lightning before it is formed and hence there is no sound and light. However, the same is recorded by an electronic counter. Based on above fundamentals, there has been sharp decrease in loss of lives and property.

Conclusion

Lightning is a constant killer and the same needs to be tackled elaborately to address its adverse impacts.

Drought severity assessment and mapping in the drier region of Karnataka, India

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Abstract
Droughts, one of the major disasters that would impact the amount of water available to crops grown in areas and therefore a detailed monitoring of droughts on spatial and temporal scales is essential for the social and economic growth of the region. The present study focuses on drought assessment with an aim to understand the drought vulnerability estimates and map the drought duration and severity in drier, drought prone North Interior Karnataka region. Geographically, this region occupies nearly half the State, and comprises of seven districts and experience severe drought conditions. Time series of rainfall with data for more than 45 years available from 165 stations in the study region has been employed to understand the drought characteristics. Rainfall descriptive, variability, percentage occurrence of drought incidences and spatial distribution of rainfall were derived. Drought severity were estimated using Ponce et al (2000) model which characterize drought based on intensity, duration and recurrence interval based on mean annual precipitation and annual global terrestrial precipitation. Drought conditions were interpreted for each of these locations and the map is prepared using geographic information system. Results indicate that the region is mostly semi-arid which has undergone drought in more than 55% of the occasions. The occurrence of droughts with moderate intensities was high compared to severe intensities and extreme drought intensities were observed only on few occasions. Analysis indicates that severe drought conditions were observed in almost 40% of the area and only a less percentage (9%) was under moderate drought. The results confirmed that the area is under severe drought for a period of more than 10-15 % of the total events with an average intensity of more than 2.2. Increasing drought severity has been forecast in this region due to declining rainfall, increasing temperature caused due to climate change. The outcome of the study would be useful in understanding the drought pattern, severity and extent in the study area which can be used by scientists and water management professionals so as to plan drought mitigation measures.
Key words: Drought, Severity mapping, Karnataka, Rainfall analysis, Geographic Information Systems.

Introduction

Droughts are among the most costly disasters over the World. Drought is a complex, multifaceted phenomenon (Eg. Van Loon 2015). Unlike many other natural hazards, drought develops slowly, making it difficult to pinpoint the onset and termination of an event. It is an extreme climate phenomenon that can last for weeks, months or even years. Being a natural hazard as well as a disaster (Paulo et al 2012) with extensive spatial dimension it can be characterized quantitatively for their spatial extent, intensity and duration. Frequency and vulnerability of drought are also important characteristics that define droughts. These parameters help in assessing the drought and help in preparedness and planning to cope with the adverse impact of drought events (Misra and Singh, 2011)

Droughts are assessed by simple mathematical indices, which is a single number that characterize droughts in terms of their intensity, duration, frequency and spatial extent (Wilhite et al 2000). Drought planners rely on these indices to decide when to start interventions and decide mitigation and adaptation strategies (Ponce and Pandey, 2000). There are a variety of indices that describe drought based on the classification whether it is meteorological, agricultural, hydrological or socio-economical (White and Walcott, 2009, Lloyd and Hughes, 2013). All drought types originate with deficiency in precipitation and are based on rainfall analysis to assess the impact.The Index of Palmer Drought Severity-IPDS (Palmer, 1965), Standardized Precipitation Index-SPI (McKee et al 1993), Reconnaissance Drought Index RDI (Tsakiris and Vangelis, 2005, Tsakiris et al 2007), Standardized precipitation evaporation index --SPEI) (Masud et al 2015), Stream flow drought index (SDI) Nalbandis and Tsakiris, 2008, Madagar and Moradkhani, 2013) are few commonly used indices in drought assessment. Some of these are region

specific and have limitation in applicability to other climatic conditions because of the inherent complexity of the drought phenomena (Jain et al 2015).

Rainfall being the single most parameter defining water shortage in a place, analysis of rainfall would be useful in defining drought characteristics. The spatial and temporal patterns of droughts are defined by the variability of rainfall (Sen, 2008). Severity, extent and knowledge on the drought vulnerability are very much essential for drought preparedness, mitigation and planning. Mapping of drought disaster is one of the adaptation strategies to consequences of increasing climatic variability and changes. The north Interior Karnataka, lying mostly on the Deccan plateau on the leeward side of Western Ghats is one of the drought prone region in the country (Nagaraja et al 2011, Devappa 2014, Jayasree and Venkatesh, 2015). With annual rainfall of nearly 500 mm, the area has a gross annual water deficit of 1500-1600 mm. Being agriculture dominant region, frequent and consequent droughts of 2001-02, 2003-04, 2009, 2012-14, 2016 resulted in huge economic loss for the State. The region has been taken under the drought prone area programme. In spite of frequent droughts, there are no comprehensive contingency plans for drought mitigation. Most of the efforts are at state level which are lacking at district or Taluk at the bottom level where the interventions would be more. Therefore it is necessary that we need to understand the drought characteristics and map the same from the bottom level so as to make the interventions would be more effective and meaningful. The present study focuses on drought assessment with an aim to understand the drought vulnerability estimates and map the drought duration and severity in drier, drought prone North Interior Karnataka region. The results would be useful for developing plans for drought management and mitigation. In this study, an attempt has been made to understand drought severity and extent based on rainfall characteristics. Spatial and temporal variability of rainfall would be analysed and drought intensity, duration and severity would be estimated. Drought severity would be mapped for the study area which would be useful for researchers, planners and policy makers to plan drought mitigation measures.

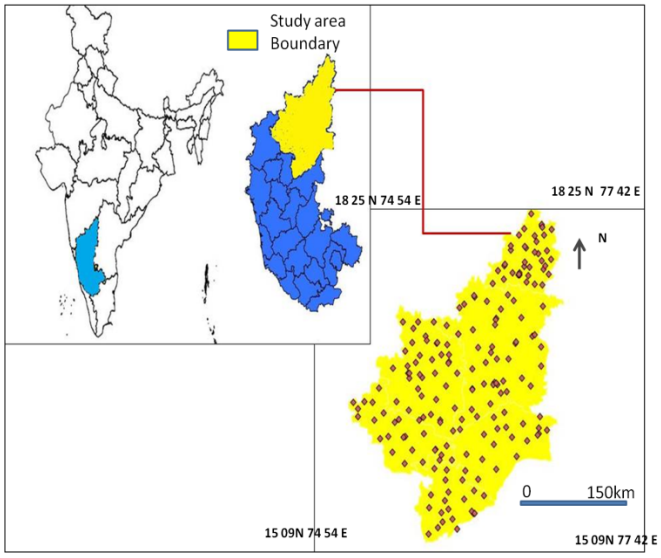

Figure 1. Study area and location of rain gauges

Study area

The study has been carried out in the most drought prone North Interior Karnataka region comprising of seven districts namely Bagalkot, Bidar, Bijapur, Gulburga, Koppal, Raichur and Yadgir distributed within 34 taluks located between 15° 09' - 18° 25' latitude and 74° 54' -77°42' E longitude. This region occupies 31.2% of the total area of the state, with almost 83% land under cultivation (KSAP, 2013) of which 70% rain fed and rest 30% area supplemented with irrigation. Region is characterized by hot, dry climate with an average annual rainfall of nearly 650 mm.

Data and methodology

Data used: Daily rainfall data for 165 rain gauge stations in the study region available for the period 1970-2015 have been used for the present study (Source. DES, Karnataka). The data have been compiled and checked for quality and consistency. Missing and erroneous data have been corrected using standard procedure. Locations of the rain gauge stations in the study area are presented in Figure 1.

Methodology: The drought intensity, duration and frequency were analyzed using the conceptual model developed by Ponce *et al.* (2000), shown in Table 1. The conceptual approach is applicable to subtropical and mid-latitudinal regions, and is limited to meteorological droughts lasting at least one year. In the Ponce *et al*. (2000) methodology, the climate types, which encompass the climatic spectrum from super-arid to super-humid, are defined in terms of the ratio of mean annual precipitation P_{ma} to (mean) annual global terrestrial precipitation P_{agt}. The ratio P_{ma} / P_{agt} = 1 represents the middle of the climatic spectrum. This enables the division of the climatic spectrum in subtropical and mid-latitudinal regions into the following eight types:

Table 1 Conceptual model of drought-intensity-duration-frequency

Type	Classification
Super-arid	$P_{ma}/P_{agt} < 0.125$
Hyper-arid	$0.125 \le P_{ma}/P_{agt} < 0.25$
Humid	$0.25 \le P_{ma}/P_{agt} < 0.5$
Semi-arid	$0.5 \le P_{ma}/P_{agt} < 1$
Sub-humid	$1 \le P_{ma}/P_{ag}t < 2$
Humid	$2 \le P_{ma}/P_{agt} < 4$
Hyper-humid	$4 \le P_{ma}/P_{agt} < 8$
Super-humid	$P_{ma} / P_{agt} \ge 8$

The conceptual model is also defined in terms of the ratio of annual potential evapotranspiration E_{ap} to mean annual precipitation P_{ma}. The ratio E_{ap} / P_{ma} = 2 describes the middle of the climatic spectrum. To complement the description, the length of rainy season L_{rs} is also indicated. The drought duration varies between 1 year at the extremes of the climatic spectrum, and 6 year at the middle.

$$\text{Stations Index (S)} = (P_{ma} - P) / P_{ma}$$

Finally, the regional annual index, RI for each year, is the average of station index of all the stations during that year. For any year for which P is the annual precipitation, drought intensity is defined as the ratio of the deficit (P_{ma} - P) to the mean (P_{ma}). For any one year, an intensity of [(P_{ma} - P) / P_{ma}] = 0.25 is classified as moderate; 0.5 is severe, and 0.75 is extreme. For drought events lasting more than one year, intensity is

$$RI = \frac{1}{N} \sum_{1}^{N} S$$

the summation of the individual annual intensities. Longer drought durations are associated with higher intensities. The dry periods (droughts) are generally followed by corresponding wet periods. Therefore, the drought recurrence interval (i.e., the reciprocal of the frequency) is always greater than the drought duration. Drought recurrence intervals increase from 2 year on the dry side of the climatic spectrum (super-arid) to 100 years on the wet side (super-humid). Drought severity has been classified under moderate, severe and extreme. Severity has been mapped using ArcView3.2 and QGIS software.

Results and Discussion

Rainfall in this region is highly variable both in space and time and so is the drought since drought characteristics are assessed from rainfall. Average annual rainfall and rainy days for the study area has been estimated using Thiessen polygon method in GIS platform. The study region receives an average annual rainfall of about 650 mm in about 48 days with maximum falls during August and September months. Rainfall variability is very high in western and north-western districts of Bijapur, Koppal and Bagalkot with average annual rainfall of 540, 548 and 578 falling within 40, 38, and 43 days. SW monsoon season is the principal rainfall season contributing almost 63%. Centrally located Raichur district receives 590 mm

in 41 days. Rainfall gradient is trending towards east and north-east in the study area. Rainfall characteristics of few stations in the study area are presented in Table 2 below. The region, being situated on the lee ward side of the Western Ghats, rainfall is dependent on the exposure of the monsoon winds and distance from the mountain belt.

Table 2. Characteristics of rainfall from selected stations

Station Name	District	Avg-rain-mm	Std-rain	CV-Rain (%)	Avg-Days	Std-Days	CV-days (%)
Galgali	Bagalkot	550.8	212.8	38.6	49	17	35.5
Gudur	Bagalkot	600.9	192.0	31.9	47	12	25.3
Kaladgi	Bagalkot	573.6	164.7	28.7	44	13	29.2
Kandgal	Bagalkot	509.8	177.1	34.7	38	14	36.5
Rabakavi	Bagalkot	533.5	165.4	31.0	50	21	43.1
Andoor	Bidar	849.1	239.7	28.2	42	12	27.3
Bidar	Bidar	920.6	243.7	26.5	69	16	22.9
Chittaguppa	Bidar	730.7	265.2	36.3	46	13	27.0
Dabka	Bidar	730.2	235.9	32.3	51	10	20.6
Nittur	Bidar	867.6	210.8	24.3	56	9	16.0
Almatti dam	Bijapur	566.3	162.0	28.6	51.3	13.3	26.0
Bijapur	Bijapur	555.4	163.6	29.5	40.0	16.0	40.1
Hhippargi	Bijapur	490.8	190.7	38.9	31.0	10.5	33.8
Nagathan	Bijapur	460.0	215.1	46.8	32.3	7.0	21.6
Zalki	Bijapur	543.0	174.0	32.0	48.6	13.2	27.2
Aland	Gulbarga	762.4	232.1	30.4	60.0	13.2	22.0
Choudapur	Gulbarga	591.6	214.7	36.3	40.5	12.9	31.9
Mhippargi	Gulbarga	538.9	216.9	40.2	38.4	12.5	32.5
Narayanpur	Gulbarga	546.8	187.2	34.2	56.4	50.4	89.3
Wadgera	Gulbarga	589.9	208.3	35.3	46.7	51.2	109.6
Bevoor	Koppal	538.3	160.9	29.9	30.7	6.2	20.3
Kinhal	Koppal	623.5	235.7	37.8	40.8	11.3	27.7
Koppal	Koppal	605.9	183.0	30.2	45.5	14.1	31.0
Munirabad	Koppal	601.7	209.0	34.7	55.8	19.6	35.2
Tavaragere	Koppal	544.0	211.0	38.8	33.1	6.9	20.9
Galad	Raichur	574.6	223.3	38.9	29.0	10.3	35.7
Hatti	Raichur	621.5	186.2	30.0	54.9	11.4	20.8
Kallur	Raichur	439.9	151.0	34.3	38.4	13.7	35.6
Raichur	Raichur	690.0	188.6	27.3	58.2	13.1	22.6
Yermearas	Raichur	619.5	197.0	31.8	52.0	17.0	32.7
Gurumitkal	Yadgir	752.0	258.8	34.4	57.4	50.1	87.3
Kakkera	Yadgir	630.5	188.6	29.9	52.2	62.1	118.9
Balichakra	Yadgir	626.5	253.9	40.5	50.7	51.8	102.1
Shorapur	Yadgir	688.4	268.4	39.0	59.7	44.4	74.3
Yadgir	Yadgir	853.2	246.7	28.9	65.9	42.2	64.1

Drought characteristics were derived for the study area Ponce et al (2000) methodology and were classified based on Table 1. The average drought intensity, duration and frequencies for selected stations are presented in Table 3. The period chosen for the calculation of indices were from 1970-2015 as most of the station has data during this period. Total percentage of drought occurrences in the study area has been estimated in addition to the average drought intensity-duration-frequencies (IDF).

Results have shown that in the study region, drought has occurred for more than 55% of the occasion half of the times in most of the stations considered for the study. The estimates of IDF show that the average drought intensity for stations in Bagalkot district is about 0.54 varying between 0.33-0.82 during the time considered. While average drought duration is about 2.5 years, some stations showed frequencies as high as 4 years. Most of the stations in Bidar district had average drought duration of more than three years. Bijapur had average intensity of 0.57 which varied between 0.22–1.11. Average drought duration was about 2.29 years with return period of 3.71 years. In Gulbarga, drought intensities varied between 1.9 and 1.23, within 2.52 years and 4 years. Yadgir showed a similar pattern to Gulbarga with variations between 0.44 and 1.18. Average drought duration was 2.92 years. The IDF pattern in Raichur and Koppal districts were closer. Maximum duration of 2.75 in Koppal was 2.75 whereas for Raichur recorded 3.36 years.

Table 3 Percentage of drought incidences, Intensity-duration-frequency (IDF) and Severity class for selected locations

Station Name	District	Drought occur	Duration	Inten	Freq.	Severity class
Galgali	Bagalkot	0.56	2.44	0.69	1.68	E
Gudur	Bagalkot	0.52	2.30	0.59	1.35	E
Kaladgi	Bagalkot	0.55	2.83	0.65	1.83	E
Kandgal	Bagalkot	0.66	2.90	0.88	2.55	E
Rabakavi	Bagalkot	0.59	2.40	0.46	1.10	S
Andoor	Bidar	0.52	2.00	0.47	0.93	S
Bidar	Bidar	0.59	2.00	0.37	0.73	S
Chittaguppa	Bidar	0.55	3.83	0.99	3.81	E
Dabka	Bidar	0.52	1.86	0.49	0.92	S
Nittur	Bidar	0.47	1.67	0.35	0.58	M
Almatti dam	Bijapur	0.47	1.88	0.47	0.88	S
Bijapur	Bijapur	0.56	2.14	0.46	1.00	S
Hhippargi	Bijapur	0.48	2.00	0.49	0.98	S
Nagathan	Bijapur	0.62	1.50	0.34	0.51	M
Zalki	Bijapur	0.59	1.60	0.32	0.90	S
Aland	Gulbarga	0.55	2.36	0.50	1.18	S
Choudapur	Gulbarga	0.56	2.63	1.03	2.72	S
Mhippargi	Gulbarga	0.61	2.33	0.65	1.53	S
Narayanpur	Gulbarga	0.57	2.67	0.68	1.80	E
Wadgera	Gulbarga	0.58	1.92	0.49	0.93	S
Bevoor	Koppal	0.50	2.29	0.53	1.20	E
Kinhal	Koppal	0.48	2.33	0.78	1.81	E
Koppal	Koppal	0.54	2.45	0.48	1.18	S
Munirabad	Koppal	0.61	2.22	0.54	1.19	E

Station Name	District	Drought occur	Duration	Inten	Freq.	Severity class
Tavaragere	Koppal	0.62	2.75	0.61	1.67	E
Galad	Raichur	0.60	2.08	0.56	1.16	S
Hatti	Raichur	0.50	2.17	0.51	1.10	S
Kallur	Raichur	0.60	3.00	0.77	2.32	E
Raichur	Raichur	0.57	2.17	0.40	0.86	S
Yermearas	Raichur	0.53	2.13	0.52	1.10	S
Gurumitkal	Yadgir	0.55	4.20	1.21	5.08	E
Kakkera	Yadgir	0.54	2.33	0.59	1.38	S
Balichakra	Yadgir	0.54	2.57	0.82	2.10	S
Shorapur	Yadgir	0.62	4.25	1.05	4.44	E
Yadgir	Yadgir	0.53	2.75	0.67	1.83	S

For all the stations, the intensities were divided into categories based on the average duration of 2.5 years and moderate (less than 0.625), severe (0.625-1.25) and extreme (>1.25). Histograms were constructed for these events and presented in Figure 2.

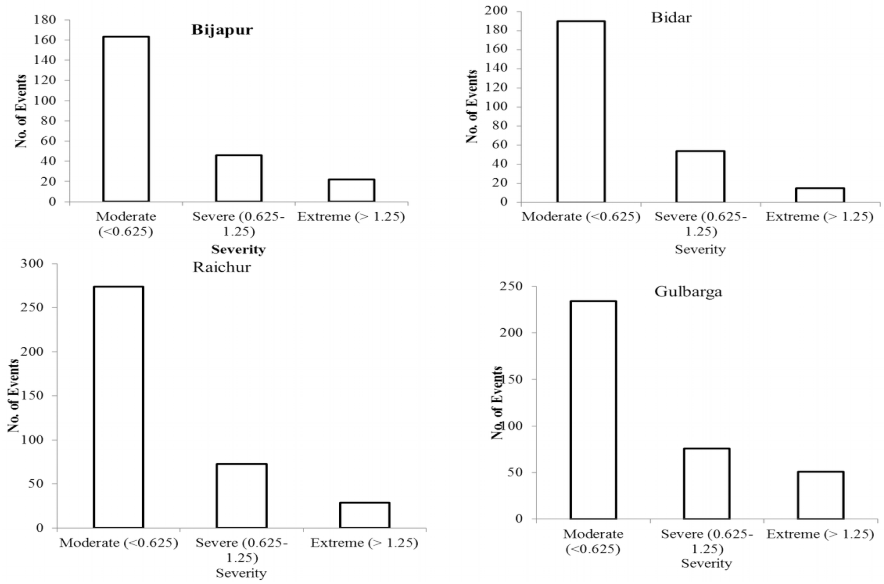

Figure 2. Histogram showing occurrences of different drought intensities

From the histograms, it is evident that most of the occurrences of drought intensities are under moderate category followed by severe and extreme intensities. Relationship between drought intensity and probability of excedance would help to predict and know the average duration of future drought and intensity based on annual rainfall values. The graphs (Figure 3) show that there are only very few high intensity drought occurrences. Events of lesser intensities occurred most of the time.

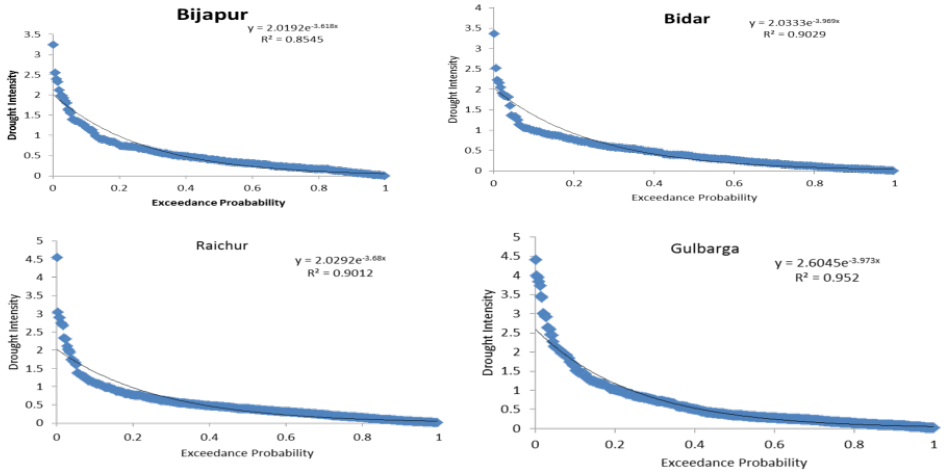

Figure 3. Relationship between drought intensity and probability of excedance.

Drought severity has been classified for all the stations in the study area and the severity map has been generated using GIS platform. Inverse distance weighing (IDW) method of interpolation has been followed in this study. Drought severity map (Figure 4) has been generated using ArcView 3.2 GIS software.

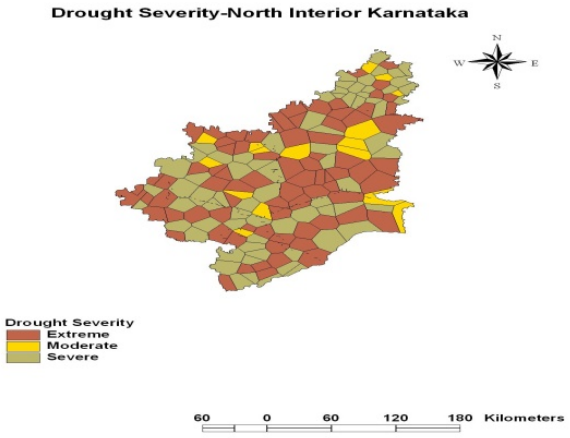

Figure 4. Map of drought severity in the study area.

Most severe and frequent droughts are noticed in the northern region. West, north and north-west regions have severe drought conditions. Extreme drought conditions persist in the central region. In the study region, about 51% areas were under severe drought 39% under extreme drought and rest under moderate drought.

Conclusion

Drought analysis of north interior Karnataka region has been carried out using climatic data available for 165 stations for the period 1970-2015. Study showed that rainfall is highly variable in space and time and therefore drought also showed variations similar to rainfall. Drought was experienced for more than 55% of the occasions with highly intense drought conditions for a period of 10-15% of the total period of study. Moderate intensity drought instances events were more compared to severe and extreme conditions and average drought condition was more than 2.2 years. Results indicate that the study area is drought prone. Rainfall forecast show a decreasing trend which implies that drought will continue even in coming decades. This type of classification using different criteria is the first attempt of this kind for defining areas with drought risks.

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Empowering local governments in disaster management: a policy initiative for sustainable governance

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Disaster results in a serious disruption of the functioning of the society, causing widespread human, material or environmental losses which often exceed the ability of the affected society to cope with it using its own resources. Disaster has been viewed as 'a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or human-made causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of property, or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area'.[1] Disaster influences the socio-economic, political and cultural aspects of the affected area. The damage caused by the disaster is not easily measurable and may likely to have ever-lasting impacts on the psyche of those affected and survived.

India has been traditionally vulnerable to natural disasters like floods, droughts, earthquakes, landslides and cyclones, on account of its geo-agro-climatic zones. Because of very large geographical size of the country, India often faces natural hazards like floods, cyclones, drought, etc. occurring frequently in different parts of the country. Significantly, some of the areas that are normally subjected to drought situations may be flooded in subsequent years and vice versa. In the National Policy on Disaster Management, it has been highlighted that 58.6 per cent of the landmass is prone to earthquakes of moderate to very high intensity; over 40 million hectares (12 per cent of land) is prone to floods and river erosion; of the 7,516 k.m. long coastline, close to 5,700 k.m. is prone to cyclones and tsunamis; 68 per cent of the cultivable area is vulnerable to drought, and hilly areas are at risk from landslides and avalanches.[2] Very large population, large number of housing units, significant size of BPL population, significant number of illiterate population, lack of sanitation coverage, non-availability of potable water to all, poor health, low nutrition intake, poor infrastructure, absence of multi-purpose institutional facilities, etc. add to the vulnerability of the country, from a disaster perspective.

Number of Disasters affected India during the last three decades, especially those occurred starting from Odisha super cyclone (1999), Gujarat earthquakes (2001), Tsunami that severely affected Tamil Nadu, Pondicherry, Kerala and Andaman & Nicobar Islands (2004), Uttarkhand floods (2013) and to the Chennai Floods (2015) point towards the need for a relook towards evolving a comprehensive approach in disaster management, with necessary thrust on the adequacy of measures for preparedness and risk reduction. Setting up of the High Powered Committee on Disaster Management was made in August 1999 with the vision of 'Disaster-free India' and this step was taken just few months prior to the Odisha super cyclone. The Committee, set up by the Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, submitted its report in October 2001, along with the National Disaster Response Plan. This was the first important initiative in India where in an attempt was made to take a look at all kinds of disasters in the country in a holistic manner.

National Centre for Disaster Management advocated for 'ushering in a new culture of disaster management that stood on the four pillars - culture of preparedness, quick response, strategic thinking and culture of prevention. The report indicates that destruction from natural hazards can be minimized by the presence of well-functioning warning systems, combined with preparedness on the part of the vulnerable community. The report comments that 'timely prevention is often far more cost effective than post disaster relief and rehabilitation'.[3] Formulation of the Disaster Management Act (2005) that laid down institutional, legal, financial and co-ordination mechanisms at different levels was the next important step. The Central Act advocated for a paradigm shift in Disaster Management from relief-centric approach to a pro-active approach that lays greater emphasis on preparedness, prevention and mitigation for conserving developmental gains and to minimise loss of life, livelihood and property.

Formulation and release of a national level policy framework was an important initiative taken up. Government of India, through the National Policy on Disaster Management (2009), visualised a holistic and integrated approach towards disaster management with emphasis on building strategic partnerships at various levels. Community based disaster management, capacity development in all spheres, etc. were some of the themes underpinning the policy. A review of the policy reveals that the Local Governments do not have any specific role, especially in disaster preparedness and risk reduction. However, while analyzing the objectives of the policy document, certain key words like traditional wisdom, developmental planning, efficient mechanism for identification, and caring approach towards the needs of the vulnerable sections of the society could be spotted. These aspects are in alignment with the attributes of Local Governments. And it is noted that in disaster preparedness and risk reduction, the Local Governments have a larger operational role than any other Government Departments/ Institutions/ Organisations. This paper analyses the specific role and functions of Local Governments in different phases of Disaster Management. This analysis was taken up with the conviction that Local Governments have an important responsibility in the pre-disaster phase, especially in Disaster Preparedness and Risk Reduction. The paper advocates the need for a policy initiative in the domain of disaster preparedness and risk reduction, with an important role for Local Governments.

Interactions and deliberations with the key informants like the elected members of Local Governments, office bearers of political organisations, functionaries of non-political/development/civil society organisations and community members provided inputs for this paper. Elected members in their capacity as local leaders and opinion makers among the community provided the important inputs. Among the elected members of Local Governments, more thrust was made to interact with young men and women, using semi-structured interview schedule. Focus Group Discussions were held with the office bearers of youth wing of major political parties across the country towards understanding their involvement and participation in disaster preparedness and risk reduction. Interactions with the functionaries of non-political organisations like Youth Clubs, mahila mandals and Self Help Groups (SHG) were also undertaken. In addition, the researcher interacted with the officials of various local level institutions like Schools, Health Centres, Anganawadis, Public Distribution System shops, Agriculture Office, etc.

Role and Functions of Local Governments in Disaster Management

It is noted that 73rd and 74th Constitutional Amendment Acts have resulted in changing the dynamics and equations of power significantly at the local level. The uniqueness of Local Government is that, it not only provides direct participation of people in administration, but also plays an important role in bringing good governance at the grassroots through various dimensions like accountability, transparency, responsiveness, equity, inclusiveness, effectiveness, efficiency and consensus. And, it is noted that there is a wide disparity in the thrust, extent and impact of functioning of the Local Governments in Disaster Management at different parts of the country. High Powered Committee on Disaster Management reported that 'Local Governments can be effective instruments in tackling disaster through early warning system. They can be relied on at the time of relief distribution, providing shelter to the victims, medical assistance, etc. since they are closer to the communities. These institutions are in a better position to undertake relevant tasks than the State and Central Governments due to their proximity to the communities'.[4]

Government of India (2009), through the National Policy on Disaster Management, indicated that local authorities like Panchayati Raj Institutions and Municipalities will ensure capacity building of their officers and employees for managing disasters, carry out relief, rehabilitation and reconstruction activities in the affected areas and will prepare Disaster Management Plans'.[5] These local authorities will play a significant role in the entire process, particularly in response and rescue operations, relief and rehabilitation, awareness generation and disaster preparedness, restoration of livelihood options and co-ordination with NGOs and civil society. However, interactions with the elected members and other key functionaries of LGIs, representatives of civil society organisations, youth volunteers, leaders of youth-wing of different political parties and other stakeholders across the country, revealed that LGIs and YOs do not find an appropriate place in disaster management in general and disaster preparedness in particular. According to the National Policy of Disaster Preparedness and Management (2010) by the Republic of Uganda, 'Disaster management is an integral part of the Local Government system. Local Governments prone to natural and human-induced hazards should take disaster risk management into consideration when developing their annual work plans and budgets. Every district shall have a district disaster policy

committee and district disaster management technical committee. It will ensure that every district captures the natural and human-induced risks and hazards that regularly affect the district in its annual work plan and budget. It is suggested that the Ministry will ensure to develop disaster preparedness plans for that local councils at all levels develop disaster preparedness plans for their area'.[6]

It is noted that Local Governments in rural and urban areas have an important role to play in disaster management, with special reference to disaster preparedness and risk reduction. Some of the major roles of Local Governments in different phases of disaster management (pre-disaster, during disaster and post-disaster) are discussed subsequently.

The role of Local Governments in the pre-disaster phase is significant, as they are expected to take appropriate measures for disaster preparedness and risk reduction. Local Government is in a better position to analyse the hazard, risk, vulnerability and capacity effectively, which is imperative in disaster preparedness and risk reduction. Local knowledge about the resources, facilities and support systems, and the alternative options are crucial in disaster preparedness. Being close to the people and bestowed with the mandate for local leadership in its functional area, the Local Government has a greater responsibility to take all possible efforts to forecast, prepare and meet any such eventualities. It is noted that 'Local Governments are in a better position to understand the social vulnerability of the natural and human-made disasters. They are expected to address differential impacts of disasters on different sections of the society, with special reference to women, children, sick, elderly and the differently abled'.[7] They are expected to formulate a Village Disaster Management Plan, which is an essential component for disaster preparedness and risk reduction and that needs to be revised at specific intervals highlighting changes in the context. During this phase, 'Local Government is expected to function as a *Leader*, through mapping of resources and facilities, formulation of a plan and constitution of a team with defined functions and responsibilities'.[8] However, interactions made by the primary author with the stakeholders from different parts of the country revealed that the measures adopted towards the disaster preparedness and risk reduction are far below expectation.

During disasters, people look up to the Local Government for addressing their basic needs, concerns and issues. Being the closest government, it is likely that the affected persons will approach the Local Government for their basic services and other requirements. Local Government is expected to gear up its activities to take all possible steps to monitor the situation and ensure that forward and backward communication is established at the earliest. 'Local Governments are expected to gather and verify that the information furnished is correct and complete to enable them to seek and receive necessary support from the District Administration and other agencies. In this phase, the Local Government is expected to perform as a *Co-ordinator and Communicator*'.[9] Interactions with the different stakeholders indicated that the LGIs across the country could play only a very limited role in this phase. During disasters, it is reported that many Local Governments did not even open a control room and wherever it was initiated, many of them did not have the facilities for communication and stand-by power supply. And no proper recording of the communication (both inward and outward) was noted. All these show that there was no sign of any significant role played by the LGIs during the disaster phase.

It is noted that Local Governments have an important role to perform in the rescue, relief, rehabilitation and reconstruction activities during the post-disaster phase. In this phase, 'it is expected to function as *Provider, Co-ordinator and Facilitator*. It has a primary function as a *Provider* of various basic services and facilities, followed by special services depending upon the local context. In addition, its role is visualised as a *Co-ordinator* as co-ordination of various activities in the field cannot be successfully carried out without the active involvement of Local Governments. Being the government institution at the grass root level, Local Government is expected to take the role of a *Facilitator* also, as they are notified as the nodal point for distribution of food and other basic services'.[10] Interactions with the elected members, officials and citizens revealed that the Local Governments played an important role during the disaster phase. They took special efforts to provide drinking water, food, clothes, medicines and other basic services. Construction of temporary shelters, running community kitchen, organising medical camps, arranging mobile medical facilities, etc. were some of the important activities carried out by the Local Governments during this phase.

It is noted that the Local Governments did not have the adequate administrative, functional and financial autonomy to conceive the requisite initiatives and interventions to function during the different phases of disaster management. It is noted that they were able to provide the services with the limited

resources and facilities at their disposal, but could not take up any long-term projects without the required support from Government Departments and other agencies. Many Local Governments have not made any process documentation of the disaster situation and could not scientifically project their requirements to the Government and other funding agencies.

Need for a Policy initiative

This section discusses certain aspects about the policy formulation process, perspectives, priority areas, strategies, etc. It is reported that 'disasters can induce poverty, making better-off people poorer and the poor destitute despite programmes aimed at fighting poverty. In policy terms this means that poverty reduction can help reduce disaster risk, but this requires an in-built, proactive focus on addressing such risk rather than seeing it as just another constraint to work within. At the same time risk reduction efforts can promote poverty reduction by helping people avoid the impoverishing effects of disasters.'[11] This points towards the significance of a policy initiative in disaster management.

The National Policy for Disaster Preparedness and Management viewed that 'the primary responsibility for disaster risk management rests with the citizens and the Government plays a supportive role. The main thrust of this policy is 'to make disaster management an integral part of the development process'.[12] While analysing the policy, it is noted that 'Local Governments, prone to natural and human-induced hazards, should take disaster risk management into consideration when developing their annual work plans and budgets. It is suggested that every district establishes a district disaster policy committee and district disaster management technical committee. It will ensure that every district captures the natural and human-induced risks and hazards that regularly affect the district in its annual work plan and budget.'[13] Significantly, this was the unique policy initiative with special thrust on pre-disaster management rather than on post-management measures. Here the citizens occupy the centre stage of operationalisation of the policy, which highlights the significance of the community taking up the ownership for its decisions and actions, which are supported by the Government.

It is viewed that 'nobody can understand local opportunities and constraints better than the local communities themselves, who therefore need to be involved in the identification and resolution of disaster vulnerability issues. Nobody is more interested in understanding local affairs than the community whose survival and well-being is at stake. Therefore, the information shall be generated in a manner and language that is understood by the community.'[14] It is noted with concern that ignoring the potentials of local resources and capacities will increase the vulnerability of the community. Here the emphasis is on Community-based disaster management which provide adequate space for active involvement of the vulnerable population in the planning and management of various measures along with the state and non-state actors.

While promoting a people-centred approach to Disaster Risk Reduction, it is viewed that 'People at risk are central to all disaster risk reduction activities. Special attention is given to promoting gender equity and the full participation of vulnerable groups including boys and girls, older people, people with disabilities, and other marginalised groups.'[15] The need for giving preference to the vulnerable population in the measures of disaster preparedness and risk reduction has been emphasised here.

Prioritisation of areas and categories is an essential aspect while dealing with disaster preparedness and risk reduction. Regarding the priority areas to be taken care during disaster risk reduction and management, it is reported that 'Disaster risk reduction is cross-cutting and bridges and emergency response, recovery and development. The three priorities that directly support disaster risk reduction for food-insecure households are: mitigating the effects of recurring natural disasters in vulnerable areas; helping poor families to gain and preserve assets; and, helping households that depend on degraded natural resources to shift to more sustainable livelihoods.'[16] This enables the system to focus the attention and resources to priority groups and categories that support disaster preparedness and risk reduction.

Disaster preparedness needs concerted efforts of various stakeholders, which includes elected members of Local Governments, officials, functionaries of youth organisations, community members, etc. 'Towards functioning effectively and efficiently during disasters, Local Governments must have the following: an organisational set up, a specific disaster management plan and capacity building of its stakeholders.'[17] The organisational set up must include representatives from all major stakeholders. It must have a disaster management plan with the details of resources, facilities and equipment for any rapid

action, and the roles, responsibilities and functions of various stakeholders must be clearly delineated.

Formulation of Village Disaster Management Plan (VDMP) is an important component in implementing Community Based Disaster Management in any area, as it is expected to empower the community to deal with disasters on their own with necessary preparedness. 'The development of disaster management plan at the village level aims at building the capacity and resilience of the community to equip them with skills so that management of various hazards becomes a way of life for them. The framework of VDMP is built around four pillars: Development of Village Disaster Management Plan; Formation of disaster management committees and teams; Conduct of mock drills; and, Generating awareness through different mediums.'[18] VDMP includes the list of activities the village is expected to follow to prevent loss of life, livelihoods and property in the event of a disaster. It identifies several steps in advance, which special reference to the action to be taken by the community members so that each individual knows what to do on receipt of a warning message or in the event of disaster.

Capacity building for the elected members of Local Governments will include mapping of the resources and facilities, mapping of vulnerable areas and points, preparation of evacuation plan, early warning and reporting system, starting of a disaster management cell at the local level, preparation of the disaster management plan for the area, etc. Building the capacity of the key functionaries of Community Based Organisations (CBO) in the locality is also very much significant. By undergoing suitable training sessions, the skills and competencies of the community members in general and youth in particular need to be enhanced, which is expected to develop their capacity to adopt suitable measures for disaster preparedness and risk reduction and integrate disaster-specific measures in their programmes and activities.

Interactions with the stakeholders from the field revealed that most of them have not received any specific training pertaining to disaster preparedness and risk reduction. The practice of keeping the details of the resources and facilities was noted in certain places, though it was not maintained keeping in view of disaster preparedness. 'Traditional wisdom and knowledge contribute significantly to take appropriate measures for disaster preparedness, but no serious effort was made to document them.'[19] Discussions with the young elected members of Local Governments, functionaries of CBOs and young citizens indicated that dynamism, energy and voluntary spirit of the youth could not be incorporated necessarily for adopting measures for disaster preparedness and risk reduction.

A policy initiative in an important domain like disaster management in a country like India with multiple geo-agro-climatic zones and diverse socio-economic features needs no special emphasis. Formulation of a policy provides for visualising the dynamics and dimensions of an important area, with specific roles and responsibilities for all major stakeholders that can pave way for better co-ordination of functions on a situation. And it is not just the policy document that emerges out, but the process through which the same has been formulated with the active ownership of all the stakeholders highlights significance. In addition, the level at which the policy has been made out is also important as it could capture the unique features of the area and specific demands/requirements of the community. In this context, the need for a policy on disaster preparedness and risk reduction at the State level is highlighted here. Number of States in India has taken measures to formulate the disaster management policy, develop the state-specific institutions and initiated programmes and activities in this direction. And while formulating the policy, the thrust on disaster preparedness and risk reduction with specific roles and responsibilities for Local Governments and Youth Organisations is to be ensured.

Conclusions

The paper analyses the major initiatives by the Government of India and examines the role and functions of Local Governments on Disaster Management. It advocates the need for a policy initiative at the state level with thrust on disaster preparedness and risk reduction with an important role for Local Governments. It is viewed that aiming at disaster preparedness and risk reduction is a better strategy as it can save thousands of lives and vital economic assets and reduce the cost involved in post-disaster measures.

Local Government is the most important political institution to realise community based disaster preparedness by ensuring active involvement of elected members of Local Governments, officials at the local levels, members of youth organisations, and other stakeholders. Local Government can analyse the hazard, risk, vulnerability and capacity effectively and there is a need to formulate a VDMP. It is in a

better position to understand the vulnerability of the disasters with differential impacts on various social categories, and integrate the same into the VDMP, which is very crucial in disaster preparedness and risk reduction. During the exercise of formulation of a policy, the requisite thrust should be given towards ensuring the ownership of the local leadership and involvement of community members in the whole process. Formulation of a policy on disaster preparedness and risk reduction with a central role for Local Governments will add traction to the several initiatives towards realising sustainable governance.

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Management of animals in disasters

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Disaster is the occurrence of a sudden event which disrupts the normal functioning of the community beyond the capacity to cope and the operational activities required to prepare, mitigate and respond to disasters is known as Disaster Management. Hazards such as floods, cyclones, tsunamis and earthquakes are the potential events which trigger the situation which poses a level of threat to life of people and animals, health, property and environment. The ability to hold, receive or absorb the shocks of disaster varies from community to community depending on the exposure and the capacities.

The common feature on the field were disaster affected households often refuses to evacuate without their animals whereas survived population of animals often get deprived of food, shelter, water and health care during emergencies. The animal welfare which is a complete state of physical, mental and social wellbeing, where the five freedoms are ensured such as freedom from hunger & thirst, freedom from discomfort, freedom from pain, injury and disease, freedom to express normal behavior and freedom from fear and distress. The animal welfare often gets compromised as animals are exposed to the disaster impacts. There can be immediate impact on animals that lead to drowning and deaths in case of floods, cyclone and tsunamis while injury due to falling, hitting by hard object, hemorrhage (Internal/external) in case of earthquakes, Hypothermia/Hyperthermia common in extreme temperatures. The progressive impacts lead to starvation, debility, stress and make the animal susceptible to diseases due to fragile immune status, the management practices are disturbed. As the feed and water supply for animals are often seen as the issues at the forefront during disaster management however shelter and veterinary care (basic and advance) are equally important welfare needs that arise during and after a disaster.

In a primarily agrarian society like India, where animals form an integral part of the daily life of more than 70% population and has a direct bearing on livelihood issues of rural population, this issue deserves a priority attention from the Government at appropriate levels. It is important because a report of the National Disaster Management Authority (NDMA) mentions that, on an average 94,830 animals perish in floods alone in our country. This does not take into account loss of animals in other disasters, which by and large remain unreported. An exercise carried out by the World Animal Protection in 2012 in consultation with stake holders at National, State and District levels in the country identified the three key existing gaps regarding management of animals in emergencies, being, inadequate training facilities/ infrastructure, inadequate trained human resources and non-availability of any preparedness plans for management of animals in disasters.

This issue has become all the more relevant in the wake of emphasis given on the Livelihood Protection in the 'Sendai Framework of Disaster Risk Reduction' (2015-30) in the Third World Conference on Disaster Risk Reduction held at Sendai (Japan) in March 2015. One of the resolutions adopted in this Conference highlights "substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, business, communities and countries" as the central premises of its strategy 2015-30. Further, Para30 (p) lays specific emphasis on "strengthening the protection of livelihood and productive assets, including livestock, working animals, tools and seeds.

In the wake of these developments, the Policy Perspectives Foundation (PPF) and World Animal Protection is working in collaboration with various stakeholders including DoAHDF, Govt. of India, NDMA, NDRF, NIDM, SDMAs and veterinary colleges to build capacity of people on management of animals in disasters and to protect animals and people's livelihood. As part of our policy work we worked with DoAHDF, Govt. of India to develop 'National Disaster Management Plan for Management of Animals in Emergencies'. This National Plan was formally released by the Hon'ble Union Minister for Agriculture on March 3, 2016. The release of the National Plan and recommendations of the National Workshop is a key milestone in acknowledging the role of Departments of Animal Husbandry, both at the centre and state

levels, in the field of Disaster Management. It is hoped that these initiatives would go a long way in integrating the Department of Animal Husbandry in a structured manner in the overall framework of Disaster Management in the country aimed at initiating concrete steps to comprehensively address the needs of animals in disasters, thereby contributing significantly in the field of livelihood issues of rural population in the country. We have been safeguarding animal lives in disasters and as a result supporting the livelihoods of communities.

Prepositioning of capacities among farmers using agriculture supply chain and disaster resilience approaches

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Abstract
Agriculture plays a fundamental role in Indian economy. The wide range of climatic, geographical conditions and land use patterns make India a 'food basket'. Farming system is complex, and it is constrained by many risk factors. Farmers' attitudes and desires are influenced by the culture of society. The agricultural risks dependencies are not just hazard(s) alone but it also depends on the existing vulnerability and the available capacities. There is a need to look at farm system through the lens of disaster management which deals directly with various aspects of farmers as producers and their vulnerabilities management. This paper looks into the feasibilities and advantages of prepositioning of capacities for vulnerability management among producers in the farm system. Building risk consciousness with the help of agriculture supply chains which farmers are familiar with has been suggested and might improve the resilience of the farm system.
Key words: Farm system, prepositioning of capacities, risk consciousness, supply chain, vulnerability, resilience.

Introduction

India is considered as world's oldest and largest agrarian country and its day to day activities largely depend on the agricultural base. India has around 12 per cent of world's arable land and is the world's third largest producers of food grains and second largest producers of fruits and vegetables (Parwez, 2014). The growth of Indian economy is strongly linked to the agricultural development of which the growth of fruits and vegetable sectors play a crucial role as high value commodities. The wide range of climatic and geographical conditions of India is suitable for growing diverse fruits and vegetables. The intake of fruits and vegetable in the diet play a significant role in human health and nutrition. The growing health consciousness makes their demand growth also at a high level (Oguntibeju et al., 2013). Fruits and vegetables are perishable in nature and have short shelf life, to maintain and improve their quality it requires an efficient supply chain (Negi and Anand, 2015). The agricultural products are affected by many factors such as weather changes, seed quality, market availability, government policies, technology, coordination and role played by different stakeholders in the supply chain (Raju and Patil, 2014). They have also indicated that post harvest loss and wastage could easily happen due to large lead time between the production and consumption. The supply chain is complex for the perishable products and therefore they commonly face high fluctuation in the demand and price due to variations in the factors such as rainfall and temperature. The supply chain consists of various intermediaries with different functions from the farm gate to consumer (Negi and Anand, 2015).

Connell and Dillon (1997) explains agricultural system as an assemblage of various components united by interactions and interdependence operation within a boundary. It is a complex land utilization unit that produces and transforms agricultural products and involves the service sectors. It has both ecological as well as socio-economic perspectives that include climate, soil, human resources etc undoubtedly asserting the fact of strong linkage between agricultural system and socio-economic processes. Indian agricultural system is unorganized and is more complex and difficult to manage due to the presence of various intermediaries (Parwez, 2014). Agricultural system could be categorized into five sub-systems-agricultural input, agricultural production, food processing, distribution, marketing and consumer demand. Every stage of agricultural supply chain has inefficiencies due to lack of adequate infrastructure to procure the produce from farm gate to consumers which leads to transit loss. The presence of intermediaries impact on the farmer's income as they hardly get benefit even when the price rises (Verma, 2013). Even when there is excess production, farmers are forced to sell their produce at a

throwaway prices. The large mark-ups in price are due to the presence of extra layer of intermediaries (Parwez, 2014).

A farm could be considered as a system of interactive parts transforming inputs to outputs. Farming system and farm system are different, while the former is the class of similarly structured farms system, the later is a decision making unit. Farm system, primarily a decision making unit transforms land, labor, capital into product of consumption and sale. Farm system comprises of three subsystems, namely, farm household system, cropping system and livestock system. Each of these has sub-systems of its own (Fresco and Westphal, 1988). Farm system has the interconnection/linkages between biological processes, natural resources, ecosystem services, weather pattern and climate. It gets impacted by social-ecological system. Farmer's decision is based on reliability or variability of the above interconnectedness. Farm resilience framework incorporates risk management strategies and capacities to respond to uncertain circumstances (Schuster and Colby, 2013). The agricultural supply chain suffers about 25 to 30 percent of the produce wastage of around US$ 11 billion which 9.8 per cent of the agricultural component of Gross Domestic Product (GDP) due to improper handling, inadequate storage, lack of transportation infrastructure and poor logistics (Parwez, 2014). This situation demands strengthening of agricultural supply chains by improving consumer response capabilities, redesigning organizational structures, improving risk mitigation measures and time to time technological input (Roekel et al., (n.d)).

Farm Risks

Risks of farming show an increasing trend and every day farm operations involves decisions which gets into a difficulty in making due to uncertainties. Every decision comes with its consequences. Farmers need to understand the type of risk involved concerning the farm system and environment, must develop efficient skills to manage the risk themselves. Risks that affect the production rate could be due to meteorological variations, plant diseases and pest infestations. Other risks involved are break down in supply chain, market price fluctuation and inefficient equipments. These risks affect the entire farm system consequently impacting directly the farm income. This makes farmers more vulnerable. Farmers adequate and informed decision making process depend largely upon the complexities of associated risks. The farmers need to have proper information regarding farm business and ways to deal with the risks and uncertainties. Farmers attitude depend on the societal culture, mostly they are willing to accept risk and can be called as 'risk takers'. Their financial ability plays a major role in relation to the farm risk along with their personal feelings. The decision on the cropping patters along with what to grow, how to grow and when to grow also play a significant role (Kahan, 2008).

Problem identification and better preparedness and planning reduce the detrimental effects of farm risks. Farm system is associated with various risks, the common sources of risks are- production risk, marketing risk, financial risk, human risk, institutional risk. Production risk basically depends on the processes such as shift in weather, rainfall, temperature, humidity that lead to crop loss. The input processes at the farm is at risk due to uncertainty in weather. Breakdown during harvesting time will increase the production risk. Market price fluctuation depends on the supply and demand of the product and on the cost of production. A market risk is associated with the farmers' decision on the combination of production, consumer's preference and purchasing power, the input cost and output price. Financial risk is the income generation with respect to the yield (Miller el at., 2004), human risk is associated with migration due to inevitable environmental condition for cultivation and this leads to labor shortage. Institutional risk includes different stakeholders providing support system, subsidies and regulations on quality and export, income support through banks. Other institutions that can increase the risk factors are cooperatives, marketing organizations, agents or dealers. All these risks are interrelated and occur due to unexpected changes. Therefore, there is a need to understand the trends and patterns of changes in the farm system. The different source of risk depends on the nature and circumstance of the farmers like the location, available resources and process of production. There is a risk factor associated with the high value products or commercial products in terms of price fluctuation. Time plays a vital role to assess the complexity of risk. Adopting a new crop also have a wide range of risk, it can bring either gain or loss (Kahan, 2008).

Major risk associated with agricultural supply chain are weather related risks, natural disasters, biological and environmental risks, market related risks, logistical and infrastructural risks, management and

operational risks, policy and institutional risks and political risks (Jaffee, *el at*., 2008). Table 1 describes these risks.

Table 1. Categories of Agricultural Supply Chain Risks, ARD (2008).

Type of Risks	Description
Weather related risks	Periodic deficit and /or excess rainfall or temperature, hail storms, strong winds.
Natural disasters	Major floods, droughts, cyclones, earthquakes
Biological and environmental risks	Pest and disease, human contamination and illness, contamination and degradation of natural resources, environment, production and processing processes
Market related risks	Changes in supply and /or demand affecting domestic and international input and/or output price, changes in market demands for quality and quantity, changes in market demands for product delivery time, changes in supply chain reputation and dependability
Logistical and infrastructural risks	Changes in transportation, communication, energy cost degraded/ undependable transport, physical destruction, energy infrastructure, labor disputes and conflicts
Management and operational risks	Poor management decision in asset allocation, livelihood selection and use of input, poor quality control, use of outdated seeds, inability to adapt changes in labor and cash flow, forecast and planning error and unpreparedness in the change of process, product and market
Policy and institutional risks	Uncertain monetary, fiscal and tax policies, changes in financial policies, regulatory, legal policies and enforcement, changes in trade and market policies, labor policies and tenure system, government related uncertainty and weak institutional capacity
Political risks	Security risk and uncertainty related to politico- social instability within country, trade interruption, Confiscation/nationalization of assets

Supply Risks

Supply chains are complex entities that serve many functions. They are institutional arrangements that link producers, processors, marketers and distributors. Supply chains are forms of industrial organization which allow buyers and sellers who are separated by time and space to progressively add and accumulate value as products pass form one member of the chain to the next (Roekel *et al*, (n.d.)). Agriculture supply chains are also economic systems which distribute benefits and share risks among participants. Supply chains impose the internal mechanisms and develop incentives for timely delivery commitments. The supply chain is interconnected through information sharing, the process linkages require participants to have coordination in their activities and it attaches value to the agricultural products. Supply chain creates synergies through:

- expanding traditional market boundaries and increased sale
- reduce delivery cost of produce and increase the gross margin
- increasing consumer perception of delivered product value through target specific marketing (Roekel *et al*. , (n.d.)).
-

The effective and efficient logistics is a critical factor for supply chain system. Logistics network integrate food supply chain and the potential market. Stakeholders such as farmers, vendors/agents, wholesalers, rural retailers and suppliers and transporters are involved in the supply chain. The proper flow of input resources, information and capital is essential. Figure 1 shows the type of flows between the producers and consumers (Gebresenbet and Bosona, 2012).

Logistics and communications are set in all three flows identified in the modern supply chain, namely, physical product, financial and information flows. Poor logistics and communications are often a major source of risk faced by an agricultural supply chain. An agricultural supply chain may be subjected to or experience multiple risks, with farmers and farms facing risks from different sources. Such risks can impact the reliability, costs and efficiency of production, processing and marketing activities (Jaffee *et al.*, 2008).

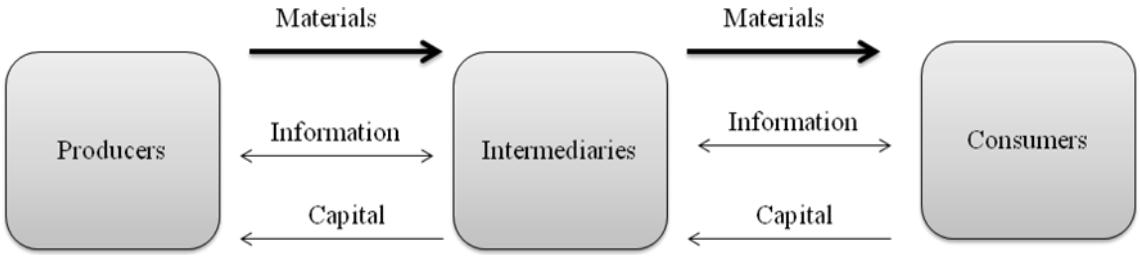

Figure 1. Materials, capital and information flow between producers and consumers.

The farm system undergoes changes and requires a resilience thinking to deal with these changes over long term either to 'bounce back' or 'bounce forward'. Farmers have to cope with problem in the farm system due to unexpected extreme weather, uncertain markets and unavailability of labor. Farmers need to mobilize the available resource and pool new resources to maintain the disruption in farm system. The farm resilience depend on the ability to integrate capabilities by addressing to slow onset and continual changes, sudden shocks and unpredictable events and farmers ability to face these situations (Darnhofer, 2014).

The disaster management research intends to focus producer's resilience as a strategy in agriculture. Producer's social relationship among family member and peer groups play an important role, their learning ability depend on the fellow farmers and the social dynamics of their discussion groups. The agricultural decision making priority are interdependent on the social, cultural and economic factor as culture influence include the behavior and possessions. The agriculturalist's thinking on development of agriculture is 'a way of life', which function as a means of livelihood and economic growth to reduce hunger and poverty and increase standard of living. Farmer's role in agriculture is to produce food for consumption. Their focus is to access the resources and to develop technologies for water and soil conservations and mechanization of agriculture system using smart farming techniques (Zevallos, 2016). The Disaster management role in agriculture is to develop a solution for the challenges farmers face in agriculture sector. Developing the technical capacities by raising awareness and knowledge transfers are the good practices seen in the field. Better prevention and preparedness measures can reduce the impacts of weather variations and damages to agricultural infrastructure. Resilience in farm system can be improved through the prevention and mitigation measures along with existing capacities. While most of the literature focuses on output risk and its reduction, a gap remains with respect to producer's capacities, the vulnerability management. Apart from the interaction between personal, social and physical context their capacities need to be identified and developed or added. Resilience can be improved in the farm system through value shared approach. This approach will enhance the farmers' capacities through various activities.

Pre-positioning of Capacities

The supply chain process depends directly on the produces. Even though there is a demand in market if the producer doesn't produce enough then it hampers the entire chain, the intermediaries will shift to different producers for their requirement. The producers face immense risk in the agriculture supply chain system. Therefore, this paper mainly focuses on the producers and their challenges that they face. Figure 2 shows the agriculture supply chain system which is interconnected with different actors or stakeholders. Risks are associated with all the actors (producers, intermediaries and consumers) in the supply chain but the risks associated with the producers are seemingly negligible.

In the entire supply chain the producers are vulnerable when compared to intermediaries and consumers. The disaster risk reduction possibilities at the conceptual level are shown in figure 3, which is an application of Chricton's triangle. The agriculture science might have considered the hazards and exposures in reducing the risk. The major component which is difficult to capture and address to manage is the vulnerability at the source level. If we don't address this fact, the vulnerability factor may not get reduced though we can reduce the risk by reducing hazards or exposures. This could be identified as a major impediment to the ongoing pursuit of increased well being of farmers. Increasing or building the capacity could reduce vulnerability and in turn increase the resilience of the farm system (Sapountzaki, 2012). Prepositioning of materials for a long time is considered as one of the strategy in disaster supply

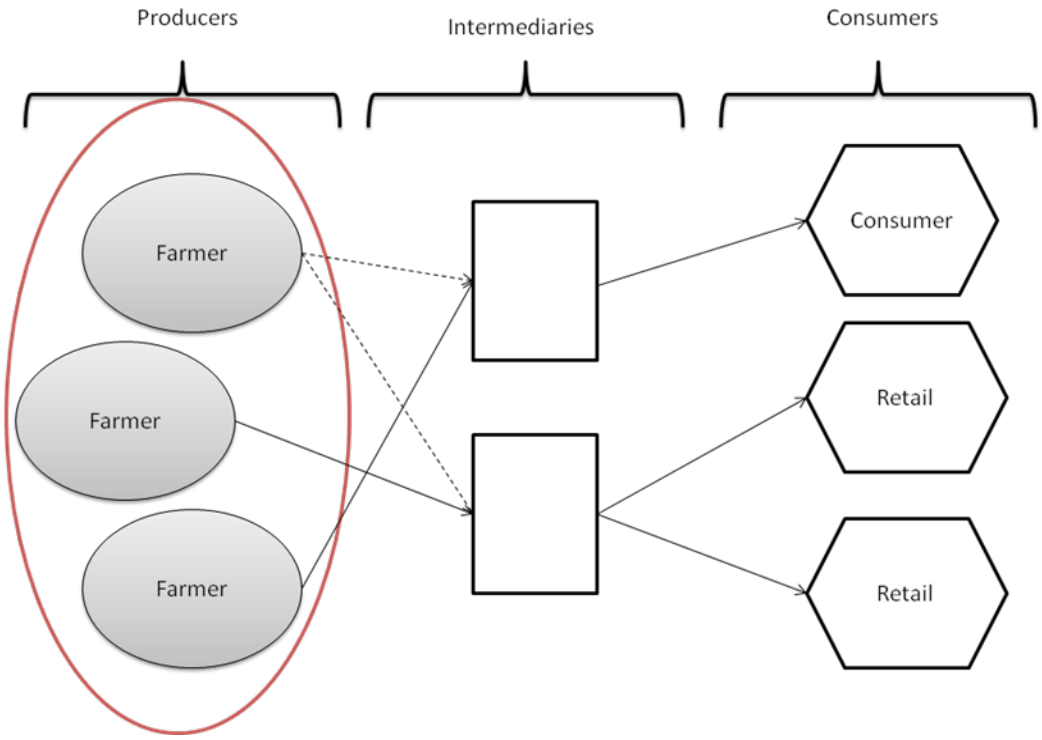

Figure 2. Different stakeholders of agricultural supply chain

chain particularly in response phase (Apte, 2011). But, prepositioning of capacities is to strengthen the supply chain system for disaster management. The pre-positioning of capacities can be done by enhancing the skills and resources through training and education. The agricultural supply chain can be efficient when the producer's capacities are pre-positioned so that they can be prepared well in advance to deal with the future social, economic and ecological risks. The farm risks are slow onset and have a localized impact mostly among the producers. Farmers must deal with various risk factors. The risk consciousness about the issues of production includes various capacities of farmers, their behaviors and perception which are determined by socio-economic features and the farm characteristics. Farmer's mentality and awareness play a critical role in their preferences and positions. Risk communication in terms of information and knowledge sharing about risks, can strengthen the decision making process. Factors like personal experience, cultural belief, social influences and their perception regarding their farm and production play a major role. The farmers are required to be conscious about the emerging risk associated with the farm system. Farmer's effectiveness will increase through capacity development and transfer of knowledge by training them and raising awareness or technical skills. They need to be exposed to the new approaches with current technologies. Farmers are required to be empowered as many lack knowledge, skill and experience of the agricultural value chain. Empowerment can be through increasing their knowledge on financial literacy, market planning, processing, postharvest handling and management. Information and skill can be enhanced on various farming operations and increasing their market knowledge on the accessing and selling their products to the long distance markets. Farmers can also be linked to micro finance institutions. The training and awareness activities enable them to understand the cultivation patterns, capital investments on modern farming techniques that would help them to generate higher production in the long run. Producer's resilience is questionable as the vulnerability factor is not well understood and the limited risk consciousness (producer's attitude, perception and behaviors depend on their ability to understand the farm system and the associated risk). The supply chain approach could be used to understand and address the vulnerabilities to reduce the risk in the farm level. The required prepositioning of the capacities could be possibly understood relatively lesser time and resources which in turn can increase the resilience.

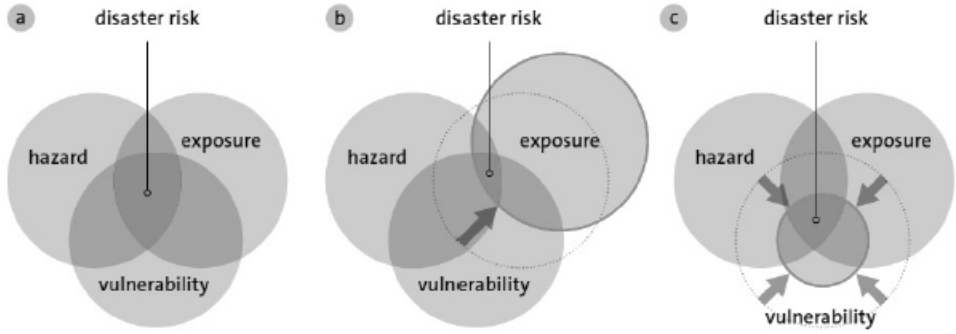

Figure 3. Vulnerability reduction approach (Srikanth, 2017).

The prepositioning of producer's capacities through risk consciousness can reduce risk in the entire farm system. The risk can be two types, event risk and outcome risk. Event risk can be caused due to any hazards, the outcome risk are the losses that occurs. The outcome risk doesn't depend on the hazard alone but it also depends on the existing vulnerability and the available capacities (Sarewitz and Keykhah, 2003). Therefore, risk consciousness is required that will be enhanced through prepositioning of capacities. Hazard, vulnerability and exposure could be reduced through risk consciousness wherein capacities could be increased for an increased resilience of the system.

When producers are unable to provide products there are possibilities they will be directly out of the entire chain as the intermediaries will access to another producer located at different place. This can create vulnerability for the producers even in the absence of any known and familiar hazards. Vulnerability is often talked about in social science literatures but concept of vulnerability management is seen mostly among information technology sectors. Therefore, vulnerability management is required at the initial stage of agricultural supply chain. The supply chain approach could easily be used to understand the vulnerability of producers as vulnerability is a function of the inherent characteristics and circumstances of a community, system or asset that makes it susceptible to the damaging effects (Giupponi and Biscaro, 2015).

Vulnerability provides the alternative known as resilience which influences the capacity of a person or group to cope, resist, anticipate and recover from the impact. Security comes through the presence of specific capacities. Vulnerability emerges from the interaction or coupling between human and environment and their exposure to hazards. Vulnerability as such cannot be reduced totally but can be managed contextually till alternative ways are available.

The consciousness will enable the producers to predict the threats and the capacities emerging out of them will enhance their decisions. Educating farmers about demand forecast, lead time, transit time, distribution routes and transportation will improve the agriculture supply chain system in turn would strengthen the farm resilience. Therefore, supply chain approach is a useful means in identifying and managing vulnerabilities of producers and can reduce risk. Further studies are required to explore the linkages at the ground zero to strengthen the assertions.

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Vulnerability assessment in urban slums of Kozhikode district, Kerala, India

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Abstract
Slums are the marginalized community of a society. It is an overcrowded area with poverty, insecurity, social disadvantages along with harmful environmental exposure and lack of access to facilities. All these features lead to decreased socio-environmental sustainability and also increase the risk and vulnerability of the community. This paper assessed the vulnerability of selected slums in Kozhikode district, Kerala. Data were collected by conducting surveys. Out of the 75 slums in the district, 9 slums were selected based on geographical location and population. For calculating the vulnerability of the slums, 3X3X3 matrix were fixed in terms of selected parameters like poverty level, deficiency in services and infrastructure as well as housing. This arrangement would help authorities to prioritize interventions in slums for improving the observed deficiencies. Such a prioritization is a necessary for sustainable development with limited funds, as, when deployed on predetermined priority areas and services, this will maximize the benefits
Key words: Slum, Vulnerability, Poverty, Population, Infrastructure

Introduction

Slums are the marginalized community of a society. It is an overcrowded area with poverty, insecurity, social disadvantages along with harmful environmental exposure and lack of access to facilities. All these features lead to decreased socio-environmental sustainability and also increase the risk and vulnerability of the community (Pelling, 2003). ‘Slum’, at its simplest, is ‘a heavily populated urban area characterized by substandard housing and squalor’. This definition encapsulates the essential characteristics of slums: high densities and low standards of housing (structure and services), and ‘squalor’. The first two criteria are physical and spatial, while the third is social and behavioural (https://unhabitat.org/). Vulnerability assessment is defined as the systematic examination of a system to identify those critical infrastructures or related components that may be at risk from an attack and the determination of appropriate procedures that can be implemented to reduce that risk. Risk and vulnerability assessment is a multi-step process, which includes analyses like hazard identification; critical facilities, societal, economic and environmental vulnerability; and mitigation opportunities. This helps to identify people, property and resources that are at risk of injury and damage. This information is important to help in determining and prioritizing the intervention measures (Thakur, 2007).

Kozhikode city is one of the most important cities in the State. Kozhikode city continues to be a centre of flourishing domestic and international trade. The current (2011 census) population of Kozhikode is 432097. The slum population is 35792 which is 8.28 percent of total population. As per Kozhikode Municipal Corporation, Slums and squatter settlements are essentially products of urban poverty. Some population does not have proper in-house water supply connection and sewerage system thus causing environmental pollution and health hazards. Proper storm water drainage system has remained non-existent in much area, causing “flooding” of localities every year and damaging lots of properties and resulting in health hazards. Hence, for the assessment of service accessibility by the urban poor, slum settlements have been considered as an appropriate representation of the urban poor.

Topography & Study area

Calicut is situated on the south western coast of India, approx 500 kilometres north of the southern tip of Indian peninsula (Cape Comorin or Kanyakumari) at approximately 11.25°N 75.77°E. Its elevation varies from 1 meter (at the sea coast) to 15 meters (towards the east). The climate is moderate with the

temperature ranging between 37°C and 19°C. The severity of the South West monsoon is felt between the months of June and August. The tides range between 83 to 160 cms. The height of the waves recorded is between 50 cms and 300 cms. The district is endowed with a coast line of 71 kms, stretching from Chaliyar to Azhiyoor.

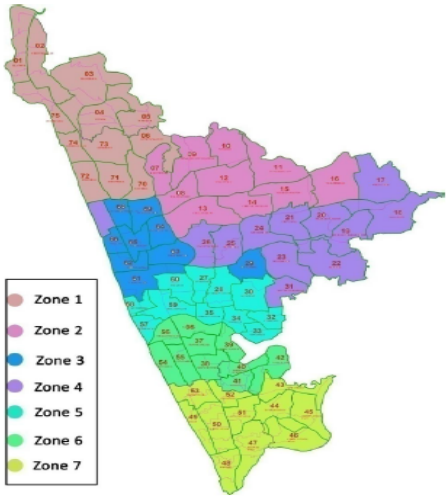

Fig.1 Map showing zone distribution of wards in Kozhikode Coorperation.

Urban slums in Kozhikode District spreads over 75 wards in Municipal Corporation and 74 wards in three Grama Panchayaths. The State government approved 75 slums from Kozhikode Municipal Corporation & Urban Agglomeration (UA). Most of the slums in Kozhikode are located along roads or major drains/nallahs, or along railway lines. Others are located on hilly tracts and beach sides. Hence for having better analysis, the city has been divided into 7 zones. The Zoning has been done on the basis of geographical location i.e. ward in similar geographical location were taken in similar zone.

Socio-Economic and Demographic Profile

The current (2011 census) population of Kozhikode is 432097. The slum population is 35792 which is 8.28 percent of total Kozhikode population. The city having slum population does not have proper in-house water supply connection and sewerage system thus causing environmental pollution and health hazards. Proper storm water drainage system has remained non-existent in such area causing “flooding” of localities every year and damaging lots of properties and resulting in health hazards. Access to individual toilets is approximately 95 per cent, but in city slums, the figures are dismal, with merely 55 per cent and 95 per cent of slum households having access to individual water connections and individual toilets, respectively. There are so many issues faced by the slum people, one of them is, there are very few people who own a government job and houses lacked a steady income. Some here work as drivers and other earn their daily income from doing jobs like painting, cleaning etc. Most of the slums are established in coastal area and fishing is the main occupation there. Women work as maids or took up jobs such as garbage collection offered by ‘Kudumbashree’. The main problem identified during the re-verification survey was the lack of getting drinking water from the Kerala Water Authority. Due to the lack of enoughspace inside the slum, people had to build their septic tanks near to house. Because of this activity the slum well water gets polluted.

As per the methodology distribution of the surveyed 9 slums were within a 3X3X3 matrix using data on poverty level, housing and infrastructure deficiency. The matrix 3x3x3 was developed on 13 parameters under three components as per table listed below (Table 1). Each parameter was given weights and the scores were generated. The weightage attached to each parameter is based on research and discussions with the communities. Each of the parameters has been divided into five parts taking the difference of minimum and the maximum values of each parameter and distributing the same in five ranges. Corresponding to each range, a score has been given from 1 to 5 in ascending order of deficiency.

In other words the maximum range has been given a score of 5 and the minimum range has been given a score of 1, while the intermediate ranges have been given the scores of 2, 3 and 4.

Table 1: Details of selected slums in each zone

Zone	Ward No.	Ward Name	Total No. Of HH in Slum	Total Slum Population
1	74	Puthiyappa	183	399
2	07	Karoorthazham	76	303
3	0	0	0	0
4	67	Thoppayil	385	1627
5	56	Pallikkandy East	459	1952
6	42	Keezhuvanappadam	353	1404
7	46	Vellilavayal	305	1380
GP 1	17	Karppathu	91	416
GP 2	16	Kizhakkedath	18	178
GP 3	02	Kunnummathadai	35	146

Three Dimensional Analysis

A three dimensional analysis was conducted with three parameters.

Housing (Housing Condition)

Infrastructure (Access to basic services)

Poverty (Socio-economic Condition)

Each parameter is further analysed based on various key indicators determining the status of parameters. Weightage has been assigned against each of the sub parameters. The weightage allotted for the each parameters are based on research and discussion with the community in terms of priority. For e.g. 60% of the weightage have been assigned for the kutcha houses on priority basis where semi pucca and House Holds (HH) with no legal rights are given 20% of the weightage.

Housing

The parameters in this component includes percentage of kutcha house as on priority weightage followed by semi pucca and tenure rights as given below. The percentage deficiency is measured on 5 point scale and total housing score was generated by adding the scores of each parameter.

All the parameters have been given scores in similar fashion and the composite score of all the parameters has been calculated by adding the scores of each parameter. The composite score is taken as the Housing score. The composite score has thereafter been distributed in three parts taking the difference between the minimum and the maximum score and dividing it in three equal parts and each part has been assigned the final score ranging from 1 to 3 as given in Table 6

Poverty

The parameters in this component includes percentage of unemployment as on priority weightage followed by % of illiteracy, SC/ST and BPL population as given below. The percentage deficiency is measured on 5 point scale and total poverty score was generated by adding the scores of each parameter.

Table 2 Parameters Weights Deficiency Score

Parameter	Sub-Parameters	Weightage
Housing Condition	%age of Kachha Houses	6 (60%)
	%age of Semi pucca Houses	2 (20%)
	%age of HH with no legal right	2 (20%)

Infrastructure

Parameter	Sub-Parameters	Weightage
Infrastructure	% deficiency of In-house Tap connection	4 (40%)
	% deficiency of In-house toilet	2 (20%)
	% deficiency of of pucca roads	1.5 (15%)
	% deficiency in solid waste collection	0.5 (5%)
	% deficiency of pucca drain	1.5 (15%)

Poverty

Parameter	Sub-Parameters	Weightage
Poverty/Socio-economic Condition	%age of unemployed population	4 (40%)
	%age of illiterates	2 (20%)
	%age of SC/ST HH	1.5 (15%)
	%age of HH under BPL/Antyodya	2.5 (25%)

All the parameters have been given scores in similar fashion and the composite score of all the parameters has been calculated by adding the scores of each of the parameters. The composite score is taken as the BPL / poverty level score. The composite score has thereafter been distributed in three parts taking the difference between the minimum and the maximum score and dividing it in three equal parts and each part has been assigned the final score ranging from 1 to 3. An illustration of the final scoring system of poverty level is given in Table 7

Table 3: Housing Deficiency Score

PARAMETERS	WEIGHTS	DEFICIENCY SCORE RANGE				
% of Kachha HH	6	0-20	21-40	41-60	61-80	81-100
% 0fSemi Pucca HH	2	0-20	21-40	41-60	61-80	81-100
% of HH no Legal Rights	2	0-20	21-40	41-60	61-80	81-100
Deficiency score value		1	2	3	4	5

Table 4: Poverty Score

PARAMETERS	WEIGHTS	DEFICIENCY SCORE RANGE				
% Unemployment	4	0-20	21-40	41-60	61-80	81-100
% of Illeterate	2	0-20	21-40	41-60	61-80	81-100
% HH SC/ST	1.5	0-20	21-40	41-60	61-80	81-100
%of BPL and antyodya HH	2.5	0-20	21-40	41-60	61-80	81-100
Deficiency score value		1	2	3	4	5

Infrastructure Deficiency Analysis

The infrastructure deficiency in each slum has again been calculated on the basis of a few parameters which were derived from physical survey as well as group discussions with households in each slum, ward councillor, ward members, teachers etc. The parameters in this component includes % deficiency of inhouse water supply connection as on priority weightage followed by % of illiteracy, SC/ST and BPL population as given below. The percentage deficiency is measured on 5 point scale and total infrastructure score was generated by adding the scores of each parameter. All the parameters have been given scores in similar fashion and the composite score of all the parameters has been calculated by adding the scores of each of the parameters. The composite score is taken as the infrastructure score.

Table 5: Infrastructure Deficiency Score

PARAMETERS	WEIGHTS	DEFICIENCY SCORE RANGE				
% deficiency of Inhouse Tap Connection	4	0-20	21-40	41-60	61-80	81-100
% deficiency of Inhouse Toilet	2	0-20	21-40	41-60	61-80	81-100
% deficiency of pucca roads	1.5	0-20	21-40	41-60	61-80	81-100
% of solid waste not collected	0.5	0-20	21-40	41-60	61-80	81-100
% deficiency of pucca Drain	1.5	0-20	21-40	41-60	61-80	81-100
% deficiency of Poles	0.5	0-20	21-40	41-60	61-80	81-100
Deficiency score value		1	2	3	4	5

The composite score has thereafter been distributed in three parts taking the difference between the minimum and the maximum score and dividing it in three equal parts and each part has been assigned the final score ranging from 1 to 3. An illustration of the final scoring system of poverty level has been given in Table 7.

Table 6. Scoring system

Infrastructure deficiency (total score)	**Rank**	**Poverty Level (total score)**	**Rank**	**Housing Condition (total score)**	**Rank**
0 – 22	1	0-19	1	0-21	1
22 – 36	2	19-32	2	21-33	2
36 and above	3	32 and above	3	33 and above	3

Vulnerability Analysis & Development of Matrix

Following the above method each of the 9 slums has been given a rank (element of the 3X3X3 matrix) in terms of infrastructure deficiency, housing and poverty. For instance, if a slum has a final score of 1 in terms of infrastructure and 2 in terms poverty and 3 in terms of housing; it is given a rank of 1/2/3 in the

3X3x3 matrix. The matrix is presented in 9 rows and 3 columns. However, for the sake of convenience, the slums have been arranged in a 3X3X3 matrix on the basis of their ranks as explained above.

Results & Discussion

Slum in zone 1 and zone 2 comes under 1X3X2 matrix. Zone 3 has no slum.GP 2, Zone 4& 5 belongs to 1X1X3 matrix. Slum in zone seven comes under 1X3X1 matrix. Slums in GP 1 and GP 3 belongs to 1X1X3 and 1X3X3 matrixes respectively.

Table 7 Slum Matrix

1/1/10	1/1/21	1/1/33	4
1/2/10	1/2/20	1/2/31	1
1/3/11	1/3/22	1/3/31	4
2/1/1	2/1/2	2/1/3	0
2/2/1	2/2/2	2/2/3	0
2/3/1	2/3/2	2/3/3	0
3/1/1	3/1/2	3/1/3	0
3/2/1	3/2/2	3/2/3	0
3/3/1	3/3/2	3/3/3	0
1	3	5	9

Analysis of Slums in 1x1x 2 Matrixes: Slum falling under the category of 1x1x2 matrix are in the best conditions as compared to all other slums of Kozhikode district in terms of all three parameters of housing, poverty and physical infrastructure. Land use of these slums is purely residential with private and local body ownership.

Analysis of Slums in 1x1x3 Matrixes: Three slums accounting for 6.6% share of total slums fall in the category of 1x1x3 matrix, having 14.6% share of total population of all slums in Kozhikode. 73.8% of population of all the 3 slums under the 1x1x3 matrix is BPL as observed in the fig 2. 27.9% households have their income less than Rs.1000 per month. Thus, showing average social infrastructure conditions. Physical infrastructure is very inefficient since 86.7% households lack in having individual tap connection, 9% households are deficient of having individual toilets, 69.2% deficiency in presence of pucca roads, 92.9% deficiency in pucca drains and 100% deficiency in availability of street light poles. But, housing conditions there are average, as 22.8% and 42.4% households are kutcha and semi pucca respectively.

Analysis of Slums in 1x2x3 Matrixes: Slum coming in the category of 1x2x3 matrix is BPL and 37.6% households have their monthly income below Rs.1000 indicating average social infrastructure. Housing conditions are moderate as 10.8% and 26% households are kutcha and semi pucca respectively. But, unsound physical infrastructure is the consequence of 96.1%, 9% and 75.2% deficiency in availability of individual tap connections, availability of individual toilets and presence of street light poles respectively. Also, this slum is deficient by 77.8% and 92.4% in having pucca roads and pucca drains laid respectively.

Analysis of Slums in 1x3x1 Matrix: Slums that fall under the category of 1x3x1 matrix have 2.6% share of all the 75 slums of Kozhikode. Ownership of the land under these slums is private, used for residential purposes only. The population under BPL category is 74.2% and 69.8% households have their monthly income below Rs.1000 indicating poor condition of social infrastructure of these slums. Housing conditions are moderate as 23.3% and 53.2% households are kutcha and semi pucca respectively. Overall average physical infrastructure still requires improvement as there is 26.3% and 50% deficiency in availability of individual tap connections and street light poles respectively, 11% deficiency in individual toilets, 69.4% and 54.7% deficiency in laying of pucca roads and pucca drains respectively.

Analysis of Slums in 1x3x2 Matrixes: There are total 2 slums that fall under this 1x3x2 matrix showing moderate housing conditions. Out of total slum population of 35,792, the population residing in these slums have 2.05 percent share of the total slum population. Land use of all these slums is purely residential. Fig 3 shown below indicates that 79% households of these slums under this matrix have income below Rs.1000 and 96.3% population is BPL indicating very poor scenario of poverty. 9% and 67.6% households are kutcha and semi pucca respectively depicting moderate housing conditions of the slum. Also, average physical infrastructure is the result of 67.4% deficiency in individual tap connections, 57.3% deficiency in availability of street light poles, 17% deficiency in availability of individual toilets, 77.8% and 56.4% deficiency of pucca roads and pucca drains respectively. Diversity is observed here as 13% people belong to SCs/STs category.

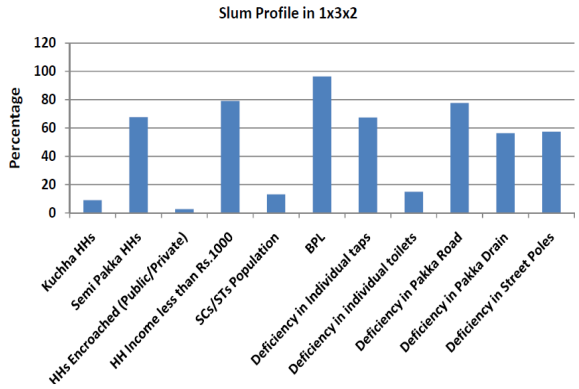

Fig.2 Profile of slum in 1/3/2 matrix

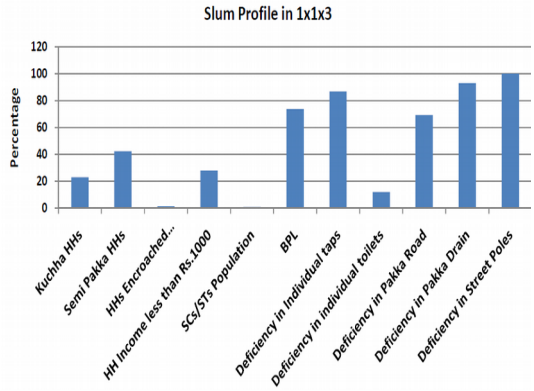

Fig.3 Profile of slum in 1/1/3matrix

Analysis of Slums in 1x3x3 Matrixes: 73.3% of total population of all the slum coming in the category of 1x3x3 matrix is BPL and 77.5% households have their monthly income below Rs.1000 indicating poor social infrastructure and poverty. Moderate housing conditions are seen as 4.7% and 31.2% households are kutcha and semi pucca respectively. But, unsound physical infrastructure is the consequence of 96.2%, 18% and 80.3% deficiency in availability of individual tap connections, availability of individual toilets and presence of street light poles respectively. Also, this slum is deficient by 73% and 89.9% in having pucca roads and pucca drains laid respectively.

Conclusion

This study stresses on the vulnerability of slums on the basis of matrixes. The parameters used in matrix include housing, infrastructure and poverty /socio-economic condition. As per experiences and discussions with the local communities, it was observed that housing itself is a separate parameter of an urban component. Therefore, this study is based on the matrix 3X3X3 which includes housing, infrastructure and poverty as main components. It may be recalled that one of the objectives of this study was to collect information on level of poverty in slum households, available municipal services and infrastructure facilities existing in the slums. This information would be useful to arrange the slums in a 3X3X3 matrix in terms of selected elements / parameters like poverty level, deficiency in services & infrastructure and housing. This arrangement would help authorities to prioritize interventions in slums for improving the observed deficiencies. Such a prioritization is a necessary for sustainable development with limited funds when deployed on predetermined priority areas and services will maximize benefits

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Forest fire hazard zonation mapping of Wayanad district of India using geospatial technology

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Abstract

Forest fires are real ecological disasters, which can create vulnerable loss to the environment or nature. It is not a matter whether it has a natural cause or artificial like human activities, it is very convenient to map the forest fire risk zones and to validate the pattern. The aim of the present study is to demarcate the forest fire risk zones in Wayanad forest area. In this study a combination of Remote Sensing and GIS technology has been used to develop the Fire Risk Index model.The factors selected in this study are forest type, elevation, slope, aspect, distance from settlement and distance from road. The forest fire risk zone map is generated using the developed Fire Risk Index model which is obtained by analyzing the percentage frequency of occurrence of historical forest fires in various categories of the influencing themes. In the prepared map, the area has been classified into three risk zones *viz.* low, medium and high. The result has been validated with the fire incidence points of the year 2016. The risk zone map of the Wayanad forest area will be helpful for natural resource managers or planners in the management and environmental protection of the resources.

Introduction

Forest is one of the most important natural resources and fundamental necessity for human survival and social development (Jinzhu et al. 2007). It is a constantly changing environment made up of a variety of living organisms. Forests influence the environment of the area. Fire has been a major influencing factor on the development and management of many of the world's forests. "Forest fire" means a fire burning uncontrolled on lands covered wholly or in part by timber, bush, grass, grain, or other flammable vegetation. It is the most common hazard in forests. In India, the estimated total fire prone area in the recorded forest area (771,821 sq. km) is 53.91% (FSI 2013). Forest fires pose a threat not only to the forest wealth but also to the entire regime to fauna and flora seriously disturbing the bio-diversity and the ecology and environment of a region. In this regard, forest fire risk zone mapping is essential for better forest management. Remote Sensing (RS) and Geographic Information System (GIS) techniques have been used by many researchers to delineate the forest fire risk zones (Jaiswal et al. 2002; Sowmya and Somashekar 2010; Ajin et al. 2014; Ajin et al. 2015). Puri, et al.,(2011) in their study demonstrate the potential use of remote sensing and Geographic Information System (GIS) in identifying forest fire prone areas in Manipur, south eastern part of Northeast India. Land cover (LULC), vegetation type, Digital elevation model (DEM), slope, aspect and proximity to roads and settlements, factors that influence the behaviour of fire, were used to model the forest fire risk zones. Using the same technique Ajin et al (2014) in their study identify the fire risk zones in Peppara Wildlife Sanctuary, Western Ghats mountain region, Kerala. They identify that forest fires are caused due to environmental and human related factors. This study considered 5 factors namely, land use/land cover, slope, elevation, distance from road, and distance from human settlements. Satish and Reddy (2016) in their study monitored the long term occurance of forest fires in Silent Valley National Park, Western Ghats, India using remote sensing data and they report that Spatial analysis of the data indicates, an area of 47.51 km2 (19.5 % of total vegetation cover) affected by varying frequencies of fires from 1973 to 2014. The aim of the present study is to demarcate the forest fire risk zones in Wayanad forest area. In this study a combination of Remote Sensing and GIS technology has been used to develop the Fire Risk Index model .The factors selected in this study are forest type, elevation, slope, aspect, distance from settlement and distance from road.

Materials and Methods

Study Area: The district of Wayanad is located in the Northern Eastern part of Kerala State. It lies between 11° 27' N and 12° 58' N latitudes and 74° 52' E and 76° 07' E longitudes. Geographical area is about 2,132 Sq.Km. Bounded on the east by Nilgiris District of Tamil Nadu and Mysore and Kodagu district of Karnataka on the north and east, in the south by Malappuram and on the west by Kozhikode and Kannur. Wayanad, consisting of the forests under the administration of North Wayanad, South Wayanad and Wayanad Wildlife Sanctuary Divisions form a major portion of Nilgiri Biosphere Reserve.

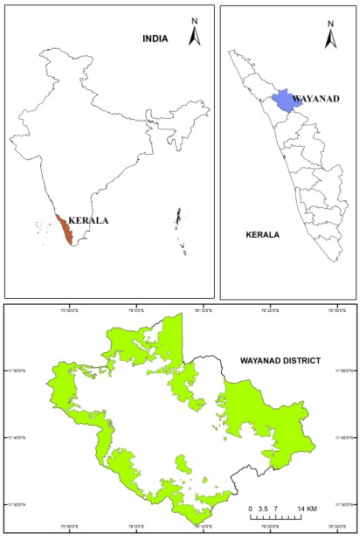

Figure. 1: Study area

The study was carried out by adopting various methods including data collection, thematic layer preparation, data analysis and mapping. The 15 year archive active fire locations data during the period between 2001 and 2015 was obtained from Bhuvan, a Geoportal of ISRO(MODIS) Terra/ Aqua data). The elevation data of the study is collected as Cartodem version R3-1 from Cartosat, which is having a spatial resolution of 30 m. The satellite image beamed by LISS III sensor of IRS-P6 with a spatial resolution of 23.5 m procured from National Remote Sensing Centre (NRSC), Hyderabad was used to prepare the vegetation cover and settlements which is used in the study. Google earth became the source for basic thematic layers such as district boundary, major places, road networks, etc. And the layer of forest cover is prepared by field survey by GPS receiver and with help of Google earth. The various data collected were vectorised and put into the Arc GIS software package as feature classes in file geo database. The prominent parameters like elevation, aspect, slope, distance from roads and distance from settlements were evaluated for their influence on the forest fire occurrence by analysing the percentage frequency of occurrence of forest fire in various categories of the influencing themes.

Fire hazard risk zonation: The ranks of the classes of each theme were assigned in a standard scale of 0 to 100 by reclassifying themes in the spatial analyst tool of Arc GIS software package through a weight of evidence approach in such a way that higher ranking is given to the class which has high positive relation with it as revealed by the percentage frequency of occurrence of the historical fire locations from the earlier analysis (table.1). Spatial modeling has been done to obtain the combined effect of elevation index, aspect index, slope index, distance from road index, vegetation index and distance from settlement index. Equal weightage have been assigned to the particular variables in relation to the area under study. The forest fire risk zone map was prepared by overlaying the index map layers using ArcGIS tools. Finally, the risk zone map was validated with the fire incidence points of year 2016.

Table.1: Thematic layers, their classes and corresponding score/ rank

Sl. no	Theme	Classes	Score/ Rank
1	Elevation	22 - 300	0
		300 - 800	50
		800 - 1200	40
		1200 - 1600	8
		1600 - 2145	1
2	Slope	0- 12	61
		12 - 25	25
		25 - 37	12
		37 - 50	2
		50 - 63	0
3	Aspect	Flat(-1)	0
		North(0-22.5,337.5-360)	10
		North east(22.5 – 67.5)	10
		East(67.5 – 112.5)	16
		South east(112.5 – 157.5)	9
		South(157.5 – 202.5)	17
		South west(202.5 – 247.5)	11
		West(247.5 – 292.5)	13
		North west(292.5 – 337.5)	14
4	Distance from road (m)	0 - 2000	45
		2000 - 4000	35

		4000 - 6000	17
		6000 - 8000	3
		8000 - 10000	0
5	Distance from settlements (m)	0 - 2000	37
		2000 - 4000	31
		4000 - 6000	11
		6000 - 8000	11
		8000 - 10000	8
		10000 - 14032	2
6	Vegetation	Wet evergreen primary forest	10
		Wet evergreen secondary / disturbed forest	4
		Secondary moist deciduous forest	8
		Degraded formation in potential area of wet evergreen forest	7
		Primary moist deciduous forest and degradation	13
		Primary dry deciduous forest and degradation	25
		Treesavanna to grassland in wet zone and Montane grass land	3
		Commercial plantation	3
		Forest plantation	16
		Degraded formation in deciduous forest	11
		Water body	0

Result and Discussions

Elevation: The elevation of the forest area of Wayanad district ranges from 22-2145 meters. From the study it is observed that most of the fire incidences are reported in the range 300-800 meters and 800-1200

meters together consists of 90% of the fire incidences This elevation mostly comes in the Wayanad Wildlife Sanctuary which consist the major portion of Wayanad forest region. Occurrence of forest fire in higher elevations are very less, it is only 1% of the total incidences. Also very lower elevations report very less number of fire occurrences (Fig.2).

Slope: The slope of the forest area was classified in degrees and it ranges from 0 to 63 degrees. It is found that the areas which have lower slope have the most number of fire incidences. 61% of the total fire incidences are reported in the slope of 0 to 12 degrees. The slope class of 12 to 25 degree has 25% of fire occurrences. The higher slope regions have less number of fire incidences i.e., 2% in the slope class with 37 to 50 degrees. The higher slope 50-63 does not show any fire occurrences. The fire occurrences in the slope show a decreasing trend from lower to higher slope areas (Fig. 2).

Aspect: The direction of slope of the study area were divided into nine classes which were flat, north, north east, east, south east, south, south west, west and north west. Fire locations frequently occur in the slope having the direction facing south which is about 17%. 16% of the fire occurs in aspect range of 67.5-112.5^0 which is in east direction. West direction which falls in the range of 247.5-292.5^0 posses 13% of the fire locations. North direction has about 10% of fire occurrences. Rest of the locations falls in North east, Southeast, South west and North west directions. No locations come in flat areas (Fig.2).

Distance from road: The chance of forest fire is more near the roads, mainly due to carelessness and irresponsible deeds like throwing lighted cigarette butts, minor fires set by inhabitants for developing land for agriculture, and lack of properly maintained forest fire belts on either side of the roads traversing the forest land. The distance from road classes have been grouped into five *viz.*,0-2000m, 2000-4000m, 4000-6000m, 6000-8000m and 8000-10000m. Highest occurrence of fire is observed near the road, i.e., 45% in the range 0-2000m. There is a decrease in the number of occurrences of fire from distance away from the road (Fig.2).

Distance from settlement: The forests in areas close to the human settlements are more prone to forest fire, because of the possibility of accidental fire due to the cultural/livelihood practices of the inhabitants. There is high density of settlements within the sanctuary area with human and cattle population. The distance from settlement classes have been grouped into six viz, 0-2000m, 2000-4000m, 4000-6000m, 6000-8000m, 8000-10000m and 10000- 14032m. Highest number of fire occurrence was observed in the area near to the settlements and lowest in the area far from the settlements.37% of the fire occur in the region 0-2000m distance from the settlement and only 2% occur in the distance 10000-14032m from settlement(Fig.3).

Forest types: Forest type one of the major factor affecting the fire incidences of the study area. The Wayanad forest area consist mainly 3 type of forest i.e., moist deciduous, dry deciduous and evergreen forest. This type is again classified into primary, secondary and degraded formations. Also the region consist forest plantations and commercial plantations. From the historical fire locations it is observed that 57% of the fire incidences occur in deciduous forest and its subtypes and degradations. 21% of the forest fires occur in evergreen forest and its subtypes.16% of fire incidences are reported in forest plantations (Fig.3).

Forest fire hazard zonation: the forest fire risk zone map of wayanad forest area is prepared from the reclassified index maps of forest type, distance from settlement, distance from road, slope, elevation and aspect, by overlaying them using gis weighted overlay analysis techniques. The area of the risk zone map is grouped into three classes' *viz.*, low, medium and high (Table 2, Fig.3).

Table13: The area under different fire hazard zones

Fire risk	Area in Sq.Km.	Percentage
Low	50.9719	6.04
Medium	324.0187	38.38
High	465.16	55.10

From the table above it is clear that 55% of the total area comes under high hazard zone with an area of 465.16 Sq.Km. 38% of the area is under medium hazard and 6% area is at low hazard and their areas are 324.01Sq.Km and 50.97 Sq.Km. respectively. Result shows that out of the 330 forest fires during the

period from 2001 to 2015, 220 (67%) occurred in the high hazard zone, 92 (28%) occurred in medium hazard zone and only 18 (5%) occurred in low hazard zone. The major high hazard zones come in the Wayanad Wildlife Sanctuary regions. Majority of the fire incidence points spatially fall over areas closer to roads, used by the local inhabitants. This validates the fact that majority of forest fires are due to deliberate or accidental human intervention.

Finally the risk zone map is validated with the fire incidence points of the year 2016 collected from the Forest Survey of India (FSI) during the period 01-01-2016 to 17-11-1016. The data is reliable even though data of all months are not available because only one incidence of fire is reported in December in historical fire data. (Fig.3).

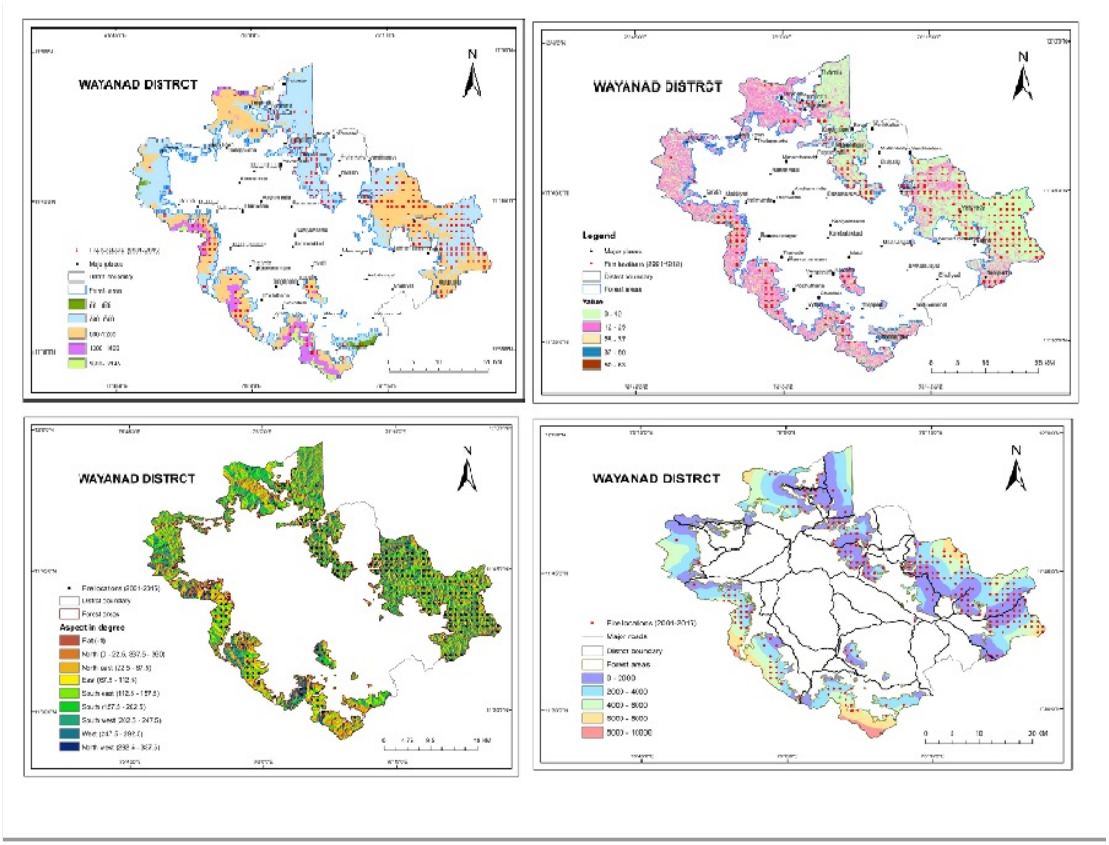

Figure 2. Showing Base Layer Parameters

Conclusions

Forest fires are real ecological disasters, which can create vulnerable loss to the environment or nature. It is not a matter that whether it has a natural cause or artificial like human activities. But it is very convenient to map the forest fire risk zones and to validate the pattern and other properties in relation with various factors including physiographic, environmental and anthropogenic. The study shows a positive result that GIS and remote sensing could be successfully engaged in the identification and mapping of forest fire prone areas and their future management in Wayanad forest area. The area of the risk zone map is grouped into three classes' *viz.*, low, medium and high. 55% of the total area comes under high hazard zone, 38% area under medium hazard and 6% area is at low hazard zones. This shows that the present methodology based on RS and GIS techniques is reliable and can be efficaciously used in the process of delineation of the forest fire risk zones. The study confirms that the majority of the forest fires occurred in areas closer to road networks and human settlements. This point out that most of the forest fires are induced by the people. The methodology presented in this study becomes an excellent tool used to obtain a classification of the risk zones, necessary for the analysis, study and forest fire risk assessment in order to prevent and to

reduce their frequency. The final forest fire hazard zone map of the Wayanad is to be helpful for natural resource managers or planners in the management and environmental protection of resources.

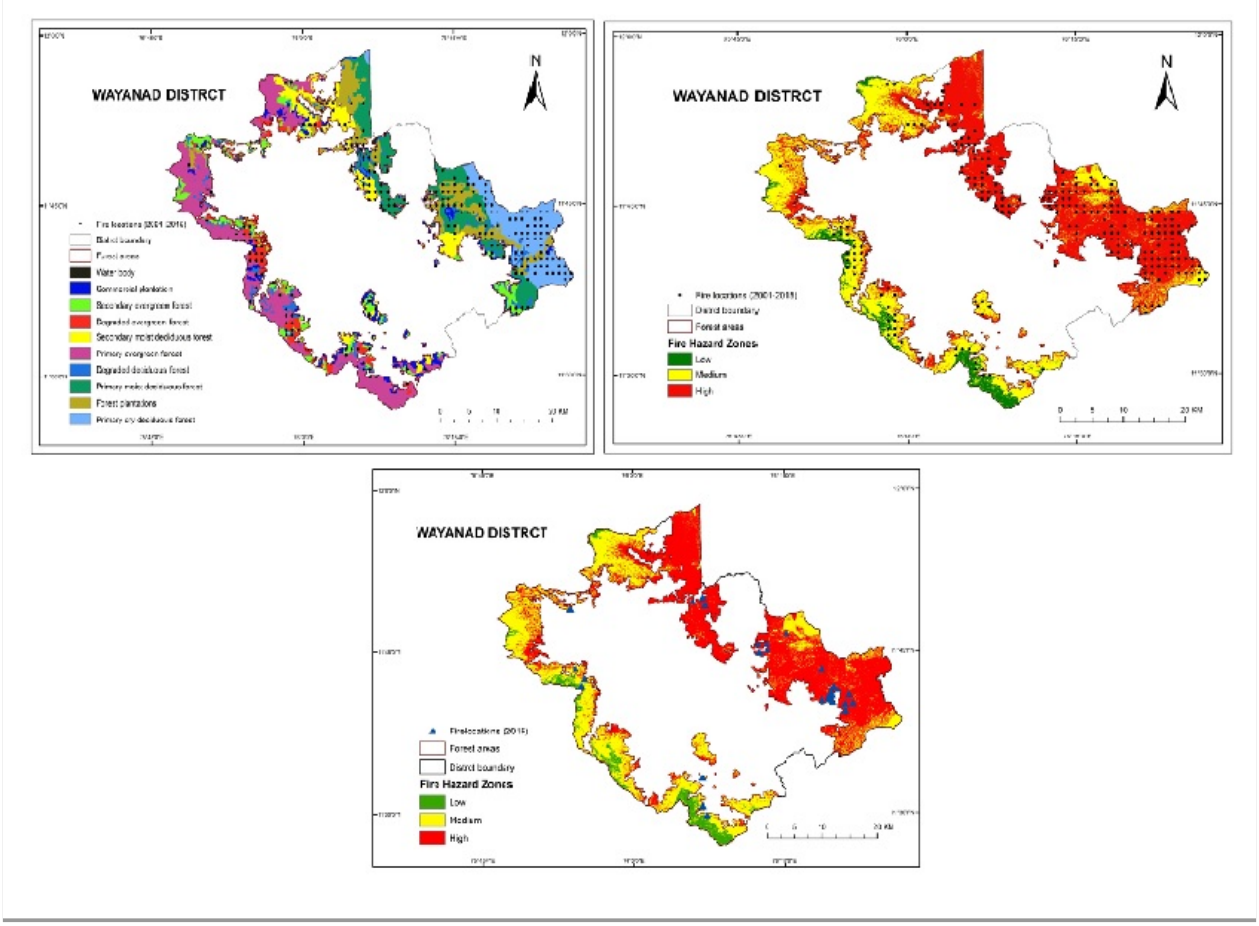

Figure 3. Fire Hazard Zonation Map.

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Hydrogeology of the Sasthamkotta Lake: A dying fresh water lake of Kerala

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Hydrogeology of the Sasthamkotta lake, Kollam district has been studied. Sasthamkotta lake is one of the fresh water lakes in Kerala. The lake occupies 440 hectares and the catchment area of the lake is 1269 sq km. The aquifers of the area is represented by lucustrine sediments, alluvium, laterite, Tertiary formations and crystalline aquifers. The occurrence and movement of groundwater in laterite is mainly controlled by the topography. Laterite and sand stone forms potential aquifers along the hills surrounding the lake and valleys and topographic lows. The groundwater from the wells flows towards the lake. As the water level lowers in the lake the groundwater level also declines. In April, 2015, about 30% of the dug wells in the catchment area of the lake were dry, whereas in 2017 the number of dry wells increased to 70%. It is observed that the dry wells are located in the southern part of the lake. Groundwater recharge from rainfall is not sufficient in those areas. Deepest well is located at the western part of the lake. Shallow wells are located in south western part of the lake. North western part of the lake becomes marshy area; this will indicate the shrinkage of lake.

The water level in the lake is gradually decreasing and the groundwater from the surrounding region reaches the lake. The lake itself has a base flow and water flows through the eastern side of the lake. Heavy soil erosion is also noticed in the area. A comparison study is attempted to identify the quality variations in the groundwater and lake water. The comparison shows that the chemistry of groundwater and lake water is more or less similar. This means the groundwater is continuously mixing with the lake water. The groundwater from the nearby areas of the lake is flowing towards the lake. Soil texture analysis is carried out. The data shows that the upper portion of the lake is marked by sandy loam, below which silty and clay loams are present. Carbonaceous clay is present below 2 m. Soil erosion is common phenomena in around the lake. Silt accumulation leads to the reduction of lake and production of marshy land instead of lake. A geospatial comparison of the lake between 2015 and 1988-89 was attempted. The area of the lake during 1988-89 was 3.6723 sq km. and presently it reduced to 2.91759 sq km. That means around 0.7541 sq km area has been reclaimed/covered within 26 years. For the prevention of sediment deposition into the lake and protection is done by coir geotextiles, building bunds and terraces to prevent soil erosion. Mixed vegetation or crops are cultivated along the surroundings of the lake. Acacia plants need to be removed from the catchment very carefully and replaced with grass.

Assessing relative coastal vulnerability to sea level rise along the Thiruvananthapuram coast, Kerala using GIS-based CVI model

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Abstract

The coastal area is a transitional zone of land and water directly influencing the processes of landform formation due to hydrodynamic action like waves, current, tide and sea level rise, etc. Coastalareas highly vulnerable to beach erosion and shoreline retreat cause damages to landform settings, properties and livelihoods. During the last two decades, stretches of Thiruvananthapuram coast experience adverse impacts due to natural and anthropogenic factors. Several coastal districts in Kerala including Thiruvananthapuram were hit by the 26th December 2004 tsunami waves changing the coastal landforms significantly. Sea level change is also a predominant factor influencing variation in coastal landforms. In addition, high population density and developmental activities foster vulnerability of landforms along the coast. Understanding coastal vulnerabilities is a primary requisite towards management of the coastal zone. Many countries have been taking efforts to protect coastal zone through advanced tools of coastal management and planning. Remote sensing integrated with GIS technologies provides an effective platform for analyzing shoreline changes combined with spatio-temporal impacts on the coastal landforms. The present study deals with the analysis of CVI (Coastal Vulnerability Index) model using multiple parameters that influence coastal dynamics. The study reveals that a 20 km longcoastal stretch in sector 4 categorized as high vulnerable would likely to experience damages to coastal landforms and properties (estimated vulnerability rate is ranging from 20.45 to 54.43). In the most vulnerable areas, coastal landforms such as sandy beaches, coastal plain and sea cliffs experience severe erosionat places leading to erosion scarps along the berm dueto high-energy wave breaking, and steeply sloping continental shelf along the coastline. A total of 37 km coastal stretch along the Zone 3 depictsmoderate vulnerability with an estimated range of 22.30 – 32.40. This coastal stretch includes young coastal plain, estuaries, and beach ridge complexes getting affected seasonally due to changes in littoral current regime.Incidentally, the coastline also records high rate of erosion for a stretch of 27 km during the south-west monsoon. The coastal stretches along the zone 1 and 2 comes under very low vulnerability enumerating a range of 1.98 to 12.56. The area characterizes accreted beaches during favorable periods due to washing of sediments along the gentle sloping face of the beaches. The mapping of coastal vulnerable zone provides priori information for sustainable management of coastal zone by adapting adequate remedial measures.

Introduction

The coastal zones are valuable for resources for socioeconomic developments worldwide; however, theirhighly dynamic nature and complex multi-functional systems encounter hazards and disasters due to natural and anthropogenic factors. During the 21st century, sea level rise is recognized as one of the most threatening issues along the Indian coasts. During the last few decades, coastline along the Thiruvananthapuram District experienced high pressure due to anthropogenic interventions causing degradation to coastal landforms. The degree of coastal vulnerability is due to multiple parameters influencing the coast such as wave height, sea level rise, modification in the nearshore bathymetry, tidal fluctuation, shoreline change and transformation of the landforms, etc. Sea level rise directly influences the coastal landforms due to erosion along with other coastal hydrodynamic parameters. Cumulatively, they produce large-scale changes in the coastline, configuration of nearshore and ocean floors. Changes in landforms along the coastal stretches are also due to the rising sea level submerging coastal habitats in the low land area. Moreover, rising sea level causes cliff erosion by altering the hydrodynamic forcing exerted

by waves impairing the headland features like sea cliffs, caves, wave-cut platforms, and notches along the rocky coasts. Assessment of coastal vulnerability reveals the potential to deformation coastal landforms due to many natural and anthropogenic factors in the study area. Understanding the coastal vulnerability requires investigation on the potential magnitude of physical, environmental and socioeconomic factors contributing to vulnerability in the coastal area (Patnaik and Narayanan 2009). Coastal vulnerability assessments at the regional scale require exhaustive understanding of coastal systems, dynamics,site-specific metrics and indicators that would form inputs to a complex and data-intensive model (Alder et al., 2004; Kumar and Kunte, 2012). Mapping of vulnerable zone causing damages to coastal landforms can be performed through an integrated approach of remote sensing and GIS techniques. Remote sensing and GIS provides effective platform for assimilating and analysis of spatial database for assessment for coastal vulnerability (Hammar-Klose et al. 2001). Satellite image provides attributes for coastal stability evaluation synoptically than the conventional methods (Hegdeet al. 2007). Coastal vulnerability studies using satellite data is a prudent practical approach for the management of coastal zones (Mahendraet al. 2011). Multiple spatial and non-spatial data sources are widely being used to address the vulnerability characteristics in a coastal area (Pendletonet al, 2005; Kumpulainen, 2006).Geodatabase of coastal vulnerability is currently considered as a pre-requisite to help manage the coastal areas for decision makers and planners.

Profile of the study area

Coastal vulnerability studies along the Thiruvananthapuram coast in Kerala has been performed through a composite approach using remote sensing and GIS techniques. The coastal zone of the Thiruvananthapuram District covers a coastal stretch of about72 km extending landward for 5 km from the coast bound by the Lakshadweep Sea. The geographical extent of the area is between the latitudes 8°17' Nand 8°54' N and longitudes 76°41' E and 77°17’E. The coastal stretch is highly dynamic due to the hydrodynamic forces such as waves, currents and tides, etc., The coastal area also undergoes variability in terms of nearshore bathymetry and landforms of different types, such as, sandy berms, beach ridges, beach cusps, and beach scarps, etc. The landforms along the coast underwent morphological instability due to both natural and anthropogenic factors. Major locations of the coastal stretches are active in business, tourist attractions and are very densely populated with thick settlements. Along the coast, human settlements and properties are threatened due to severe coastal erosion during the monsoon months. The study area experiences a sub-tropical climate with average annual rainfall varying from 826 mm to 1456 mm and the annual mean minimumand maximum temperatures rangingfrom 23.78º C to 33.95º C respectively. Along with the multi-parametric approach of mapping the coastal vulnerability, the present study also attempts to map the coastal landforms and their changes. For convenience of the study, the coastal stretch has been divided into five zones based on the administrative blocks for providing the databases independently for governance of the stretches for sustainable coastal zone planning and management.

Materials and Method

The coastal vulnerability analysis is performed using multiple physical and environmental parameters using remote sensing and GIS techniques. Thematic layers of the parameters are derived from various digital spatial data sources such as Landsat TM(Thematic Mapper) image (30 m), and OLI (Operational Land Imager) image (30 m), ASTER DEM (30m) and SRTM 30cPLUS (90m); and otherdata sources include SOI topographical map, bathymetry chart, tide gauge data, wave height from ERA (European Resource analysis) interim, and mean sea level data from PSMSL (Permanent Service for Mean Sea Level). Data from these sources were systematically analyzed using various functions of GIS software.

Sea-level rise is an important consequence of climate change influencing the landforms along the coastal area. The sea-level change rate is derived from the PSMSL, tide gauges and wave rider buoy data for the period of 1989 – 2016. Sea level rise estimated for locations are based on the linear interpolation method using ArcGIS platform. Coastal zones recording sea level rise at the rate of more than 6.0 mm/yr. are considered as potentially vulnerable to physical damages due to pooled effects of waves and tides (Kaliraj and Chandrasekar, 2012). The present study deals with computation of the CVI algorithm to understand the

coastal vulnerability. It refers the square root of the product of the weighted variables divided by the total number of variables (Thieler, and Hammar-Klose, 2000; Pethick and Crooks, 2000) and is expressed as,

$$CVI = \frac{\sqrt{a*b*c*d*e*f*g}}{7} \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where,***a*** refers to geomorphology; ***b*** is the shoreline erosion/accretion rate (m/yr);***c*** is the coastal slope (degree);***d*** is for rate of sea level rise (mm/yr);***e*** is the mean significant wave height (m);***f***is mean tidal range (m); ***g*** is suspended sediment (m^3/sq.m); The mean wave height (*e*) is obtained from derived products of ERA interim, UK. The relationship of these parameters is directly expressed as wave energy which is proportional to the mean wave height in the offshore (USGS, 2005). All the parameters are segmented by assigning weights from 1 to 5 based on their vulnerability ranks from very low to very high level respectively. The result of the analysis provides vulnerability values for each grid of the raster image, which reflects the coastal vulnerability of the corresponding location.

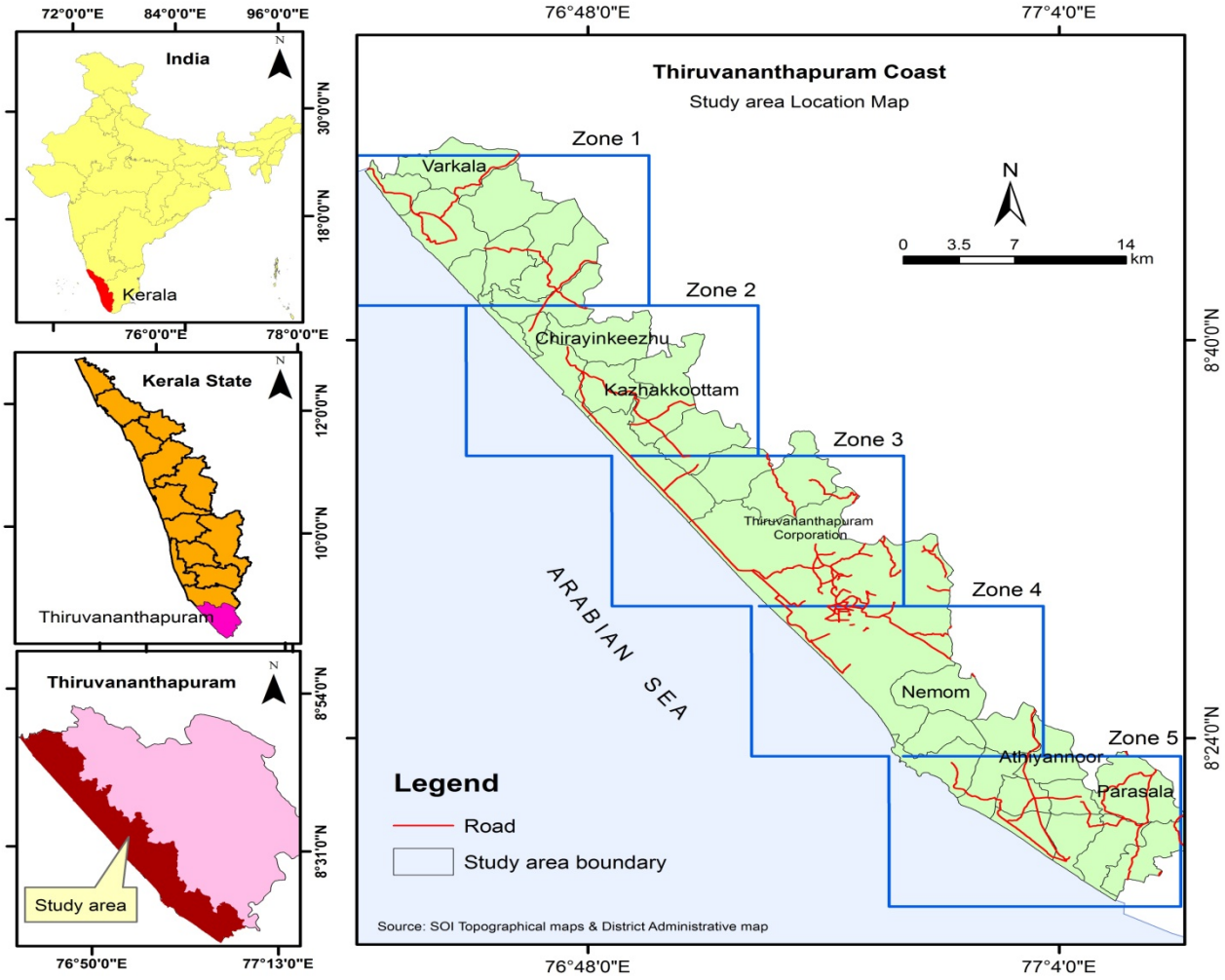

Figure 1. Location of the study area.

Results and Discussion

Sea level rise triggers enduring inundation of coastal areas resulting in serious impacts on the coastal habitats as well as hampering the socio-economic wellbeing (Dwarakish et al, 2009).In the long run, global warming induced sea level rise may inundate the shallow areas of the coast throughout the world

(Subramanya, et al, 2009).It would directly result in a corresponding shift in the breaker zone due to wave action, accelerating shoreline recession (Capobianco, et al, 1999). Increasing of sea level would not onlyworsen the coastal erosion by transporting sediments offshore from theinundated foreshore, but will alsobroaden the effects of coastal flooding by allowing waves to act furtherlandward. This would on one side will degrade the coastal landforms on the other side will affect gradually the man-made structures causing heavy socio-economic loss. The coastal vulnerability reveals the adverse impacts through the deformation of coastal landforms due to sea level rise that would gyrateto environmental degradation and habitat damages in the study area. Figure 3 shows the zone of vulnerability leading to damages of thelandforms and habitats due to change in the various parameters considered for computing CVI in the study area.

Major parts of the coastal stretch in the Zone 5 records very high vulnerability. Certain coastal stretchesshow higher rate ofcoastal retreatduring the period1997 - 2017. Those areas have experienced severe erosion resulting indamages to coastal landforms due to increase in the wave height. Hydrodynamic processes *in situ*releases higher energy to the coast resulting inerosion features such as beach scarps and cusps as well as triggering cliff erosion along the rocky coasts. However, certain stretches experiencelow-energy regimeinducing accretion due to swashing of sediments. The landforms include estuaries, shallow marshes, backwater, creeks, and human settlements in the low-lying area (< 1.4m from MSL). High vulnerability for flooding inundation is an inevitable result of the changing sea level, coastal hydrodynamics and nearshore bathymetry. However, areas having elevationsabove 10 m have potential vulnerabilityin the case of severe events such as high wave run-up, tsunami and storm surge, etc. Sea level riseincreases in the zone 4 and 5 during storm events, which enhances the wave energy. This results in the maximum vertical extent of wave “up-rush” inundating the coastal landforms above the instantaneous water level or storm-tide level which can cause severe land loss at short-term periods.

Table 1. Important factors influencing coastal vulnerability along each sector.

Sectors	CVI value	Rate of Vulnerability	Factors Influencing coastal vulnerability
Zone 1	1.93 - 6.57	Very low vulnerable zone	Swashing of sediments on gentle slope leading to formation of beaches, reducing vulnerability to erosion
Zone 2	2.98 - 15.8	Low vulnerable zone	The coastal configuration,man-made structures and nearshore bathymetry are favourable for coastal stability
Zone 3	5.36 - 25.12	Moderate vulnerable zone	Seasonal changes of waves and littoral currents causes shoreline erosion damaging even the landforms in the shallow coastal stretches
Zone 4	8.88 - 34.4	High vulnerable zone	Beaches get severely eroded by the strong wave run-ups resulting from seasonal rise in sea level
Zone 5	12.68 - 54.43	Very high vulnerable zone	Increasing sea level damages the landforms due to action of high energy waves approaching through the deepernearshore

Table 1 shows important factors influencing coastal vulnerability along each sector. The combined action of storm-tide plus wave run-up damages the beaches, overtopping the berms and seawalls along various parts of the study area. Sea level rise increases the wave height at the breaker points releasing high-energy to the foreshore causing increased backwashing of sediments from the berm crestinfluencing the shape of beach profile.The result of CVI model is derived through systematic application of different geoprocessing tools by inputtingdesired data as predetermined for processingwith the model. The coastal zone 4 are highly vulnerable due to erosion.The majority of the geomorphic classes along the coastline comprised of sandy beaches and mudflats that are rated at high risk. Coastline comprising of estuaries, back swamp and coastal plain are assigned with moderate vulnerability. The study area is exposed to mean significant wave heights ranging from 1.08 to 1.21 m. The region in the within Zone 5have beencomputed as very high vulnerable areas due to the high wave impact, deep nearshore bathymetry as well as tidal effect. Average of every minute interval data throughout 1989 to2016 have been considered for assessing sea level to input into the CVI model.The CVI model enumerates that the coastal areas in the Zone 5 are under very high vulnerable zones. Whereas, the stretches coming under Zones3 and 2 are computed with moderate and low vulnerabilities respectively.

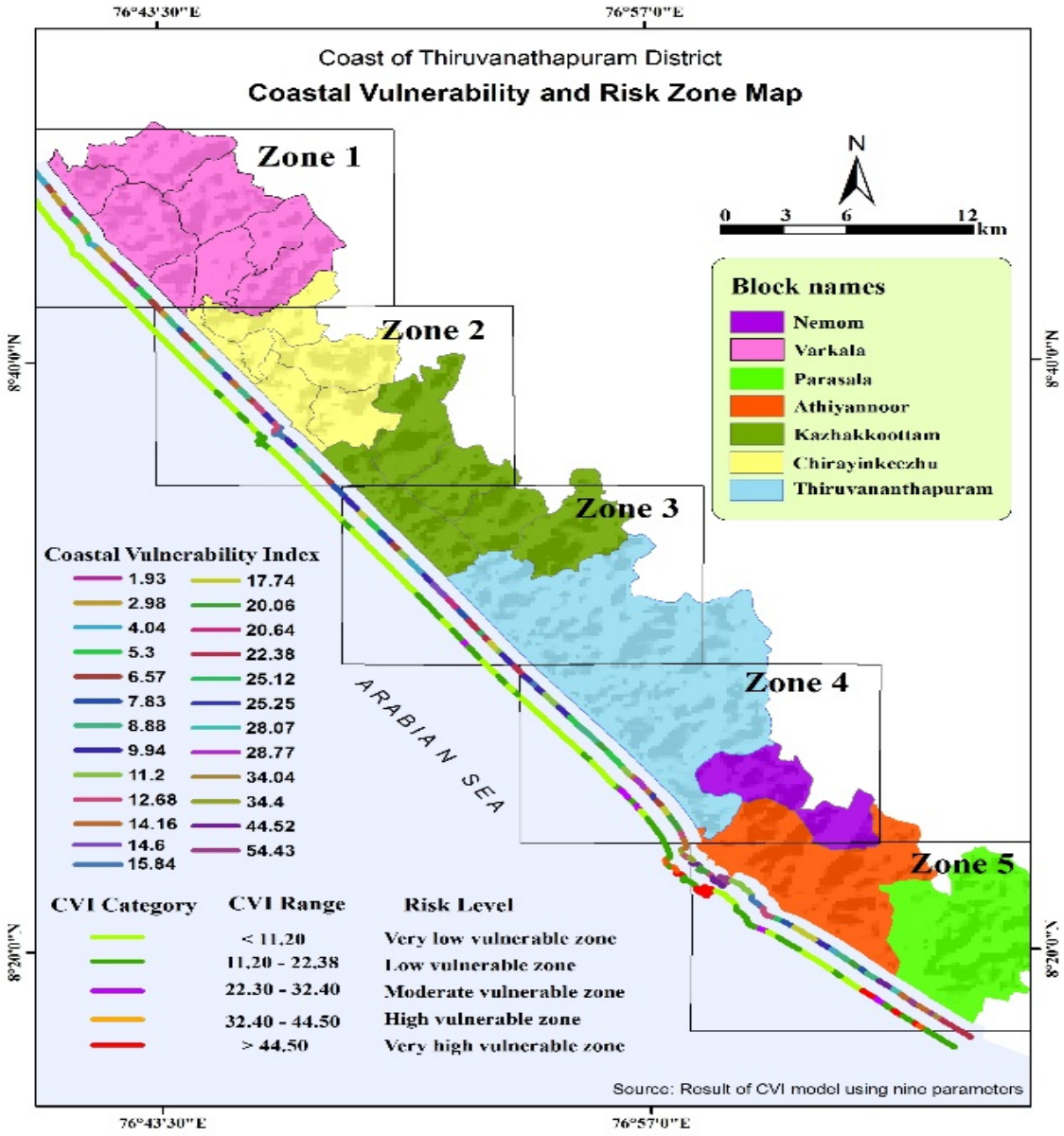

Figure 2. Map showing plots based on CVI model indicating the coastal vulnerability along the study area.

Conclusion

Coastal vulnerability increases physical damages to coastal landforms, habitats and human settlements. The coastal landforms in the low-lying region are extremely vulnerable to shoreline change and land loss during storm surge, tsunami and other natural hazards. Overall observation reveals that the low-laying areas prevalent with high-energy wave actions are the most vulnerable locations to effects of projected sea level rise. The CVI computation depicts vulnerability rates for each grid zone in the study area demarcating the risk level of the location. The result of the CVI analysis through an integrated remote sensing and GIS is a robust tool for assessing the coastal vulnerability and mapping. The geodatabase on coastal vulnerability is primary information for sustainable planning and coastal management that would help decision makers and planners.

Acknowledgement

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Identification of groundwater potential zones of Karuvannur river basin,Thrissur district Kerala using GIS and Remote Sensing

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Introduction

Increasing dependence on ground water over the years has led to depletion of ground water levels in several areas of the country. Therefore, there is an urgent need to address the issue of management of water resources in these areas in a sustainable manner. Integrated remote sensing and GIS can provide an appropriate platform for converging diverse data sets for analysis geared towards decision making in ground water management. The knowledge of groundwater location is important for the management of water resources, especially when the groundwater forms the main resource for supply of water. The Remote Sensing data can provide useful information on the factors controlling the occurrence and movement of groundwater. A systematic study of these features help in better delineation of prospective groundwater sources in a region. Besides,the identification of linear features, certain geomorphic units (alluvial fans, buried channels etc.) soil moisture zones and topographic and vegetation indicators help in selecting the potential areas for groundwater exploration. GIS can be applied in identification of water recharging areas, delineating groundwater potential zones, development of water resources, watershed management, monitoring of ground water pollution etc. Using the GIS tools, knowledge based weightages is assigned to each map such as geology, geomorphology, land use, slope, etc. and each unit in these maps are rated depending on the influence of each to the ground water movement and storage. By integrating these layers the ground water potential zones are delineated. The advantages of GIS are that everything is defined with in a spatial context. The distribution of precipitation, ground water recharge zones etc can be brought in a single map. GIS is one of the advanced information system which can be used for scientific investigation, research and development. In the present project an attempt is made to study the groundwater potential zone mapping for the Karuvannur river basin, in Thrissur district, Kerala, using an integrated remote sensing and GIS based methodology.

Study Area

The Karuvannur watershed lies between 10°15’ and 10°40’ North latitudes and 76°00’ and 76°35’ East longitudes, covering an area of about 957km^{2}in parts of Thrissur district of Kerala state. The area is bounded by Thrissur and Chavakkad taluks of Thrisuur district in the south, Alathur and chittur taluk of Palakad district in the east and Arabian Sea in the west. Karuvannur river takes its origin from the western Ghats and drain through the hilly and undulating terrains in the east, before entering into the low lands and finally emptying into the sea. The main tributaries of the Karuvannur river are the Kurumali and Manali rivers. The other streams which feed these tributaries include the Chauralaaar, Chimonipuzha, Talikuzhi, Muplipuzha, Idukuparathodu, Sinikuzhithodu, Kurumalipuzha, Manaliar, pullathodu, and Kunjirupuzha. The main rock type found in the area are charnockite, genisses, hornblende gneisses and granite of the Precambrain age and the laterites formed over them during the Tertiary period. The granites and massive charnockites form the high hill in the eastern parts of the area. The charnockites and gneisses spread out a large area forming the medium to low hills. The laterite and hornblende gneiss are found in the midland while the alluvial plains and valleys towards the south western side of the study area are covered by quaternary alluvial deposits.The occurrence and movement of ground water is controlled by the presence of joints, fractures, porosity and thickness of the weathered zones in the underlying formations.Geomorphology and land forms affect the movement and storage of ground water in any terrain. Alluvial plains: In the study area, the alluvial planes are concentrated toward the western side. These are the areas with high amount of moisture and mostly with cultivation.

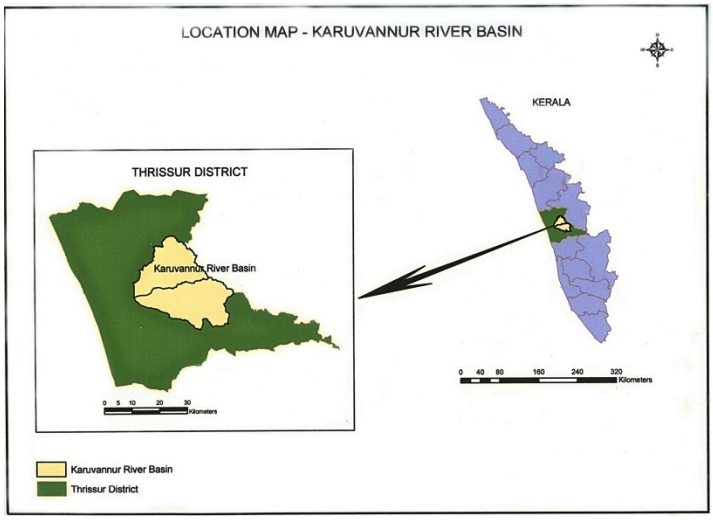

Fig 1. Location map of Karuvannur river basin.

Methodology

The survey of India toposheets (58 B/3, 58 B/6 58 B/7, 58 B/11) on 1:50,000 scale is used to prepare the base map, drainage map, geomorphology map and land use map of the Karuvannur watershed. The IRS LISS III imagery of the area is used to prepare and update the land use, and geomorphology maps of the study area. The SRTM elevation data of the study area is used for generating the contours of the area. The geological and Mineral map of Kerala prepared by Geological Survey of India is used as a source data for the geological map of the study area. The GIS software used in the study is Arc GIS (Version 9) from ESRI. A personal geo data base named 'ground water' is created in Arc Catalog and a data set is created for Karuvannur watershed. Point, line and polygon feature classes are created within this dataset for vectorising the different features of the study area.

Preparation of maps

The study area comprising Karuvannur watershed is delineated from the Survey of India Toposheet No 58B/3, B/6, B/7 and B/11. The drainage network of the study area is vectorised from the SOI Toposheets -58B/3,B/6,B/7 and B/11 of 1:50,000scale using the Arc GIS software. The stream ordering is done using the method proposed by Strahler (1964). The land use classes of the study area are delineated using the data on the toposheets and also by interpretation of satellite image of IRS LISS III data. Land use classes in the area include paddy cultivation, mixed crops, forest, rubber plantation, settlement, water body etc. The geology map of the study area is extracted from the Geological and Mineral map of Kerala on 1:500,000 scale by Geological Survey of India as well as using SOI toposheet. The Geological units of study area include hornblende gneiss, charnockite, granite and laterite. Geomorphology has a very dominant role in the movement and storage of ground water in any terrain. The occurrence of ground water depends on the geological structure and depth of weathering of the area. The Geomorphological map of the study area is prepared using the IRS LISS III image and with the help of the toposheets. The geomorphic units of the area include high hills, moderate hills, low hills, residual hills, alluvial plains, valley fills and water body. Slope is considered as an important in ground water assessment of the area. And it has a greater impact on the amount of water lost as run off into drainage channel network and the amount of water infiltrating into the ground. The slope map is prepared by using the Digital elevation model and slope generation tools in GIS software.

Data Analysis

After the base data is prepared, analysis is carried out for determining the morphometric parameters for the watershed and also for delineating the ground water potential zones for the study area. The methodology adopted is represented in the Flow chart.

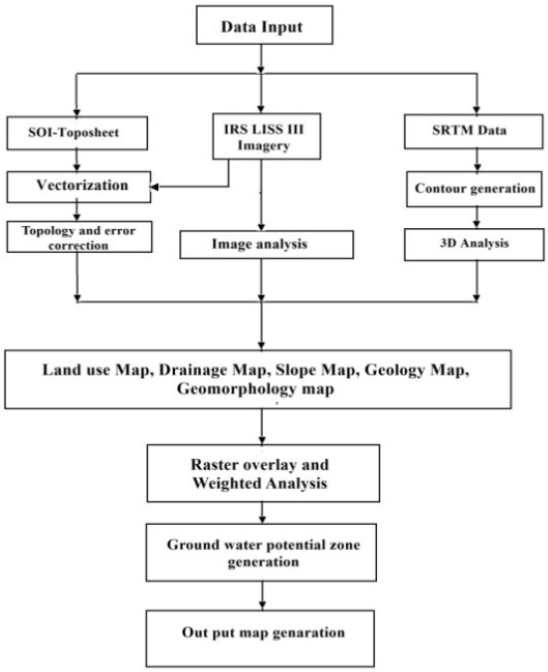

Fig 2. Flow Chart showing methodology.

Preparation of Ground Water Potential Map

The parameters used in assessing ground water potential are geology, geomorphology, land use type and slope of the area. These parameters are in the form of vector format and are converted into raster format using the conversion tool in spatial analyst extension. These different raster layers are reclassified and given ranks based on their composite values obtained by overlying different layers.For the assessment of ground water potential of the study area, all the raster data sets for different layers which give the score for each class are overlaid and the scores of each composite class are added selection queries or type in Map Algebra Syntax The final scores after due raster calculations are reclassified to generate the output map showing various classes of ground water prospect.

Result and discussion

The land use cover of the Karuvannur watershed is differentiated into paddy cultivation, mixed crop, rubber plantation, cashew plantation, teak plantation eucalyptus, built up area, stone quarries and water bodies. The most dominant land use type is dense forest, which comes to 46.97%. This is followed by mixed crop (21.67%) and paddy field (13.39%). Geomorphologically, study area includes alluvial plain, high hill, moderate hills, low hills, residual hills, valley fills and water body. The valley fills and alluvial plains are the area having higher porosity and permeability and are intensely cultivated. Alluvial plains cover about 30% of the total area. Valley fills that comes to about 1.73% areas are also areas of good infiltration. The dominant type of rock in the study area is the laterite, and is porous and permeable and can serve as good, but shallow aquifers. Higher rating has been given to water body, paddy cultivation, alluvial plain, valley fills and laterites units since they have higher contribution to the ground water. However, lower rating has given to the higher hills (26 %) and moderate hills (31.12 %) considered as the poor zones of ground water. Moreover, Charnockite and Gneiss are the dominant rock type found in the area which together forms about 54% of the study area. The scope for the ground water potential is comparatively much less in these crystalline rocks as the ground water occurs only in their fracture zones. In fact, the areas with gentler slope will allow the water to remain on the ground for longer time and hence provide for a greater amount of water to infiltrate, while the steeper slope lead to faster runoff and thus less infiltration. The areas of higher slopes are found in the eastern and north eastern part of the study area.

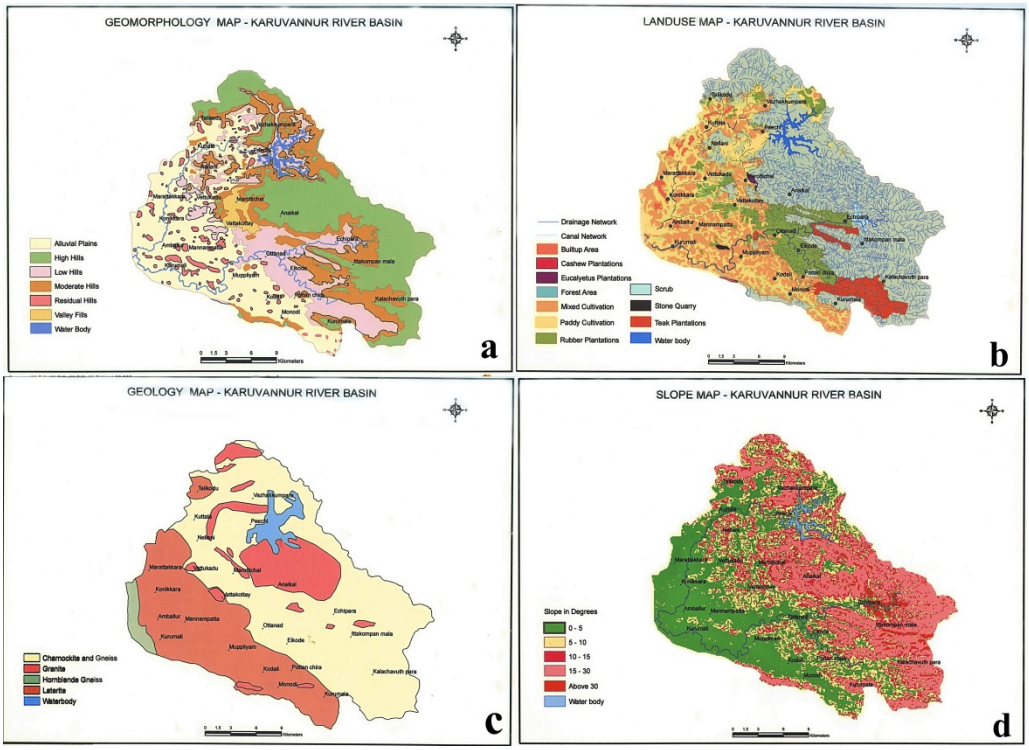

Fig 3 (a) Geomorphology map **(b)** Landuse map **(c)** Geology map **(d)** Slope map of Karuvannur river basin.

Ground water potential zone map

By integrating various thematic using the weighting and ranking method a ground water potential zone map has been generated for the Karuvannur watershed (Fig. 4). The potential zones have been classified into four categories on the basis of ground water prospects (1) very high (2) high (3) moderate and (4) low and their respective areas in the two sub watersheds were calculated.The two sub watersheds, namely manali and kurumali, have been compared in terms of their ground water potential as follows

1) *Manali sub-watershed*: Very high potential zones cover nearly 24.9% of the area in the southwest of the study area. This region is mostly under alluvial plains and valley fills. Geologically this area is identified with the presence of laterite with alluvium cover. This area is much it becomes a good prospective zone for ground water exploration. High potential zones spread over 59.7km^2 (19.7%) of the area in the south eastern part. They are the areas with moderate slopes and low and residual hills with laterites. The moderate and low potential zones covers an area about 69.6km^2 (23%) and 98.51km^2 (32.4%) respectively. These are the areas of high hills with charnockite and gneisses which are considered to be poor source of ground water.

Table 1. Ground water potential zones of Karuvannur river Sub-watersheds.

Sl No	Sub-watersheds	Total area	Very high		High		Moderate		Low	
		Km^2	Km^2	%	Km^2	%	Km^2	%	Km^2	%
1	Manali	304.18	76	24.9	59.7	19.7	69.9	23	98.5	32
2	Kurumali	374.18	114.5	30.6	54.9	14.7	80.5	21.5	124.3	33.2

2) *Kurumali sub-watershed:* Very high potential zones cover an area about 114.5 km^2 (30.6%). This region is mainly alluvial plains and valley fills having paddy cultivation as the major land use. As the area is a flattened land with alluvium and laterite, it act as good ground water potential zones. High potential zones is about 54.9 km^2 (14.7%) which is spread east to the very high potential zones. They are the area with low hills and valley fills which make them high ground water potential zones. Moderate and low ground water potential zones comes to about 80.5 km^2 (21.5%) and 124.3 km^2 (33.2%) respectively. They are concentrated on the eastern side of the study area having high hills with steeper slopes and granite and

hornblende as rock types. On comparing both the sub watersheds, it is found that Kurumali basin is having the larger area of ground water potential zones (30.6%) as compared to Manali (24.9%) basin this is because the factors contributing to the ground water potential zones exist over larger area in this basin. On the other hand both of the sub watersheds have almost equal areas of low potential zones (33.4% and 32%) because of the presence of steeper hills in the higher reaches towards east covering both the sub-watersheds.

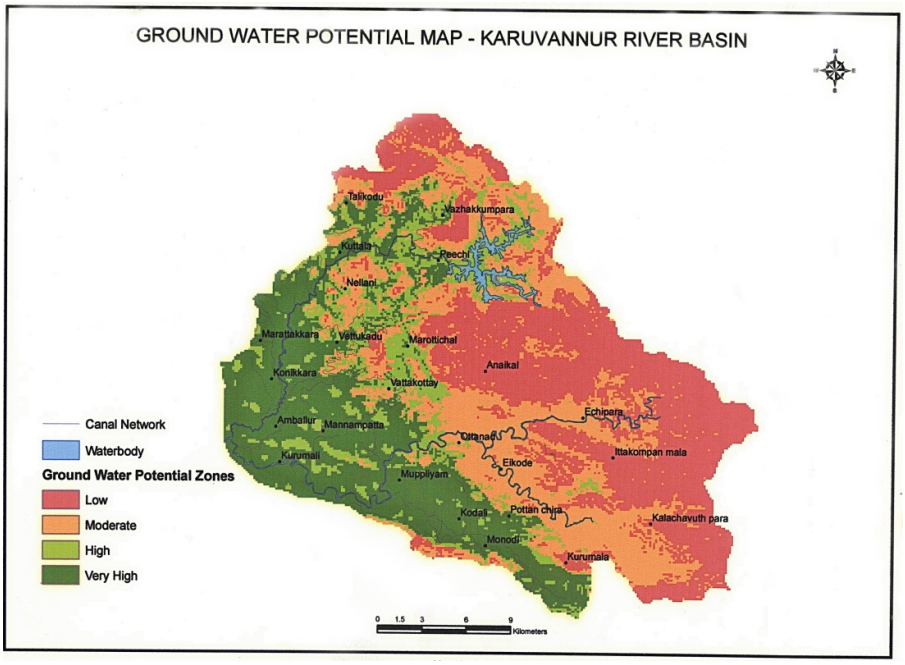

Fig 4 Ground water potential map of Karuvannur river basin

Conclusions

The study demonstrates the usefulness of remote sensing and GIS techniques in identifying potential zones for groundwater. The groundwater prospect map is the result of a systematic effort of integration of various factors which influence the water yield. The map shows different zones of groundwater potential and can form the basis for planning and execution of groundwater exploration in the two sub watersheds. The high potential zone because of favourable surface and sub-surface conditions like occurrence of alluvial deposits and valley fills with the presence of permeable aquifers and nearness to streams create a conductive environment for higher water yield as well as favourable discharge. The water availability is concentrated to western part in the case of both the sub watersheds. On the other hand, the eastern part of this zone, because of compact and unfavourable formations provides very limited scope for water yield. Low potential zones include high hills over the rock types like charnockite and gneisses which act as run-off zones.

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Rescue time saver (RTS)

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Introduction: We, hereby introduce an advancement system, which can be applied in the existing traffic control signals at junctions which allow the emergency vehicles to cross these signals without any delay and head to the rescue sites as fast as possible.

Problem analysis: Loss of golden minutes during rescue operation due to traffic jams at signals. With the increasing number of traffic day by day, it is a very tough situation for different emergency vehicles like

fire-fighting machines and ambulances to reach their destinations without any delay caused by the traffic, especially at traffic signals. So, here we may like to introduce an advancement in the existing traffic signal systems for avoiding this delay.

Objectives: From the visits we have done in a few fire stations we were able to recognize a serious problem they face during the initial response operation, the loss of golden minutes at the traffic signal blocks. So our objective is to reduce response time of emergency vehicles.

Methodology: In this system, we may require:
1)Transmitter unit (in ambulance) 2)Receiver unit (at traffic signal) 3)Alert unit (signal light and alarm)
These are the equipment to be added to the existing system of traffic signals.

Rescue time saver: Here we will be having a transmitting module, which we will be fixed in every emergency vehicle. This module is operated at the time of emergency and they emit signal.We will fix the receiving unit at the traffic station which is linked with the traffic signal. Now, in the case of such an emergency vehicle passing through these roads, the signal is send from the vehicle and will be detected by the receiver unit at the signal and now, the system turns the signal RED on all other roads expect that of the road in which the emergency vehicle is coming. This will allow those vehicles to cross the traffic signal without loss of the golden minutes.

Deliverables: A transmitter unit provided to the emergency vehicles will communicate with the receiver and alert unit at the traffic signal and ensure uninterrupted passage of the emergency vehicles and hence save a few golden minutes of the response time.

Working: The traffic **Signal Module** is set up at a particular point

GPS coordinates of 4 different points (North West East South) which are situated at constant distance from the signal module

The traffic signal module is connected with the **Android** device at the signal using **Bluetooth** connectivity

The coordinates obtained in step 2 is inserted to the **Android** device in the rescue vehicle

When the rescue vehicle approaches the signal and the **GPS** coordinates of the vehicle matches with any one of the coordinates obtained in step 2(within a specified range), a coded **SMS** is sent to the android device at the signal

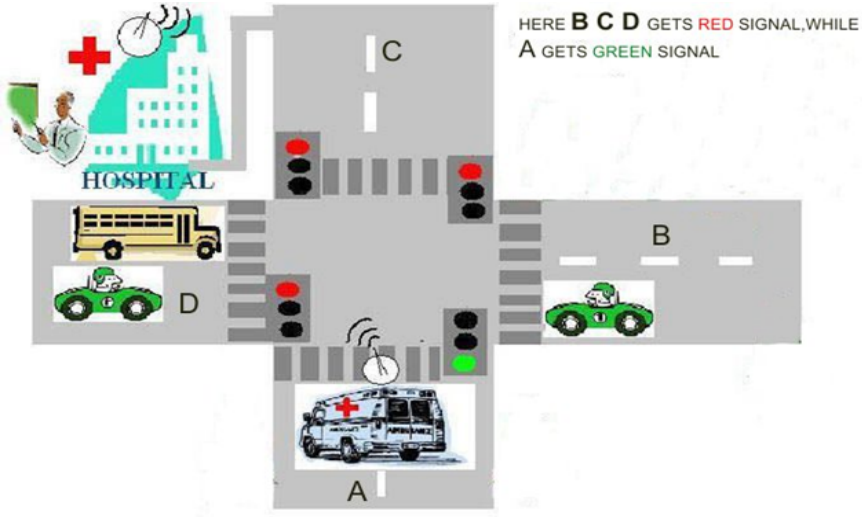
The coded **SMS** is decrypted by the android device near the signal and sent to the traffic light control module via **Bluetooth** connectivity.

Now, the signal light at the direction in which the rescue vehicle approaches turns green with an alert at the junction.

The signal light system will turn back to normal cycle after the specified time.

In case of multiple vehicles coming in different lanes the preference is first come first go.

The time for the signal is to be calculated according to the traffic pattern at each junctions.



Scalability

- This system can be designed in such a way that it could be operated in every traffic signal according to the type junction, traffic strength, accident prone areas such as industrial areas etc.
- Real time tracking of the emergency vehicle is possible and we can send the emergency response unit which is nearer to the location.
- Centralisation of the emergency response units such as ambulance can be done by registration of the vehicle through our module.
- Misuse of emergency vehicles can be avoided.
- Allocation of more units of emergency vehicles near accident prone areas is possible.
- Fire stations and hospitals can monitor the current position of their emergency response vehicles.

Acknowledgements

It gives us immense pleasure to express our deepest sense of gratitude and sincere thanks to our highly respected and esteemed guide Asst. Professor Sarun P Murali of mechanical stream-automobile engineering department snit, Adoor for his valuable guidance, encouragement and help for completing this work. We would like to express our sincere thanks to ILDM for giving us the opportunity to undertake this project and funded this. We would also like to thank to our respected principal for whole hearted support. We are also grateful to our facilities for their constant support and guidance. We also wish to express our indebtedness to all our family members whose blessings and support always helped us to face the challenge ahead. At the end, we would like to express our sincere thanks to all our friends and others who helped us directly or indirectly during this project.

Environment and conflict reflection on Sudan and South Sudan

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Abstract

The conflict and environment are related to many communal disputes in Sudan as well as many sub-Sahara countries when they are observed in the reduction in the length of the rainy season and, severe drought, and a decline in vegetation and water resources. However, the paper endeavours to punctiliously enunciate the impact of environmental hurdles which is arduously floundered in Sudan in the late 70s and 80s in the last century and its tremendous and ginormous impact on natural resources, agricultural production, and acute shortages in water availability which unfortunately culminated in steadfast competition over natural resources between pastoralists and farming communities in Sudan. Furthermore, environmental factors have been major contributors to the local conflict which is a link to shortages of natural resources in Suan especially in Darfur conflict, which erupted in western part of the Sudan. The conflict was weighed to be staunchly, caused by the environmental problems and land degradation. However, livelihoods in Darfur sturdy depends on natural resources and rural production systems achingly based on farming and pastoralism. However, during the past drought, local people in Darfur adapted their livelihoods through multiple strategies, by adapting several livelihood strategies, or by moving their livestock to water-rich areas. Additionally, the household has become more adaptive to climate changes when livelihood activities became under pressure from drought. Trends in migration increased during the early 1970s and mid-1980s because livelihood systems were affected by drought and famine. Meanwhile, most of the pastoralists depend on transhumant mobility in the quest for water and pastures and this habit makes their life more vulnerable and volatile in badly need and the quest for these resources. Furthermore, in the recent years, we have seen acute shortages in rainfall, followed by, the decline in water, which imminently, culminated in high competition, and led into communal conflict, in Darfur of Sudan, and South Sudan had been profound, exacerbated by climate change factors. However, the paper will strenuously, unpack and elaborate explicable and the connection between the environment and conflict. However, it is, therefore, sine -qua- non and precursor to rigorously observed environmental cataclysms to painstakingly circumvent conflict of shortages in resources.

Keywords: ***Climate, Pastoralism, Resources, Conflict, Drought. Disaster, farmers***

Introduction

The issue of environmental changes is obvious and conspicuous in many areas in Africa, it became an incontrovertible and indisputable conundrum. However, the gradual evidence increase in the global average air and ocean temperature, the precipitation and gradually, increases in some areas in the world such as (eastern parts of North and South Africa, north Europe and northern and central Asia) and this in addition to serious decline the Sahel, the Mediterranean, southern Africa and parts of southern Asia these areas were established for rainfall data of more than a century since 1970s. However, the climate change impact manifested its self in the reduction length of rain season and shortages of water and resources in general and this affect livelihood especially, among pastoralist communities and led them to migrate to further places. However, as the result of climate change, the drought intensified in many places in Africa which are also followed by desertification in the north. However, there is a vehement believe that climate change impact has a causal link with conflict: as is it the case with all resources based conflict. However, many conflicts in Africa is wrought by environmental changes which led to acute shortages in resources. However, the paper will surmount with the presumption that the climate change has made significant changes in the natural environment and in human life and affects socio-economics and finally it has a direct link with resources based conflict.

Sudan

Sudan also was known as **North Sudan** since South Sudan`s independence and officially the Republic of the Sudan is a country in Northern Africa. It is bordered by Egypt to the north, the Red Sea Eritrea and Ethiopia to the east, South Sudan to the south, the Central African Republic to the southwest, and Chad to the west and Libya to the northwest. It is the third largest country in Africa. The River Nile divides the country into eastern and western halves. Before the Sudanese Civil War, South Sudan was part of Sudan but broke away in 2011.

The Environmental Problem dwindling Resource in Sudan

The environmental issues affecting agriculture in Sudan result in a dwindling natural resources are as follows: **Desertification, soil erosion, and soil exhaustion**

Depletion of nutrients lower agricultural productivity and, in the worst cases, take land out of use for the long term.

Deforestation, particularly in the drylands, has resulted in a near-permanent loss of resources including seasonal forage for pastoralists and natural soil recovery services for farmers.

Historical climate change has reduced productivity in some areas due to a decline in rainfall.

Forecast climate change is expected to further reduce productivity due to declining rainfall and increased variability, particularly in the Sahel belt.

The increasing demands on resources

The demand for natural resources in Sudan is increasing, due to the following factors.

Human population growth: Is the driver of increased demand for natural resources, Sudan has an overall growth rate of over 2.6% percent per annum, masking much higher localized rates indicative of large-scale in-migration, in this case of the migration from the north due to environmental factors such as desertification.

Livestock population and growth rates: Government officials and academics have tracked the population increase of livestock since the 1960s. In northern and central Sudan alone, it is estimated to have increased by over 400 percent between 1961 and 2004.

Land use changes a diminishing share of resources for pastoralists: The expansion of agriculture into areas that were either rangeland or forest has been a well-recognized trend for the last four decades. The northwards expansion of rain-fed agriculture into marginal areas historically used for grazing has been damaging the resources for pastoralists.

Institutional Factors affecting Agriculture

The rural environment has been impacted by a combination of ill-fated reform and development programs, as well as legal reforms and failures in environmental governance. One key issue is the difficulty of developing and applying a practical, just and stable system of rural land tenure in an ethnically complex society of intermingled sedentary farmers and transhumant/nomads. These institutional factors include

Lack of development and livelihood options.

Rural areas in Sudan remain very poor and underdeveloped. Rural populations have very few options to solve these agricultural crises, as solutions such as agricultural development, improvements in pasture and stock quality, and using working capital to cover short-term needs and alternative employment is not available.

The Disappearing livelihoods for dryland pastoralist societies

The significant long-term increase in livestock density on rangelands that are reducing in total area, accessibility and quality. In environmental terms, there is overgrazing and land degradation. Pastoralist societies are facing permanent loss of livelihoods poverty. Pastoralist societies in Sudan have been relatively vulnerable to losing their livelihoods due to erratic rainfall, that affects many pastoralists and lead into abject poverty, displacement, and conflict. Their coping strategies, which have been well documented include:

Abandoning pastoralism as a livelihood in favor of agriculture, or displacement to cities;

Increasing or varying the extent of annual herd movements where possible, with a general trend towards more southerly migration.

Maximizing herd sizes as an insurance measure assisted by the provision of water points.

Changing herd composition, replacing camels by small animals, sheep, in response to the curtailment of long-distance migration.

Competing with other grazers for areas of higher productivity.

Moving and grazing livestock on cultivated land without consent and

Reducing competition by forcing other pastoralists and agriculturalists out of shared land. **Displaced population** settle on the outskirts of towns, such as in El Fasher, where the new settlement is distinguished by white plastic sheeting. These new arrivals add to the environmental burden on the surrounding desert environment.

The Conflict and Environment in Sudan

The Darfur conflict: a focus on the environmental dimension: The conflict in Darfur can be deemed as created by complex problems with many dimensions. However, livelihoods in Darfur are linked with natural resources. Rural production systems are based on sedentary cultivation and transhumant and pastoralism. Furthermore, during the past drought episodes, local people in Darfur managed to adapt their living systems through different strategies, such as diversifying their livelihood strategies, or by moving with livestock to fodder and water-rich areas. Nomadic pastoralist migration from within the region to more distant areas and urban centers. In addition, household mobility has also enabled adaptation to climate variability when core activities became under ecological pressure from drought. Trends in migration increased during the early 1970s and mid-1980s because livelihood systems were affected by drought and famine

However, the majority of households in the region migrated southwards and others opted or preferred to live in refugee camps. Additionally, the increase in population in south Darfur, due to migration to the region from other parts of the region, and neighboring countries, to settle in order to make a migration across regional and national boundaries could be considered as livelihoods strategies. The declining resources and the weak institutions and administrative power exaggerated the situation. The conflict, on the other hand, has impacted the migration and nomadic seasonal mobility, which restricted the movement of people and livestock. The forced displacement and blocking of physical mobility d contributed to the loss of livelihood strategies, assets, and properties and sometimes brought the death of livestock.

Meanwhile, other factors that contributed to the escalation of the conflict in Darfuris the late response to the fact that conflicts over resources that start at the local level, and, as was not given the consideration at the right time. In addition to the loss of traditional wisdom, the collapse of a traditional administration system, the proliferation of small arms smuggled across the region and heightened internal and cross-border tensions caused by large-scale migrations. Moreover, the policies employed in the past to address climate-related disasters were characterized by a primary focus on short-term solutions. Addressing the symptoms rather than the causes has further aggravated vulnerability and undermined traditional coping capacities. The ill-informed regional and international interferences further complicated the situation.

Environmental linkages to local conflicts over rangeland and rain-fed agricultural land

The environmental problems affect rangeland and rain-fed agricultural land across virtually all of Sudan, they are strongly linked to the conflict in a minority of cases and regions only. These linkages exist, but their significance and geographic scale should not be exaggerated and there is substantial evidence of a strong link between the recent occurrence of local conflict and environmental degradation of rangeland and rain-fed agricultural land in the drier parts of Sudan. Furthermore, the actors of conflict at the local level include three major competing and conflicting groups. The rural ethnic and livelihood structures of Sudan are so complex. For instance, traditional pastoralist and agricultural societies in Sudan are not clearly separated in many areas, societies practice a mixture of crop-growing and animal-rearing. There are there are some relatively clear boundaries -defined as much by livelihoods as by any other factor- between

different tribes, clans and ethnic groups.There are three major groups, based on livelihood strategies -- Predominantly sedentary crop-rearing societies/tribes; Predominantly transhuman livestock-rearing societies/tribes; and Owners and workers on mechanized agricultural schemes. All three groups depend on rainfall for their livelihood. The other major rural group is comprised of farmers using river and groundwater for irrigation. However, irrigated agriculture has not been a major factor in local conflicts in Sudan. Most of the local conflicts are between pastoralists and agriculturalists fighting over access to land and water. However, the conflicts in Darfur of Sudan in the last two decades could be conspicuously seen in the following five instances of conflict:

1. **The Arab-Fur war of 1987-1989**

The environmental causes of the Arab-Fur war subsume the droughts of 1984-1985 and of the early 1970s, and the migration from North Darfur to other parts of the region, which put more pressure on the farming communities. The developments in farming led to an increase in a number of farms and increased the use of land in the area

2 .**The Arab-Masaleet conflict of the mid-1990s:**

The main conundrum of this conflict was an aggressive assertion of claims over land. The Masaleet perceived that the government seemed to endorse these claims under new **n*air*s** who challenged the Sultanate of the Masaleet and his traditional claim to the land. This conflict was different from the others due to a high degree of violence, killing of people, incidents of rape, stripping of assets, and systematic destruction of agricultural assets. This in addition to, deliberate attempts to instill terror through forcing people to flee and restricting their movements, or blocking them from accessing their homes and their land, were among the contributing factors in this conflict.

3. **The Zaghawa and Aulad Zeid dispute 2001.**

The ***Aulad Zeid*** groups are a branch of the Muhamad. These groups come from ***abbala*** and have their traditional areas in North Darfur, but go back and forth between the areas south and north of the Jebel Marra. The *Aulad Zeid* groups came under great pressure from the Zaghawa because of the scarcity of water and resources, caused as a result of their encroachment and the conflict culminated in the killing of several Zaghawa.

4. The rebellion of 2003.

The Government of Sudan reacted to this rebellion in different ways. The violence that the government used was a classic counter- insurgency, for it was brutal and relentless including the looting of assets, undermining of the popular base of the insurgency and displacing people. The pattern of the conflict was that those who were involved in the violence would attack a particular area, and then stay from one to three days before leaving. Such a pattern of conflict could indicate that the aim was to loot but not to occupy the land. This conflict was very different because, in the areas of Western Darfur, which are well watered and fertile, there were no intense rebel activities. Instead, these places were relatively calm and less destructed.

5. Rebel tactics since 2006:

It is believed that the government has encouraged local conflict by creating competition over resources. At the government level, the approach has been to manipulate local conflicts as a means of arming groups supporting the Government of Sudan; whereas, for the rebels, it has been essential to block camel herding groups and other pastoralists, from accessing pasture.

South Sudan: South Sudan was a part of the Sudan, and the Southern provinces of Bahr el - Ghazal, Equatoria, and Upper Nile were, administered under the Turco-Egyptian Sudan from 1821 to 1885. However, in the Anglo-Egyptian Condominium from 1899 to 1955, the three southern provinces were also administered separately, by governors under the central government in the North. Moreover, from 1956 to 1972, the North Sudan persecuted the southern provinces and administered them separately. The South Sudan provinces had been the sources of slaves to the North with the gross marginalization. In lieu of the difference ethnic lines, the people of Southern Sudan confronted the marginalization by the North. Due to their similar aspirations, in 1972, the North granted local autonomy to three southern provinces which became to be known as the Southern region.

Fig. 1 Water is the most precious natural resource in the drier regions. Goats, cattle, and camels all use this crowded water point in Southern Kordofan. Camels graze in a destroyed village in Western Darfur. The trees have been cut for fuelwood and to provide the animals with fodder. Fighting over grazing land has been ongoing in Darfur since 1920 at least.

Fig. 2 Touloum refugee camp, Chad, 30 June 2007: A woman leaves the line with a container of water happy to have survived the scrum around the tap. Water is pumped twice a day and the water usually runs out before all are served. 22,718 refugees from Darfur live in this camp near the town of Iriba.

Fig. 3 Sudan and South Sudan

However, the southern region was brought back to its status of three provinces of Bahr el –Ghazal, Equatoria and Upper Nile. South Sudan become a new sovereign state and the republic which consists of three regions that were divided into tens state which had been translated in 32 states in 2015, that formed its territory. Each state is determined by political leadership headed by Governor. The Governors work with Ministers, parliamentarians, and the technical wing to form governance and administrative duties of the state respectively. The political leadership of the Republic of South Sudan derives its mandate and powers from the Constitution. South Sudan territory covering an area of 650,000 square kilometers. South Sudan is bordered by Uganda, Congo, Kenya, and Central Africa from the south, west, Sudan from the north and west and Ethiopia from the east. However, South Sudan the world`s youngest country had achieved, its independence from Sudan in July 2011.

Natural Resources factors oil and natural gas: The main non-renewable resource factors in South Sudan are oil and natural gas. The presence of these natural resources has led to the involvement of a range of regional and international actors, at various levels. However, that these resources do not play a direct role in the lives of South Sudanese than do environmental factors such as land. However, the natural resources Had been a driving force for the continuation of conflict and were key issues in the 2005 negotiations. However, the Sudanese government spent 70% of oil revenues on defense, while oil pipelines and fields were regarded as a legitimate military target by the Sudanese People's Liberation Army (SPLA).Consultations pointed to wealth division in the oil sector as a source of political tension. The 2005 Comprehensive Peace Agreement (CPA) stipulated that oil revenues from South Sudan should be shared between Khartoum and the new Southern government. This wealth-sharing agreement ends in 2011, after the independence of South Sudan. However, there was a lack of transparency in sharing oil revenues

between North and South. Moreover, oil revenue portrays 98% of the Government of South Sudan's income. With most functioning oil wells situated in the South, the Southern government received over US$ 6.5 billion during the interim period.

However, the Khartoum government used to deduct a 3% management fee and a 3% to 8% pipeline fee from revenues shared with the South and that it owes the Southern government US$ 180 million as of March 2009. Moreover, consultations were undertaken by the United Nations Environment Programme in the Central and in South Sudan also revealed grievance This in addition to the conflict over ownership and the distribution of wealth revenues, people living near oilfields are subjected to all the negative social and environmental effects of the industry. There was a form of dissatisfaction among local populations that must be addressed to circumvent environmental justice conflicts at the local level.

Environment Factors, Forests, and Timber

However, due to the population density and demand for resources, the drought under conditions has wrought vehement competition between agriculturalists, and pastoralists in a region where some 75 % percent of the population depend on natural resources for their livelihoods. The deforestation has resulted in the enormous loss of resources, subsuming the seasonal grazing for pastoralists and the natural soil recovery that farmers need. Moreover, timber resources in South Sudan are affected by the burning of trees to clear land for agriculture and to promote the growth of grass for pastoralists. However, consultations with civil society representatives active in South Sudan divulged that deforestation thanks to the use of timber and the cutting down of forests is not significant. Additionally, Southern Sudan still has the majority of its forest cover but will need sustainable resource management if this is to continue.

However, Traditional fishing in Juba with spears has been prohibited. The new commissioner has come in and made some rules on fishing and ever since there has been a problem. Moreover, people continue coming into the urban areas from the rural areas, which will lead to a conflict for resources. However, people have no alternatives and this is their source of livelihood and what they depend on. The discussions during the course of the study pointed to water and fisheries and their relationship to conflict vulnerabilities in South Sudan, in areas where water is scarce. However, without successful management and sustainable use of these resources are the use of water resources may lead to conflict. However, in Bor town, the local population fishing in the Nile River use unregulated practices. This, linked with other factors, has led to the degradation and destruction of the environment. The government has started to implement policies to prevent people from fishing in certain areas of the Nile. This has, however, resulted in fishermen moving to other areas and coming into conflict with other local populations who also fish. The degradation of the river can create fish stocks to migrate from one part of the river to another, which also results in conflict between fishermen, as they follow the fish and may intrude into the areas of other groups. Was enough fish and that people were being taught to fish sustainably, minimizing any future unsustainable use. However, water was an important contributing factor to the civil war in South Sudan in 1983, and the importance of the water has not declined over time. However, a number of institutional safeguards are likely to keep conflict.

Land and environmental degradation

Demographic and environmental factors underpin the social and political instability in Sudan. Decreased rainfall in pastoral areas, environmental degradation of agricultural areas around the center and south, and "technological-economic stagnation" combine to intensify ethnic conflicts over subsistence resources in the south and the north. In the dry land regions of South Sudan, the absence of environmental management policies are causing vulnerabilities that may lead to a large-scale ecological breakdown in the medium to long term Civil society representatives active in South Sudan indicate that land is not yet such a problem in the south parts of the country, but has been a cause of increasing conflict in areas where arable land borders on the drier parts of the country and region. Nevertheless, a lack of development of other no primary resources to grow the economy, combined with unsustainable practices, has created a pseudo-state of scarcity within an abundant resource base. It's not that there is not enough – it's that people do not have enough. Perverse and inappropriate development policies remnants of colonialism – have exacerbated resource scarcity

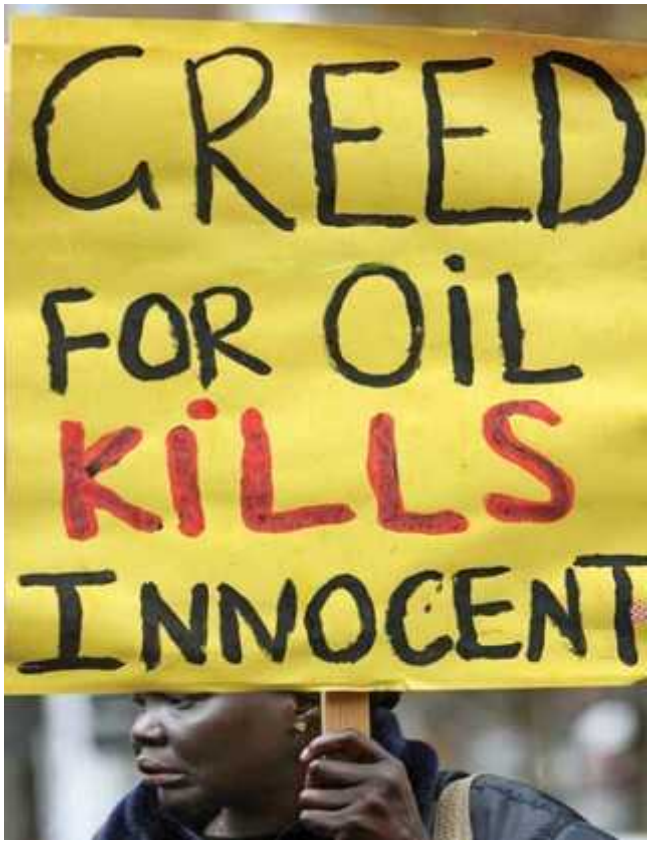

Fig. 5 Members of Australia's Sudanese community take to the streets on May 27, 2008 in protest against what they say is a lack of effort by the United Nations to stop the fighting in the Abyei region, the oil rich point of contention between northern and southern Sudan.

Conclusion

In both Sudan and South Sudan`s conflict and disaster, the environmental factors remain the main catalysts and drivers for land conflicts which are links to the livelihood of people and living or make a profit. Land scarcity and property rights enormously contribute to grievances and violent conflict. That was the situation when alternative livelihoods are not available and it is exaggerated by political rivalry which could use the situation of competition over scarcity imposed by environmental changes in the case of Darfur in Sudan which was result of environmental dimension. The conflict in Darfur was created by hurdles connected with livelihoods in Darfur which are linked with natural resources and local production depends on sedentary cultivation and transhumant Moreover, the land contains valuable mineral resources, conflicts can arise between local communities and those who seek control over land for resource extraction. The government structures and legislation are weak, the political, economic and military actors could impose changes.Population growth and movement, markets, insecure property rights and legislation, climate change, environmental degradation and mammoth other factors all appear to be variables that could be to be considered when analyzing conflicts where land plays a role. Furthermore, desertification, unsustainable use or drought could lead communities competing for livelihoods into conflict as in the case of Darfur. In South Sudan, the main non-renewable resources are oil and natural gas. The availability of these natural resources has led to the involvement of regional and international actors. However, these resources play a less direct role in the daily lives of South Sudanese than do environmental factors such as land. However, addressing natural resource factors such as oil and natural gas in Darfur and in South Sudan is important, because of their central role in the conflict in both regions. Additionally, competition for ownership and shares in the country’s oil and reserves was a driving force for the continuation of conflict and were key issues in the 2005 negotiations. Finally, culminated into the independence of South Sudan after the referendum in 2011.

Fig. 6 The dumping of waste on minefields and on top of unexploded ordnance creates a major safety problem (top); unexploded ordnance is loosely stacked and scattered across the area (bottom).

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An overview of slope failures in the Western Ghats of India and future directions

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Abstract

The Western Ghats has been the target of intense developmental activities in the last two decades. The natural stability of hill slopes is under serious threat by the unscientific human activities. The frequency of slope failures of different nature has increased in the recent past and causing death toll and severe damage to properties. Different agencies have generated landslide hazard zonation maps with very little or no ground verification of truth. Such maps are lame. The user unfriendliness of the maps is reflected in their muteness to a planner or a disaster manager. Furthermore, usually the scales of maps are not large enough to help risk analysis or future developmental planning. The paper discuss the causative factors of slope instability in Kerala Western Ghats and spotlights the gaps in landslide research with the view to stimulate a debate to arrive at the way forward.

Introduction

Slope failures are among the major geohazards that effect large parts of India, especially in the Himalayas, which forms the most prominent mountain range bordering India on the northern side and the Western Ghats on the southwestern parts. The Himalayas are a tectonically active, comparatively young mountain system with weak and fragile litho units. On the other hand, the Western Ghats is composed of peninsular gneiss, granite and other crystalline rocks of Precambrian age. The slope failures in the Western Ghats are of smaller dimension and with shallow depth compared to that of the great Himalayas. The Western Ghats extends over 1400 km and run parallel to the west coast of India at a distance of about 40 km inland from the sea shore. Numerous catastrophic landslides have occurred in the southern Western Ghats, along the steep slopes overlooking the Konkan coast. The state of Kerala comprises of the parts of the southern most segments of the Western Ghats with a total area of 38863 km. According to the Census of India, 47% of the state lies on the western slopes of the Western Ghats and has a population density of 819 per km2. The average annual rainfall in the high ranges is 500 cm. Kumar (2005) found that even though the state once supported a vast area of forest, over the 30 year period from 1940 to 1970, there was a steep drop in the forest area with cumulative loss of publically managed forest averaging 5000 ha annually. Land use changes in Kerala were unprecedented during the past half century. The substantial decline in the forest area and an increase in rubber plantations have led to frequent flashfloods, soil erosion and landslides, causing serious ecological and environmental problems. As the forests have declined at an alarming rate, especially in the upland watershed of Kerala with its rolling topography, copious rainfall and unscientific land use practices have caused land degradation, has continued unabated, leading to frequent landslide disasters. According to Sekhar et al (2009), the slope instability in Kerala Western Ghats is accelerated by anthropogenic disturbances.

The Western Ghats of Kerala region experience several types of mass movements, such as debris flow, landslides, slump, subsidence and rock fall. The region has been categorized by Thampi et al. (1995) and Sreekumar (2008) as a Highly Hazardous Zone for mass movement. The most prevalent, recurring and most disastrous type of mass movement noted in Kerala is ‘debris flows’. All 13 of the 14 districts of Kerala except the coastal district of Alappuzha are prone to landslides. About 8% (1,400 Km^2) of area in the Western Ghats of Kerala is classified as critical zone for mass movements (Thampi et al. 1995). Kozhikode district is prone to deep seated landslides, while Idukki and Kottayam are prone to shallow landslides (Sekhar et al .2009). Subsidence due to soil piping has been observed in certain parts of Western Ghats and is posing threat to agriculture and buildings. The causative factors and triggering mechanisms

are site specific. The studies by Simoni et al (2004) indicated that the pore water pressure is considered as an important factor that triggers landslides. Melelli and Tharmalli (2008) concluded that initiation of the debris flows originates in topographic depressions depicted by concave contours called hollows. A detailed analysis of ten major slope failures that have occurred during the past two decades in different geographical areas have been carried out and four case studies are discussed in detail. General slope of the hill, attitude of the joints, thickness of overburden, friction angle of the slope material, height and relative relief are inherent factors favoring slope instability. The field investigation carried out indicates that the natural instabilities are accentuated by anthropogenic factors, such as deforestation, contour terracing, obstruction of the natural drainage, artificial loading of water on the steep slopes and cultivation of shallow rooted crops. A strong relationship between slope failure and rainfall could be established in all paleoslide events. The rainfall induced pore pressure acted as the trigger force for the onset of debris flow, landslide and slump along the slopes, which were already at the threshold of failure. It is concluded that it is not the rainfall on the day of occurrence of the incidence that counts, but rainfall received a few days before the event is more decisive in causing landslides. The failures are observed in hills with gradients >20°, both in highland and midland regions. In recent years, they have gained more attention from both the administrators and public due to the increased frequency with which they occur and death toll they claim. The large scale anthropogenic activities, which are often carried out unscientifically without considering the inherent adverse aspects may further increase the chances of failure. During the development of new communication arteries, urbanization and implementation of mega projects the in situ geological and geotechnical parameters are often not taken into consideration.

Case studies

A few case studies of slope failures in Kerala Western Ghats are discussed and presented in Table 1.

Table 1: Case studies of slope failures in Western Ghats of Kerala

Location	Latitude and longitude	Date of occurance	Type of failure	Causative factors	Extent of damage
Kunjithanni	N10^{O}00’49.1” E77^{O}03’42.5”	4th August 2013.	Debris flow	Slope modification	Two died, houses collapsed
Methottimala	N9^{O}50’33.0” E76^{O}52’11.4”	4th August 2013.	Debris flow	Blockage of water	Loss of 3 acres of agricultural land
Ninumullipara	N9^{O}34’9” E77^{O}0’14”	31 July 1993	Wedge failure	Steep slope andjoints as potential slip surface	Collapse of road
Vadavathoor	N9^{O}35’43” E76^{O}33’43”	10 July 1995	Slump	Toe cutting and steep cut slope	Loss of agricultural land and buildings
Upputhara	N9^{O}39’34.6” E76^{O}59’29.3”	4August 2013.	Subsidence	Erosion of loose clay-soil mixture with low shear strength	Threat to houses and agricultural land
Pasukadav	N 11^{O}39'54.86" E 75^{O}50' 39.51"	4 August 2004	Debris flow	Artificial loading of water on slopes	Loss of agricultural land
Kakkayam	N 11^{O}33'24.9" E 75^{O} 54' 50.6"	5March 2010	Slump	Steep slope and joints	Road collapsed
Chengara	N 11^{O}10’02.2” E 76^{O} 17’ 26.4”	17July 2007	Slump	Construction on the rain pits on the slope	Extensive damage to rubber plantation covering an area of 3 acres
Akamala	N 10^{O}45’ 3” E 76^{O} 6’ 20”	5 June 2004	Debris flow	Deforestation	Extensive damage to forest land
Amboori	N8^{O}30’33” E77^{O}11’15”	9 November 2001	Debris flow	Blockage of Natural drainage	38 death and destroyed three houses completely

Kunjithanni, Debrisflow (2013)

Kunjithanni is located in Idukki District. The debris flow occurred at 8:40 pm on 4th August 2013. The failed area is situated very close to the natural drain, which is ephemeral with a width of 2 m, lies between the destructed house and partially damaged building complex. Granitic gneiss is the chief rock type and the thickness of the over burden is 2 – 3 m. The rock is rich in coarse pink feldspar and contains subordinate amount of ferromagnesium minerals. Veins of quartz are observed. The toe of the slide scar is at a height of 801 m and the distance from the toe to the crown is is 700m. As a result of the debris flow a house was totally collapsed and two people died. Indication of slope modification was observed at the top part of the scar. The slope is vegetated with shallow rooted trees such as cardamom, coffee and pepper. The width of the crown is 5 m and it widens upto 35 m as it reaches the toe. The slope of the hill is 60^{O} dipping towards $N60^{O}$. Joints present in the hard rocks got exposed by mass wasting process. Four joints with the trend of J1 is repeated in the area. The friction angle determined in geo technical lab is 22^{O}. J1 and J3 acted as the failure surfaces and the intersection of these joints fall within the crescent shaped portion. The debris flow occurred along the direction N 26. This is categorised as a typical wedge failure (Figure 1).

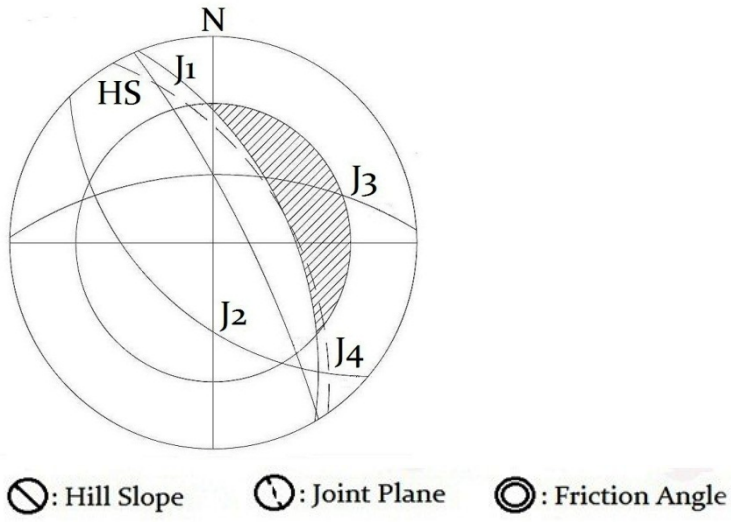

Figure 1.Stereo plot of four major sets of joints and their relationship between general hill slopes and the angle of internal friction of the rock.

Methottimala, Debrisflow (2013)

Methottimala is located in Idukki District Kerala. Two houses were destroyed and agricultural damage was caused by debris flow on 4th August 2013. Main cultivation includes tapioca, plantain and coconut. A raised metal road across the valley which partially submerges under flood season, with 29 m length and 3 m width was washed off by the hitting impacts of large boulders. The chief rock type of the area is granitic gneiss. Thickness of soil is about 3 m. Two debris flows united and flowed down slope. The crown of the scar is having a width of 3 m, attains 29 m in the middle part and runs for 1 km downhill. Dip of the hill slope is N270. The discontinuities have no role in this disaster. Chances of toppling still exist in the area (Figure 2).

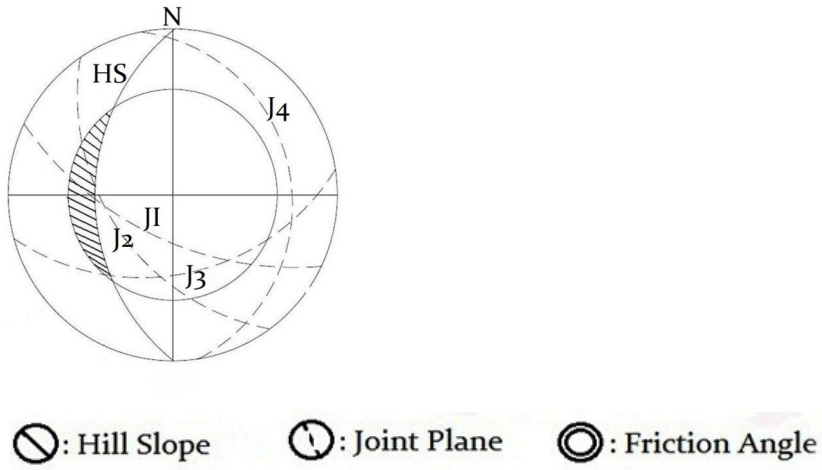

Figure 2.Stereo plot of four major sets of joints and their relationship between general hill slopes and the angle of internal friction of the rock.

Ninumullipara, Wedge Failure (1993)

The slope process in Ninumullipara (Idukki District) is classified under wedge failure. The slide occurred along the road cut cliff, which is very steep and overhangs the road in places. The valley side is deep with a high gradient and a very steep cliff with perennial water seepage. The vegetation is sparse on the cliff. The road is at an elevation of 1000 m above MSL. The relative relief in this region is 450 m. The important rock type forming the slopes is granitic gneiss, charnockite and pyroxene granulite. Pegmatite veins of width 2 to 10cm also occur. The rocks are weathered to differing degrees. The rock is well jointed and gaping of joints is greater than 1 cm. The wedge failure occurred in the road cut cliff with a height of 7.6 m. The general slope is 75°N 210 and cliff slope 84°N 210. The wedge of rock block has moved along the line of intersection of the two slide planes with attitudes 80°N 280 (J1) and 64°N 170 (J2). The friction angle for the granitic gneiss is 40°. The orientation of the joint planes that confined the slide debris and the friction angle of the rock are illustrated in the equal area projection (fig. 3). The methodology followed by Hoek and Bray (1981) was carried out to understand the mechanism of the slope failure. Water seeps through the discontinuities and the presence of water along these joints further reduced the factor of safety. The impact of slide debris caused the massive destruction of the road that snapped the main communication artery connecting the Kerala state and Tamil Nadu for a couple of days.

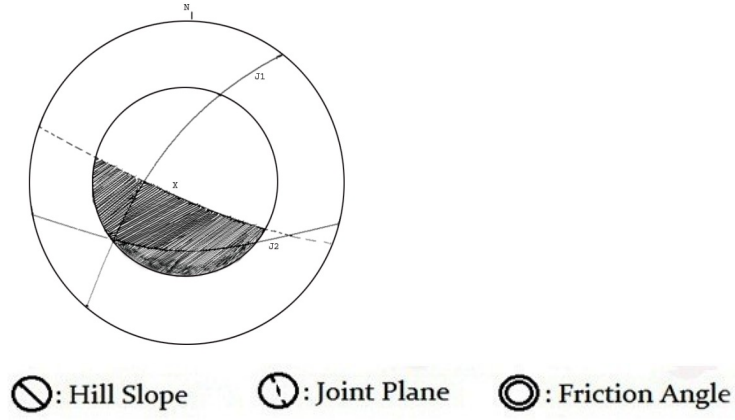

Fig 3: Stereo plot of four major sets of joints and their relationship between general hill slopes and the angle of internal friction of the rock.

Upputhara, Subsidence (2013)

Upputhara (Idukki District) **v**ertical subsidence of ground resulted a dry depression of depth 5.5 m and radius 3.2 m. The slope is cultivated with tapioca, rubber and coconut. Below 150 m downslope of this depression numerous horizontal tunnels were developed through which water mixed with suspended clay flowed down continuously for six days, according to the local people. The new tunnels have a diameter of 15 – 50 cm diameter. We could spot nine such tunnels at different height levels along the slope. The gradient of the hill is 50-60 degree towards SW. Four houses with eleven persons are living along the hill slope. The reason for the depression and tunnels can be assigned due to the erosion of loose clay-soil mixture with low shear strength. Predominant joints with attitude 80 N85E is observed. Three rain pits were located in the vicinity of the depression.

Vadavathoor, Slump (1995)

Slope failure in the lateritic profile at Vadavathoor (Kollam District) is a typical slump that occurred on July 10, 1995. Agricultural land had been damaged and a flour mill was partially destructed consequent to the slump. The maximum height of the cliff is 15 m and the slope of the cliff is 80° N50. Lithologically it is a lateritic profile with the occasional zone of weakly lateritised crystalline rocks. A minor exposure of granitic gneiss is observed at the base of the cliff. The cohesive strength and friction angle of the laterite sample from the weakest zone is 0.43 kg/sqcm and 10°, respectively. The factor of safety calculated before the incidence by the Swedish method of Fellenius(1936) under dry condition was 1.03. Water infiltrated through the porous upper soil and the lateritic zone below it. The zone below the laterite is saprolite, which is less porous and further down lies weathered and fresh crystalline rock. The vertical flow of infiltrating water was prevented because of the relatively less porous rock types. A spring resulted at the interface of the saprolite and crystalline rock due to continuous rain. Sufficient water was not drained off and caused pore pressure that acted as a buoyant force and lifted the overlying rocks. Slumping resulted from the continued effect of ground water activity and relatively weak cohesive property of the poorly lateritised rocks. Under normal dry conditions, the profile had a factor of safety value marginally greater than one and was considered to be at the geotechnical threshold. Unscientific landuse practices followed in the localities caused the disaster. Improper slope cut cliff, toe cutting and non provision of surface drainage are the causative factors for the failure. During rain storms, the rate of infiltration in the unsaturated zone of the soil exceeds the rate of deep percolations in the rock below the soil. Even though some water moves as seepage parallel to the slope, a temporary water table develops and increases the water head. As a consequence of the rise, the piezometric head increased, the pore water pressure increased and the shearing resistance decreased, causing failure.

Pasukkadav, Debris flow (2004)

Debris flow occurred on 4th August 2004 in Pasukkadav which lies in Kozhikode district. Repeated slope failures have been observed in the area after every monsoon. Pasukkadav hill slope profile has a maximum elevation of 775 m and lowest elevation of 300 m from MSL. The crest has a length of 1.2 km and granitic gneiss forms they chief rock type of the area. The overburden consists of highly weathered rocks, boulders, laterites and colluvial debris. The thickness of the overburden ranges from 1 m to 3.1 m. the terrain is characterized by isolated rocky tops with near vertical slopes. The general downward slope of the profile is 48° towards east. Entire hill slope is under cultivation barring the rocky tip. The vegetation pattern includes mixed crops containing plantain, pepper, coconut and jack fruit trees. Four major joints traverses the profile with gapping ranges from 1 cm to 2 cm. The failed surface has a dip 32 towards N 310. The scar of the slide has a crown with width 5m and 1m depth. The width of the scar increases up to 20m and depth up to 1.5 m in the middle. Further downwards the width increase up to 30 m but become much shallower.

Friction angle determined as 48°. Prominent joints in the exposed failure area are 51° N (J_1), 32 °N 90 (J_2), 22°N 90 (J_3) and 80°N 90 (J_4). J2 and J3 are the potential slide surface along the which the debris moved down slope (Figure 4). The friction angle reduced during rainy season and FOS reduced further and slope failure occurred.

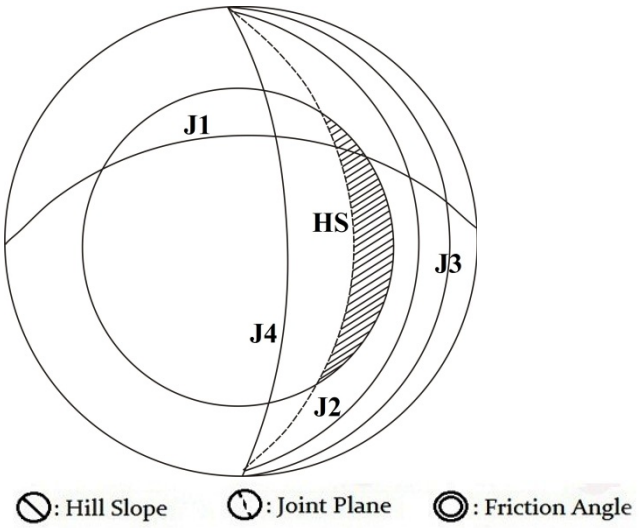

Fig 4: Stereo plot of four major sets of joints and their relationship between general hill slopes and the angle of internal friction of the rock.

Kakkayam, Slump (2010**)**

It is located in Kozhikode district of Kerala. Slope failures are reported in 2009 and 1984. Lithologically the slope consists of granitic gneiss. Minerologically it consist of 80% quartz and feldspar. Less weathered rock exposure is observed. The thickness of the overburden is 1.5 meters. It comes under reserve forest area. The rock is not well jointed. The maximum relief is calculated as 245 m. The slope of the hill is 50^0 towards North West direction. The dip amount is 58^0 and dip direction is N 290^0 towards North West. Preliminary investigation indicates the possibility of planar failure. Two failures have been reported in the year 2010. Increase in water absorption content in soils and toe cuttings have triggered the landslides in Assar (Yudhbir sing et al 2012). Repeated slumping is experienced in this location. The textural analysis of soil indicates that the silt+clay content is 25 % and coarser fraction constitute of 75 %. The friction angle determined as 20.50^0. The liquid limit and plastic limit is determined as 5.5 and 40.50 respectively. High coarser fraction in soil indicate low Cohesion and friction angle. One of the causative factors that triggered slump includes the increase in water absorption content of the soil.

Chengara, Slump (2007)

Chengara is located in Malapuram district of Kerala. Land degradation in the form of soil slump had caused extensive damage to rubber plantation covering an area of 3 acres in 1994. Another major slump occurred on 17th July 2007. The features of the failed slopes are given in the table. Cracks have been developed across and parallel to slope faces with a width of ½ m to 2-½ the overlying soil failed along an arcuate surface and caused flattening of well casing. The top water saturated soil horizon has separated from underlying impervious crystalline rocks and slumped down slope by its own weight. The crystalline rock in this area is chiefly granite gneisses. Plasticity of the soil is high. 15 houses are situated at the foot of the slope. Palaeoslides have been reported from the area. Construction on the rain pits on the slope was the main factor for the initiation of the landslip in 1994. The slope is characterised by two generation of rubber plantations. Age of trees in one sector is 12 years and the plants in the adjacent sector have growth 1 - 1½ years. The landslips have occurred only in the sector where plants are young. Deep cracks have been developed in the adjacent sector and slumping of soil is prevented by the deeper root system of the older rubber plants. The recent terracing done on the slopes in younger plantation sector has prevented the run off and excess water collected on flat terraces percolates as subsurface seepage into the thick soil column overlying the impervious crystalline rocks. This developed a temporary water table and increases the water head. The rise in peiziometric head increased the pore water pressure and decreased shearing resistance causing the arcuate failure along the plane of contact.

Akamala, Debrisfolw (2004)

Akamala is located in Thrissur District of Kerala. Akamala disaster struck on 5th June 2004 in a reserved forest area which causes extensive damage to forest land. Casualities were avoided as the settlements were a few meters away from the rolled down slide debris. Akamala hill slope profile form part of a reserved forest. The maximum elevation is 320 m and the lowest elevation is 80 m from MSL. The profile is at the western flank of the NW-SE trending ridge. Head scarp of this slide is shallow (0.5 m depth) and the width increases up to 15 m at the base and attain maximum depth up to 1.6 km. Lithologically it is composed of gneissic charnockite and sub areal weathering has resulted laterites and highly weathered rocks of varying thickness. The forest is degraded to a certain extend. The analysis indicated that in Akamala profile wedge failure occurred along the intersection of joints 30 N 315and 70 N 80 falls within the crescent shaped shaded area (Figure 5). Chances of plane failure along the joints 30 N 315 also exist in this location.

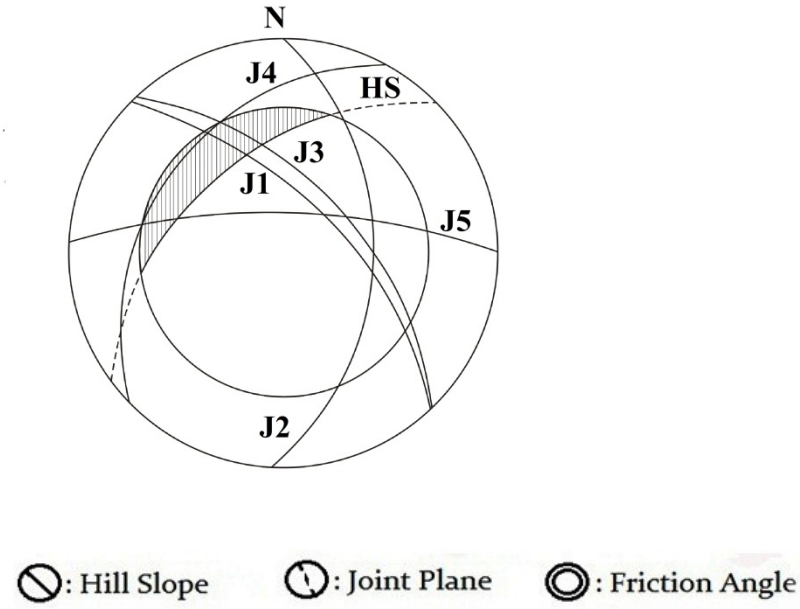

Figure 5: Stereo plot of five major sets of joints and their relationship between general hill slopes and the angle of internal friction of the rock.

Amboori, Debris flow (2001)

Amboori is located in the Thiruvananthapuram District and the debris flow occurred in 9th November 2003 is the worst landslide disaster of Kerala, which buried 38 people and destroyed three houses completely. The failed slope is located in the Kurishumala hills and has a gradient of 36°. The maximum elevation is 355m from MSL. The head of the scar of the debris flow starts from a height of 244m and extends down to Amboori-Kumbichal road, which is located at a height of 160m. The scar of the debris flow exposed fresh crystalline rocks. The debris consisted of boulders and weathered rocks. Biotite gneiss and quartzofeldspathic gneiss are the parent rock types of the area. They are well jointed. The vertical profile consists of laterite, lithomarge, weathered rock and crystalline rock from top to bottom. The thickness of the overburden and laterite together varies from 1 to 8 m. The laterite is red coloured with patches of clay minerals. White colouredlithomarges with shades of pink occur along the interface of the weathered rock and laterite. The friction angle of the weakest material (lithomarge) is as low as 14°. The entire hill, except the rocky top, is under cultivation. The slope is cultivated with rubber. Contour bunds were constructed across the slope to retain water. The natural hollows were obstructed by the bunds cut in laterite. The hill slope has scattered houses and settlements situated at the base of the slope. Excess rain water infiltrated through the upper lateritic zone with a void index 0.48 and eventually water collected in the pore spaces of the lithomarge, which has a relatively low void index of 0.19. The laterite and lithomarge were over saturated with water, the weight increased and consequently the force exerted downward on the failure plane with a trend N40° W-S40° E and dip in conformity with the slope. The water accumulated built up

pore pressure and exceeded shear strength along the contact of the fresh crystalline rock and overburden and this resulted in planar failure.

Rainfall-the trigger force

The relationship between the amount of rainfall and ten disasters is critically examined here. The amount of rainfall on the day of occurrence of slope failures and five days prior to the failures is listed in the table 2. Since the onset of every monsoon, three or four episodes occur during which copious rainfall occurs continuously for a couple of days. All the slope failures are associated with one such episode falling within the monsoon period (Figure 6). It is found that the locations experienced a prolonged and intense rainfall spell over the three days period, with a minimum cumulative value of 101.33 mm and a maximum value of 371.2 mm (Table 2). It is evident that it is not the influence of the rainfall on that day alone, but the amount of rainfall during the last couple of days is highly influential in triggering slope instability. The variation in threshold value may be attributed to the local characteristics of the location, such as lithology, hydraulic conductivity, soil depth, slope and vegetation.

Table 2. The amount of rainfall on the day of occurrence of slope failures and five days prior to the failures.

Locations	Rainfall on the day of the slide (mm)	Rainfall 3 days prior to the slide (mm)
Kunjithanni	228	371.2
Methottimala	40.5	364.3
Ninnumullipara	119	342
Upputhara	40.5	364.3
Vadavathoor	60	151
Pasukkadavu	54	292.8
Kakkayam	66.2	101.33
Chengara	85	154
Akamala	120	160.3
Amboori	64	112

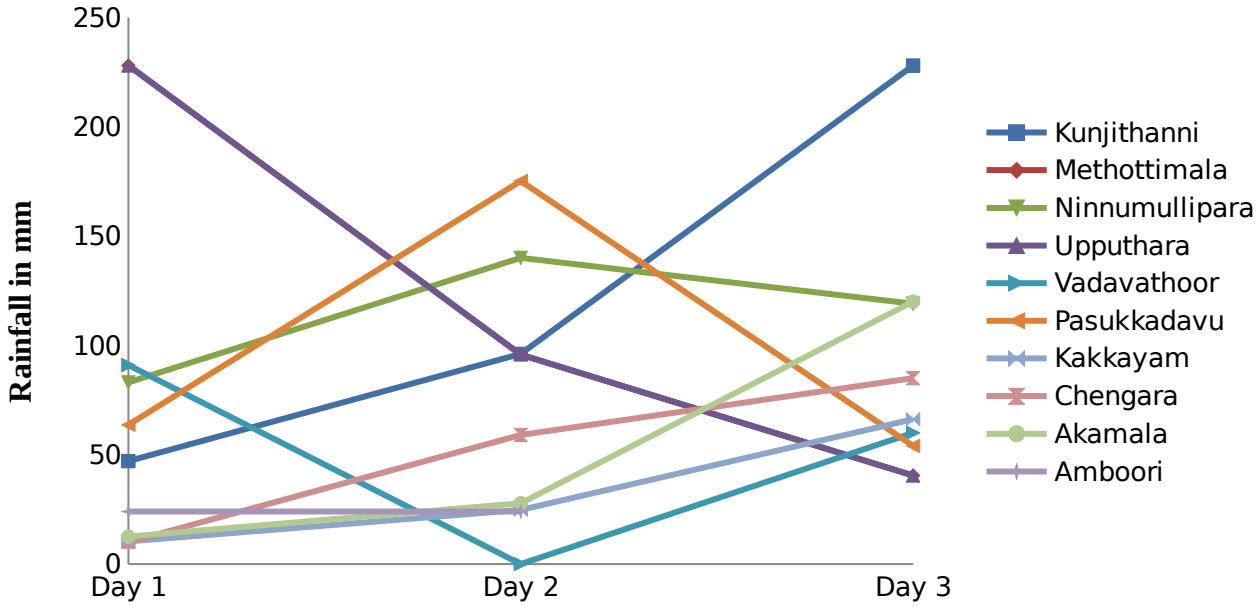

Figure 6. Rainfall cumulative graph showing the relationship between rainfall and the slope failure.

Lessons learned

Based on the analysis of various slope failures that occurred along the hill ranges of the Kerala Western Ghats, it is evident that the structural features, lithology, slope condition, anthropogenic and climate play a key role in slope failures. Four major types of slope failures more common in the state are debris flow, slump, subsidence and landslides. Almost all mass movement occurs during monsoons, indicating that the main triggering mechanism is pore pressure variation as a result of the cumulative effect of prolonged and high intensity rainfall for a few days. The slope is made more conducive for slope failures by human intervention, such as deforestation, cultivation of crops with shallow roots, terracing, toe cutting and the blockage of natural drainage. The shallow rooted trees, agricultural practices in hill slope also have contributed in increasing the dimension of debris flow and consequent damage. The continuous and copious rainfall on the day of the event and penultimate days acted as the catalyst for triggering slope failures. In all cases, the causes are site specific. It is evident that it is not the influence of the rainfall on that day alone, but the amount of rainfall during the last couple of days is highly influential in triggering slope instability. The variation in threshold value may be attributed to the local characteristics of the location, such as lithology, hydraulic conductivity, soil depth, slope and vegetation. Majority of the debris flows located close to the proximity of first order ephemeral streamlets.

The homogeneity of geotechnical properties such as cohesion, friction angle, hydraulic conductivity of the overburden and its huge thickness influence debris flows. In most of the debris flow reported the overburden has detached along the contact of intact hard rock and the upper overburden. The cumulative effect of pore water pressure along the potential failure surface such as joints and fractures, the buoyant force developed because of excess water percolation during the continuous spell of rainy days can be cited as one of the contributing parameters for the onset of series of slope failures.

Since imminent slope failures looms large in the region, there is a pressing requirement for a early warning systems, Disaster Management practices.

- Total avoidance of settlement and developmental activities, quarrying in critical and high risk zones should be made mandatory
- Chances of slope failure exist in already failed areas. Therefore at most care to be taken in these localities if you are planning for the new settlement.
- From the highly unstable areas peoples should evacuated if rain persist for 2 or 3 days. Rainguage network must be installed in such critical zones and people must be warned when threshold values exceeds.
- Rain pits, blockage of natural drainage must be discouraged in the risky zones. Only after the geotechnical studies such structures may be constructed.
- All failures have taken place at the close proximity to pre existing natural drainages and therefore one must be cautious when collecting water during continuous rainfall spells in monsoon period.
- Proper drainage must be provided before the onset of monsoon in critical areas and blockage if any, must be cleared.
- Afforestation must be practiced in degraded forest areas.
- Ward level awareness programme and first aid training must be carried out in critical areas.
- A disaster management team should be formed in Panchayath and Ward level to respond to the post disaster situation.

Research Gap Areas

- The national and regional level landslides hazard zonation maps which depict the thematic representation of slide prone areas based on general lithological, tectonic, climatic and physiographic conditions. This would be of limited use and for realistic investigation efforts for a larger scale maps at least 1:10000 scale will have to be prepared.
- Landslide study requires proper appreciation of the material properties of soil and rock in the highly hazardous zone. Site specific geotechnical investigations are to be carried out at critical sites for the calculation of factor of safety. This investigation will help in deciding the suitable preventive measures to be adopted in the site.

- There is an urgent need of adequate and well planned instrumentation for monitoring landslides. A network of rainguages must be installed in high hazardous zones and must be warned when threshold value of rainfall exceeds.
- The areas where soil piping is reported must be subjected to geophysical study through vertical electronic sounding to infer soil thickness and decipher underlying geologic features.
- Building codes have to be framed for high hazardous zones. Construction of building at the close proximity to the natural drainages must be discouraged in the critical zones. Permission for erecting engineering structures must be given only after geo technical studies. A buffer zone adjoining to the natural drainage channels (minimum 200m) should be kept free without settlement.
- Research for designing cost effective control measures to be encouraged
- Legislative and regulatory measures for land use practices to be implemented
- Insurance against landslide losses to spread cost over large population
- Dissemination of knowledge to the planners and local people through training programmes.

Concluding Remarks

The causative for slope failures is site specific and this highlights the relevance of micro level geological and geo technical studies in critical zones identified and located in hazard zonation maps. There is an urgent need of adequate and well planned instrumentation for monitoring landslides. The areas where soil piping is reported must be subjected to geophysical study through vertical electronic sounding. Legislative and regulatory measures for land use practices to be implemented in hazardous zones and knowledge should be disseminated to the planners and local people through training programmes.

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Assessment of groundwater quality of the coastal aquifers along Perumathura–Veli stretch, Thiruvananthapuram, Kerala

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The groundwater quality of the coastal aquifers of Perumathura–Poonthura stretch, Thiruvananthapuram District, Kerala state has been studied. The groundwater chemistry reveals that 40% of the samples are not suitable for domestic purposes. pH of samples are near neutral. The TDS concentrations of the groundwater samples found within the permissible limits of BIS drinking water standards. Based on TDS and total hardness values, more than 50% of the groundwater samples are desirable for drinking. Cation and anion concentrations in the groundwater samples indicate that, majority of the water samples are suitable for drinking. But the nitrate concentration indicates that, only 20% of the samples are suitable for drinking purpose, while most of the samples show higher levels of concentration than recommended value. Assessment of water samples from %Na and SAR indicates that chemically groundwater samples are suitable for irrigation. CI indicates the direct base exchange reaction between Na, K and Ca, Mg in the aquifer material, but majority are in disequilibrium condition. In the rock-water interaction, Gibbs plot indicates the chemical weathering of rock forming minerals in the aquifer is the predominant mechanism controlling the chemical composition of groundwater in the aquifer. Wilcox diagram shows that equal number of samples fall in low sodium and medium salinity hazard and low sodium high salinity hazard. The range of concentration of sodium in the study area shows that they are suitable for drinking purpose.

Keywords: Groundwater chemistry, Irrigation water quality, Coastal aqifers, Thiruvananthapuram

Introduction

The present study focuses on the assessment of major ion chemistry of groundwater samples in coastal aquifers along the Perumathura- Veli coastal stretch, Thiruvananthapuram District, Southern part of Kerala state. The objective of the work is to study the hydrogeology, water quality parameters, hydrogeochemistry and a comparison has been made with BIS and WHO drinking water quality standards. The study area is a part of the drainage basin of Vamanapuram River and Parvathy Puthanaar Canal linked with Karamana River. The broad geology of the region constitute crystalline basement of Archean rocks overlain by sedimentary formations of Eocene to Recent age. The area experiences humid tropical savanna climate.

Study area

The present study area is located in Thiruvananthapuram District, Southern part of Kerala. The study area lies from 8˚39’25.4” N latitude and 76˚46’34.4” E longitude to 8˚30’23.7” N latitude and 76˚53’27.4” longitude (Fig.1). The study area falls under the coastal low land and the midland physiographic units of Kerala. The study region is a part of the drainage basin ofVamanapuram River. The broad geology of the region constitute crystalline basement of Archean rocks overlain by sedimentary formations of Eocene to Recent age. The western side of the study area is bordered by Arabian Sea. A number of backwaters are seen along the western parts of the study area viz, Anchuthengu Lake Kathinamkulam Lake, and Aakkulam Lake.

Geology of the area

The study area is characterized by the outcrops of crystalline rocks of Achaean age in the eastern part and is overlain by sedimentary formations ranging in the age from Miocene to Recent along the western coast. The crystalline rocks include khondalites, charnockites, gneisses and migmatites. Whereas sedimentary formation comprise the (1) Recent alluvium that occur along the coastal plain and in the valleys and are mainly composed of sand and clay (2) Tertiary formation such as Warkali, Quilon and Vaikom beds and (3) laterites which occur as a capping over crystalline.(CGWB, 2013).

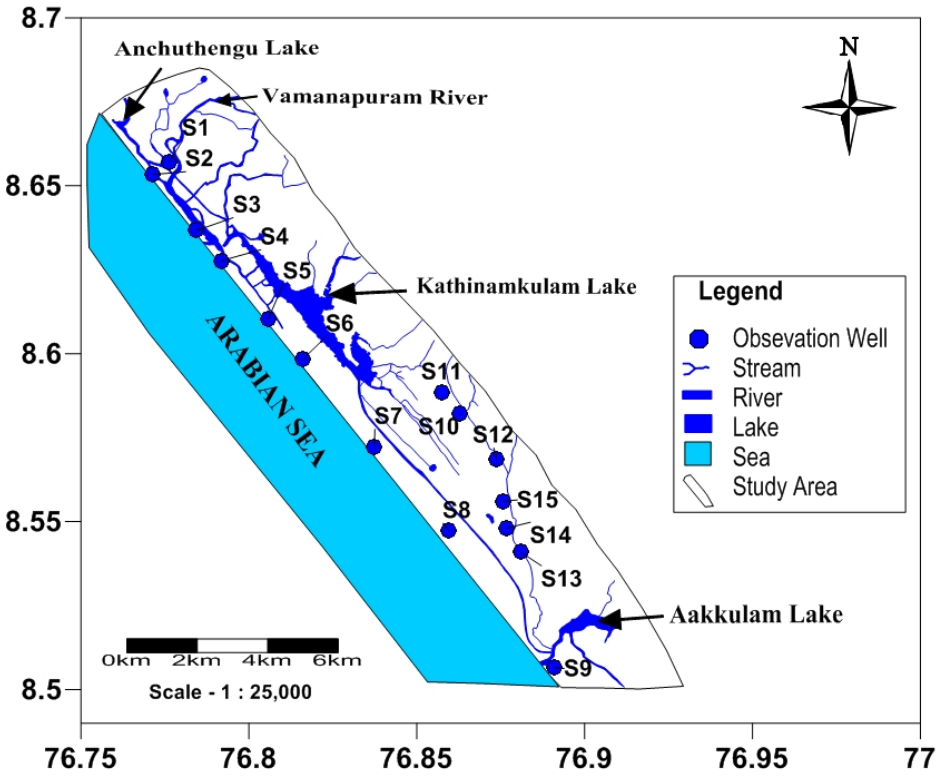

Fig 1 Location map of the study area

Materials and methods used

This study is based on the analysis of samples taken from 15 observation wells selected in Poonthura to Veli coastal stretch, which includes 3 tube well and 12 dug well groundwater samples are listed in Table 1and shown in Fig.1. The groundwater samples were collected during the post monsoon period. The sample locations were determined with handheld Global Positioning System (GARMIN GPS). The water samples from the wells were collected after pumping out water for about 5 minute to remove stagnant water from the wells.

Table.1: List of groundwater samples collected from the study area

Sl No	Location	Type of Well	Latitude	Longitude
S1	Anathalavattam	Dug Well	8.65705	76.77622
S2	Anchuthengu	Dug Well	8.65336	76.77136
S3	Thazhampalli	Dug Well	8.636694	76.784388
S4	Perumathura	Dug Well	8.62769	76.79177
S5	Puthukurichi	Dug Well	8.610222	76.80566
S6	Mariyanadu	Tube Well	8.59841	76.81611
S7	Puthanthop	Dug Well	8.572055	76.83738
S8	Pallithura	Dug Well	8.547361	76.8595
S9	Kochuveli	Dug Well	8.50658	76.89094
S11	Vettu Road	Dug Well	8.58216	76.86266
S12	Kaniyapuram	Dug Well	8.58855	76.85761
S13	Kazhakkuttam	Dug Well	8.568472	76.873805
S14	Kulathoor	Tube well	8.540944	76.88086
S15	Near Technopark	Dug Well	8.556027	76.875722

Results and discussion

Groundwater Chemistry and Water Quality Studies

The analytical result of groundwater samples in the study area along with their basic statistical summaries such as minimum, maximum, and mean values are shown in the Table 2. Groundwater chemistry in the study area reveals that, pH of groundwater samples varies from 5.93 – 7.86 with a mean value of 7.09 ± 0.6 and shows that the groundwater samples are near neutral. The Total Dissolved Solids (TDS) concentrations of the groundwater samples found in the range of 72-1160 mg/l with a mean value of 379 mg/l, is within the permissible limits of BIS drinking water standards. Based on TDS values, more than 70% of the groundwater samples are desirable for drinking (TDS <500 mg/l), 20% permissible for drinking (500-1000 mg/l) and 10% is suitable for irrigation purposes (TDS >1000 mg/l). Based on the total hardness value 50% of groundwater samples are moderately hard, and rest of the samples is hard except one with total hardness 382 mg/l which is in very hard category. Cations and anions concentrations in the groundwater samples indicates that, majority of the water samples are suitable for drinking.

Table 2: Analytical result of groundwater samples from the study area

Sl No.	pH	EC (µS/cm)	TDS (mg/l)	Na (mg/l)	K (mg/l)	Ca (mg/l)	Mg (mg/l)	SO_4 (mg/l)	NO_3 (mg/l)	Cl (mg/l)	F (mg/l)	HCO_3 (mg/l)
S1	7.83	729	362	19	17	92	2.3	36	55	43	0.67	170
S2	7.86	290	164	17	4	24	2.4	2	63	32	0.40	25
S3	7.47	2230	1160	157	14	100	32	55	135	300	0.76	270
S4	7.67	646	323	236	6	60	10	19	108	57	0.54	87
S5	7.75	337	163	24	4	28	5	10	50	50	0.38	36
S6	7.2	1217	571	97	24	64	0	81	197	113	0.35	42
S7	7.41	699	342	68	6	24	14	34	40	136	0.28	47
S8	6.54	517	259	54	15	42	2.3	51	149	48	0.26	32
S9	7.39	156	72	7	2	20	17	0	30	50	0.29	43
S10	7.1	272	138	14	15	36	2.3	44	44	14	0.26	55
S11	6.73	632	326	53	6	44	5	51	83	76	0.27	32
S12	6.64	993	510	80	21	64	12	79	183	130	0.22	43
S13	5.93	1027	509	83	26	60	10	94	156	103	0.21	45
S14	6.5	789	368	41	37	46	18	87	163	68	0.22	35
S15	6.47	822	423	83	27	56	5	76	199	92	0.25	24

Water Quality for Irrigation Purposes

The water quality assessed for irrigation purposes are based on the recommended standard parameters. The quality of the irrigation water may affect both crop yields and physical conditions of soil. Because the suitability of groundwater for agricultural purpose is depends on the effect of mineral constituents of water. The main problem related to irrigation water quality is the water salinity. Water salinity refers to the total amount of salts dissolved in the water but it does not indicate which salts are present in it. Salinity indices such as Percent Sodium (%Na) and Sodium Absorption Ratio (SAR) are the important parameters for determining the suitability of groundwater for agriculture. The classification of groundwater samples based on the SAR values are shown in Table 3 and represented in Figure 2. Assessment of water samples from %Na and SAR indicates that chemically groundwater samples are suitable for irrigation. The chloro-alkaline indices I and II are calculated for the groundwater samples. The values are shown in Table 3. Chloroalkaline index indicates the direct base exchange reaction between Na, K and Ca, Mg in the aquifer material, but majority are in disequilibrium condition.

The groundwater samples of the study area are plotted on Gibbs diagrams (Fig3.a & b). In the present study, both the Gibbs plot indicates the chemical weathering of rock forming minerals in the aquifer is the predominant hydrogeochemical process controlling the composition of groundwater.

Table 3: Different water quality parameters of groundwater samples

Sl.No.	%Na	SAR	CAI 1	CAI 2
S1	20.8514	0.54012	-0.0484	-0.0131
S2	37.8962	0.9061	0.05663	0.03478
S3	48.528	3.49792	0.15064	0.16453
S4	23.3012	0.71998	0.28041	0.12625
S5	37.1955	1.02314	0.24056	0.20969
S6	60.1433	3.33218	-0.515	-0.2956
S7	56.4706	2.69678	0.18874	0.34202
S8	54.2818	2.19376	-1.0107	-0.343
S9	12.7462	0.27798	0.74996	0.8858
S10	32.7981	0.59642	-1.4329	-0.2268
S11	48.7286	2.01967	-0.1509	-0.1106
S12	49.0494	2.39982	-0.1013	-0.0701
S13	52.9144	2.61039	-0.4656	-0.2596
S14	42.0327	1.30415	-0.4277	-0.1636
S15	57.5194	2.87278	-0.6587	-0.331

(%Na- Percent Sodium, SAR- Sodium Adsorption Ratio, CAI- Chloro-Alkaline Index)

Conclusions

The present study focused on the major ion chemistry of groundwater samples in the Perumathura- Veli coastal stretch, Thiruvananthapuram District, Southern part of Kerala state. From the chemical analysis of groundwater samples collected from the study area gives the cations and anions concentrations in the groundwater samples. The concentration of major cations and anions indicates that, majority of the water samples are suitable for drinking. Assessment of water samples from %Na and SAR indicates that chemically groundwater samples are suitable for irrigation. Only exceptional case is the higher nitrate concentration in some samples. It is mainly caused by the anthropogenic activities like excess use of fertilizers, pesticides etc.

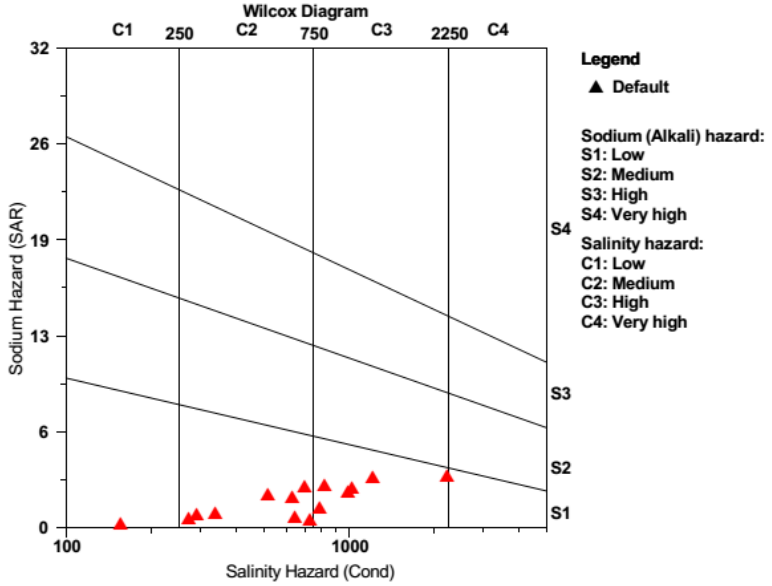

Fig.2 Wilcox Diagram showing the classification of irrigation water

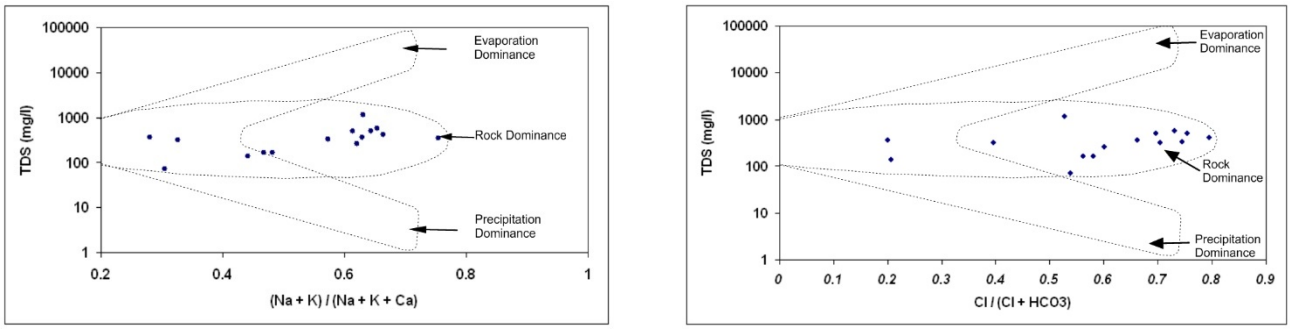

Fig3. a & b Gibbs Plot for the groundwater samples (cations and anions)

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A comparitative study on international and national standards of hospital towards hospital safety, disaster response and mitigation

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Introduction

Disaster means a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or manmade causes, or by accident or negligence which results insubstantial loss of life or human suffering or damage to, and destruction of, property, or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area "(DM Act 2005). Disaster is a result of the combination of many factors such as the exposure to hazards, the conditions of vulnerability that are present, and insufficient capacity or measures to reduce or cope with the potential negative consequences. Disaster impacts may include loss of life, injuries, disease and other negative effects on human physical, mental and social well-being, together with damage to property, destruction of assets, loss of services, social and economic disruption and environmental degradation. Hospital is an institution where the medical assistance provides to victims. Its mission is to improve the health of our community. Hospitals are basically service organisations functioning 24*7. The hospital serves the whole community and offer facilities for the improvement of health and prevention and treatment of all diseases. Its role is to save human life, serve community in all aspects of health and also should form an integral part of community.

Role of hospitals during disaster

Hospitals play a crucial role during disasters. They need to provide care in the form of life saving and emergency care for injured victims. But Hospitals also have to ensure the emergency response mechanism by sending quick relief medical team for immediate first aid and early transportation of casualties to the hospital. The important activities during immediate response include trauma care, surgery, blood banks, ambulances, blood transfusions, triage etc.

Hospitals condition when Disaster strikes: Health care is one of the most complex field which human beings engage often. Thus it is essential that its safety should be given importance .Disaster management is an important emergency support function provided by hospitals. Still, hospitals have been severely damaged due to impact of disasters.

Disasters vs hospitals

International cases: Some examples are listed here with. 1985 Mexico City earthquake struck in the early morning of, Thursday, 19 September lead to the fall of 12 storied hospital Juarez the death toll was above 561. Hospital collapse Petion-Ville, Haiti due to earth quake 2010. An overnight fire at a hospital in southern Saudi Arabia has killed at least 25 people and injured more than 100 others at Jazan General Hospital 2015. Fire broke out at The Royal Marsden Hospital UK Wednesday 2nd January 2008 at 1:30pm at the roof, no causalities was reported.

Indian Scenario: India has one of the largest populations in the world and is geographically challenged and also has severe climatic conditions, which add more importance of hospital safety. The factors like natural hazards, lack of Disaster Management plan and negligence of hospital to building codes or safety norms or due to meager neglect etc are some cause that let hospitals in jeopardy some examples are fire incident AMRI Hospital in Kolkata on 9 December 2011 lead to the death of 89. In 2001 Gujarat earthquake has lead to collapse of two hospitals on 2 May 1988. Wing of a children's hospital collapsed in

Jammu &Kashmir, and at least 14 people died in a crush of bricks and concrete here 50 children and their parent were trapped inside the building, 19 people were killed and around 30 injured when a major fire broke out at a SUM Hospital, hospital in Bhubaneswar on OCTOBER 2016 night. 18 patients in the intensive care unit of the MOIT International Hospital died due to flood December 2015 Tamil Nadu. The death toll in the Bhopal hospital collapse has gone up to three with 25 others injured shows the vulnerability of health care system towards disasters and importance of hospital safety.

Hospitals	Place	Death toll
SUM Hospital	Bhubaneswar	19
AMRI Hospital	Kolkata	89
Jammu Medical College	Jammu &Kashmir,	30
MOIT International Hospital	Chennai	18
Kasturba Hospital,	Bhopal	3
Moideen Badusha Mental Home	Tamil Nadu	28

To maintain the quality of hospitals there are sets of rules and guidelines are laid down by the national and international authorities to ensure the safety of hospitals. These guidelines are given by boards like NABH, NDMA, JCIA and WHO etc. These *Hospital Safety* standards grade the hospitals on how safe they keep their patients from errors, injuries, accidents, and infections.

The List of criteria used for comparison: Building safety, Hazard identification, Safety measures towards hazards, Management of documents, Logistics and supply chain

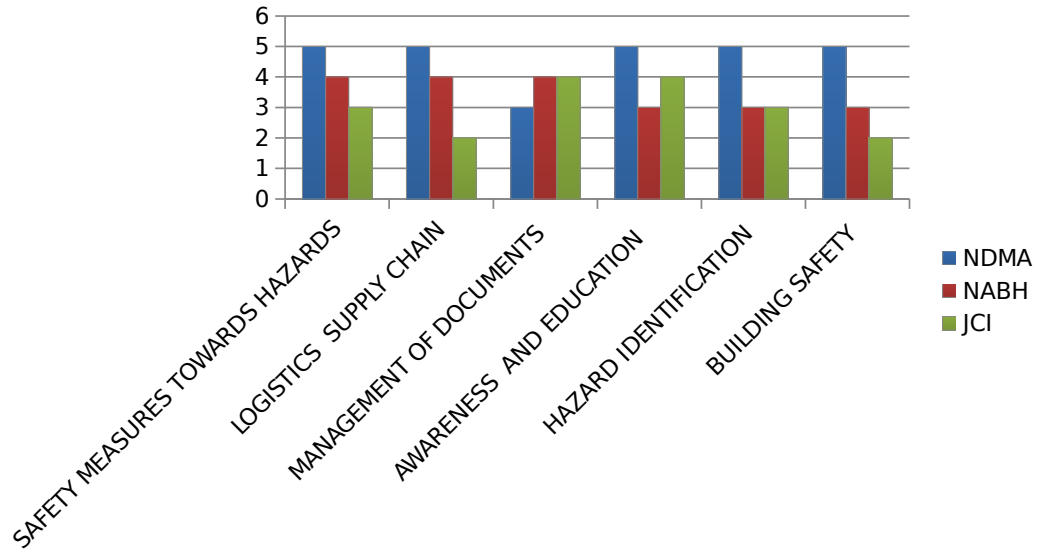

Figure 1: Compares criteria of JCI, NABH and NDMA

Conclusion

As part of the study standards like JCI,NDMA guidelines NABH guidelines are compared .NDMA guidelines mainly focus on disaster aspect . so it has a detailed structure for how to responding to disaster during in disaster scenario and clearly state about preparedness and mitigation activities .Both JCI and NABH standards also put forth importance of disaster situations and steps to address emergencies. but these standards has wider perspective which encompasses whole hospital quality and functioning .It is identified at present there is no tool for assessing hospital safety. But by integrating these entire standards hospital safety tool can be formulated.

Effect of changing land use on urban heat island formation - a case study for Ahmadabad city

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Growing urbanisation has led to increase in the built up area, reduction in open and green spaces with in the cities and the periphery. The urban saturation and the enlargement of the built space have determined environmental changes, increasing the already precarious condition of the natural systems in these spaces of high saturation. It results in to the formation of Urban Heat Island (UHI). In recent years urban heat waves and extreme droughts have been reported with increasing frequency, disturbing the environmental dynamics and the quality of life. UHI studies have traditionally been conducted for isolated locations and with in situ measurements of air temperatures. The advent of satellite remote sensing and other geospatial technology has made it possible to study UHI both remotely and on continental or global scales. Using remote sensing techniques, it is possible to analyse the thermal and environmental information gathered by earth observation satellites to produce maps of the urban surface temperature, land use and vegetation index, which can help identifying areas that are susceptible to greater risk in case of occurrence of these weather anomalies. The purpose of this study is to analyse the effect of changing landuse on Urban Heat Island formation, for Ahmedabad city, on a spatio-temporal basis. The Mono Window Algorithm has been used to retrieve Land Surface Temperature (LST) from LANDSAT-5 TM satellite data. Zonal statistics tool has been used in order to classify and identify various administrative wards of Ahmedabad that have remained, and are growing as major heat pockets, as an effect of changing landuse. Reducing the effect of heat island by environment construction is one of the key aspects for city development. This study may help unravel the pattern of growth in Ahmedabad and its implication on local climate and also on the natural resources, necessitating appropriate strategies for the better urban life.

KEYWORDS: Urbanization, Land Use, Urban Heat Island, GIS

Earthquake resistant construction in hilly areas – need to blend traditional construction approaches and latest technologies

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An earthquake is a phenomenon that occurs without warning and involves violent shaking of the ground and everything over it. It results from the release of accumulated stress of the moving lithospheric or crustal plates. Earthquakes are tectonic in origin; that is the moving plates are responsible of the occurrence of the violent shaking. The occurrence of an earthquake in a populated area may cause numerous casualties and injuries and extensive property damage. India today has an increasing population and extensive unscientific constructions mushrooming all over, including multistoried luxury apartments, huge factory buildings, gigantic malls, supermarkets and warehouses and masonry buildings. India is thus at high risk. During the last 15 years, the country has experienced 10 major earthquakes that have resulted in over 20,000 deaths. As per the current seismic zone map of the country (IS 1893: 2002), over 59 per cent of India's land area is under threat of moderate to severe seismic hazard, i.e., prone to shaking of MSK Intensity VII and above (BMTPC, 2006). In fact, the entire Himalayan belt is considered prone to great earthquakes of magnitude exceeding 8.0, and in a relatively short span of about 50 years, four such earthquakes have occurred: 1897 Shillong (M8.7), 1905 Kangra (M8.0), 1934 Bihar-Nepal (M8.3), and 1950 Assam-Tibet (M8.6). Scientific publications have warned of the likelihood of the occurrence of very severe earthquakes in the Himalayan region, which could adversely affect the lives of several million people in India. The North-Eastern part of the country continues to experience moderate to large earthquakes at frequent intervals including the two great earthquakes mentioned above. Since 1950, the region has experienced several moderate earthquakes. On an average, the region experiences an earthquake with magnitude greater than 6.0 every year. The increase in earthquake risk is also caused due to a spurt in developmental activities driven by urbanization, economic development and the globalization of India's economy. Even though the country has experienced devastating earthquakes at regular intervals, these experiences have not been fully used to initiate activities to mitigate the damaging effects of future earthquake disasters. In 1993, a major earthquake occurred near Killari in Maharashtra resulting in the death of over 7,900 people. Ninety per cent of casualties result directly from the collapse of buildings. Secondary events, such as landslides, floods, fires, and tsunamis, account for the remainder (10 per cent) of the casualties. Most of the seriously wounded casualties are trapped under rubble. Both assessment and treatment are severely constrained by the confined surroundings in which the casualties are found. In all those extricated from under the rubble, crush injuries are most common. Death and injury rates are considerably higher among those trapped as compared to the rest of the casualties. The earthquake risk can be reduced only if there is better and more widespread understanding of the contributors to the risk, and requires concerted efforts by all the stakeholders. The traditional construction of houses in hilly areas took care of all these environmental hazards. With the latest technologies embedded in to traditional building techniques a number of DRR initiatives can be taken to reduce the impact of earthquakes. This will contribute in minimizing the losses which are evident at the end of such catastrophes. The developmental aspect and pace can not be halted but technologies can be used to reduce the expected losses.

Introduction of real-time analytics in crowd safety and event management

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Mass gatherings of religious, cultural and political origin are frequently being organised across the country. The crowd size of the events ranges from few thousands to millions. In major mass gatherings, the physical area under crowd influence would spread beyond the defined venue limits adding multiple challenges to the management team. Crowd flow and movement must be monitored continuously and suitable intervention practices should be executed in real-time to avoid crowd crushing incidents. Crowd monitoring through live CCTV feeds have become a common practice in India enabling control room staff to visually observe the crowd movement. But, would that be adequate for a proper monitoring as part of integrated crowd management system?. Manual monitoring has its own limitations in detecting the crowd pressure accumulation, density changes and movement pattern. Crowd safety can be achieved by introducing innovative technological solutions for real-time crowd analytics and event management. Real-time crowd analytics based event administration was introduced by the Government of Andhra Pradesh in one of the largest mass gathering held in the State “Krishna Pushkaram 2016”. The event administration with all field departments and supporting agencies were performed from an Operational Command Control Centre (OCCC) equipped with intelligent crowd monitoring systems. The surveillance system has provided zone based real-time situational alerts covering crowd density, occupancy data and crowd movement pattern. The feed from crowd analytics was served to the real-time administration platform through a mobile application and it was used for day to day event organisation, team management and response intervention monitoring. The pilot implementation of crowd analytics can enhance with IOT sensors and crowd sourcing to drive more granular data from the field and its integration with real-time administration platform would advance integrated crowd management system.

Knowledge and practice on school safety among bharath scouts and guides instructors in Karnataka

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Schools are critical infrastructure entrusted with the responsibility of creating citizens of tomorrow. No task is as important as creating safe learning environment for our nation's children. Building a culture of Safety in schools is one of the priorities of Hyogo Framework for Action (HFA). If the current generations of students are sensitized about the culture of safety, next generation of citizens would be more empowered for the future. Teachers play a vital role in molding the students. Teachers are the role models for the students in the schools. Today's safe school environment helps in making safer world in future. Recent events of children deaths due to building collapse, fire accidents and stampede bring to light the need to be continually vigilant to ensure for safety of students and staff in schools. Considering all the factors the importance of working with school is emerging day by day. This prompted the researcher to conduct a study with the objective of assessing the existing knowledge and practice on school safety among scouts and guides instructors of Karnataka. Descriptive study was conducted. The study population included the Bharath Scouts and Guides instructors who are primarily school teachers in Karnataka. Purposive sampling technique was used to select 200 Bharath Scouts and Guides instructors attended in state level scout conference. Data was collected by using structured interview schedule. The questionnaire comprised of three parts Part I: Demographic Profile, Part II: Knowledge Questionnaire on Disaster, Disaster Preparedness and First Aid and Part III: School Safety Practice questionnaire. In this study majority of the respondents were in age group of 31 – 41 years of age, professional experience of 11-20 years, graduates and Males. 80 % of the participants did not have any formal training on disaster management or on school safety. 20 % of the participants either experienced disasters or participated in relief operation. 32 % and 68 % of the participants had moderate and inadequate knowledge respectively. The deficiencies with respect to training, practice and infrastructure on School Safety were documented. Majority of the scouts and guides instructors had inadequate knowledge. Practices on the school safety were deficient. Only 20 % of the scouts and guides instructors had formal training on disaster management, first aid, fire safety etc. None of the schools had school public address system, disaster management committee, school disaster management teams, school disaster management plan and identified hazards in school premises.

Geospatial technology for monitoring of vegetation health using foss and free data

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Drought incidence can be detected by monitoring Vegetation Health in Near-Real time. Vegetation health can be found by generating NDVI maps of the region of Interest using satellite remote sensed images. Unhealthy status of Vegetation can be interpreted as a signal to indicate the onset of Drought. Recently Kerala has been experiencing an increasing number of localized drought incidents. This is mainly due to weather anomalies and developmental pressures and has resulted in severe economic losses. To understand localized incidence of drought, panchayath level maps of each district were overlaid on the daily Vegetation health maps. A technique for monitoring Vegetation Health using freely available remote sensed satellite data (TERRA), processing images using Free and open-source software (FOSS) and dissemination of this information using a Map server is discussed. Landuse/Landcover data classified from IRS P6 LISS III image helps to identify the drought affected crops for the region. Early detection of localized Drought incidence and dissemination of this information can help the State machinery to take necessary steps to mitigate drought impacts.

Keywords: Near Real Time; Drought; NDVI; TERRA & Landuse/Landcover

Hydro rescue system

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INTRODUCTION

By considering one of the most serious mishaps occurring in various beaches, sea shores and issues related to water tourism, i.e. people being taken away by tides, people met with accidents while in boating and other fun activities related to water, a combination of **monitoring, early-warning, safety, tracking, mapping** and **rescue** system has been proposed which is reliable, economical and can be realized in the form of a jacket which contains a G.S.M, G.P.S interconnected server monitoring system. Disaster risk reduction has been recognized as one of the important elements of disaster management. The national crime records beuro points out that drowning death account for 28800 every year. It means 80 lives are lost every day in India due to drowning (refer: NCRB.GOV.IN). This happens to hapless people during bathing, swimming or crossing water bodies. Adequate awareness, safety measures and preparedness would help in increasing capacity and effectively ensuring disaster risk reduction.

Strategy: This proposal constitutes **translational engineering solution** towards disaster risk reduction and safety as far as drowning events are concerned.

IMPORTANCE

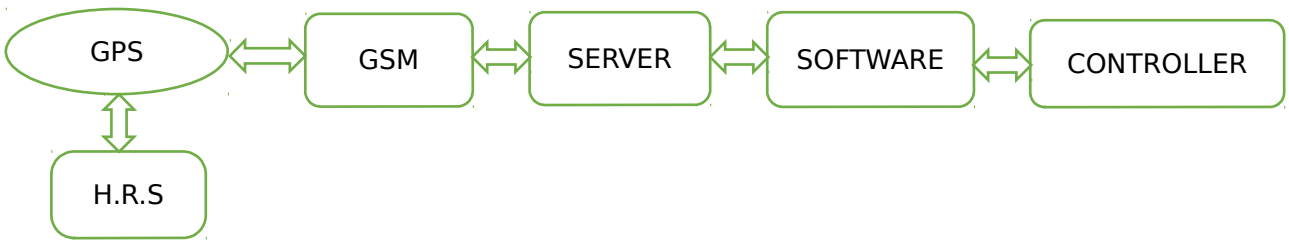
Due to lack of disaster preplanning, 8 year before Kerala witnessed a tragic accident which is the thekkady boat capsizing, resulted in death of 45 people out 82 passengers. In this type of situation our proposal is significant. Likewise this can also be implemented in Seas, Rivers and other areas of hydro-tourism to ensure monitoring, warning, safety, tracing, mapping and rescue.

OBJECTIVE

- Monitoring
- Early-Warning
- Safety
- Tracking
- Mapping
- Rescue

METHODOLOGY

Hydro Rescue System [**H.R.S**] will be in the form of a **smart** life jacket and associated systems. When a HRS-jacket is worn by a person and **clipped up**, the system will turn-on and GPS-GSM/zigbee interconnected server system locates the persons and senses his heart rate.



This data is sent to the server, which can be monitored and controlled using an application software. When the person panics or met with an accident his heart rate increases. This sensor signal are continuously monitored, if it goes above first threshold an alarm is given to the victim by H.R.S jacket in the form of

vibrations. Secondly, if the sensor signal crosses the final fixed threshold the H.R.S-Jacket will be inflated by using **compressed CO2** stored in a cylinder which will be placed in the jacket. The place of action H.R.S can be divided in to various zones or mapped namely as **safe zone**, **alarm zone, dead zones** using GPS system and when the victims crosses the zones appropriate actions can be taken real-time. Initially the sensors used here are the **heart rate sensor** and the **wet sensor.** Add-on features such as Life Detection can be added to make it helpful for rescue operation.

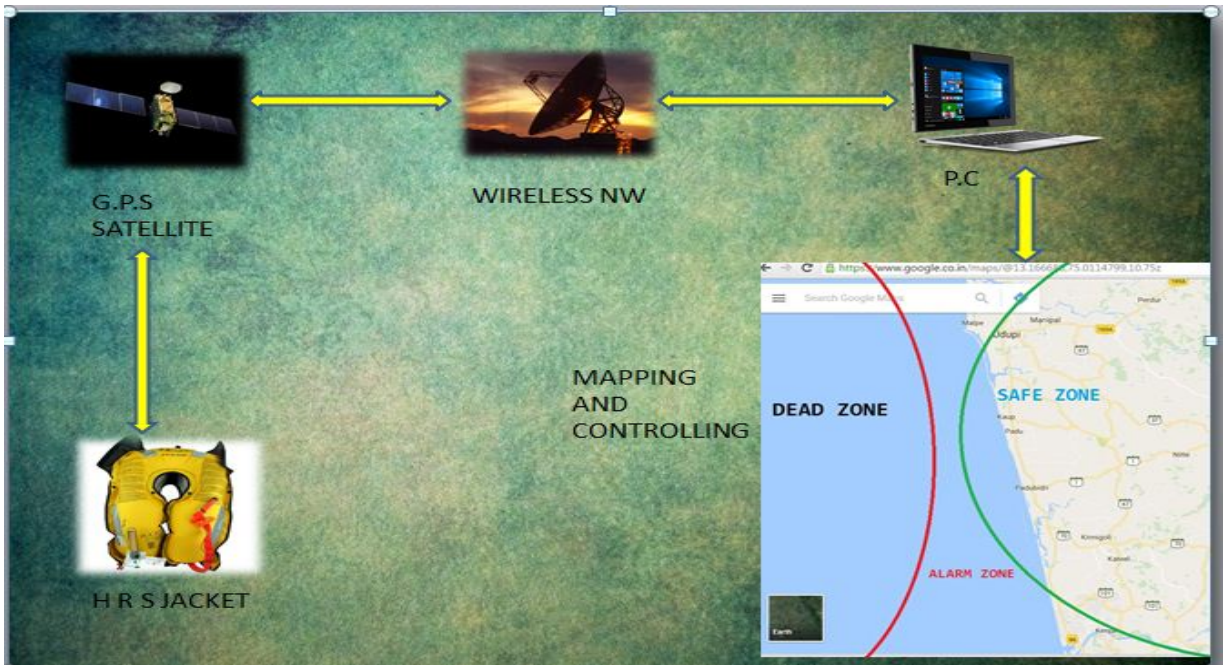


Fig: Hydro rescue system layout

BASIC PRODUCTION COST

SL. NO	ITEMS	COST(RS)
1	Life Jacket	15,000
2	G.P.S Tracker	6000
3	G.S.M module	4,500
4	Wet Sensor	3000
5	Heart Rate Sensor	4000
6	Controller	3,500
7	Servomotor	5000
8	Design and Testing(inc. consulting charges)	20000
9	Miscellaneous	10000
	Total	71,000

SCOPE OF HYDRO RESCUE SYSTEM

✓ With the granting money of 50,000 we can complete the working model of jacket and a software model. Working model includes a GPS-GSM interconnected server monitoring system.

**software model will be a web page , for real time monitoring, controlling and alarming.*

FUTURE UPGRADES

✓ In future we could develop a full featured mobile application and software for the same.

✓ Life detection unit based on micro waves can be added , which will make H.R.S an un-compromising system for rescue operation.

✓ An extra unit can be carried which helps in rescue missions.

Logical assessment of river Periyar to encounter water constraint amendment at ten diverse sampling points

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Water resource, being the most precious natural resource is getting depleted in the recent times in a drastic manner as ever before. The river water bodies, due to the discharge of industrial effluents and other wastes, is becoming more and more polluted, severely degrading its quality of usage. Recent studies have shown the serious need of Water quality assessment to know how far the resource is being polluted. The paper is on a survey work carried across the river Periyar at different sampling points to determine and analyze the water pollution trends.

Keywords: water-pollution, alkalinity, turbidity, acidity

INTRODUCTION

The work focuses on river Periyar, the longest river of Kerala. Originating from the Sivagiri peaks of Sundaramala, in Tamil Nadu; it extends over a stretch of 300 kilometers with a catchment area of 5396 square kilometers. With an estimated annual flow of 11607 cubic meters, the river along with its minor tributaries Muthayar, Perunthuraiar, Chinnar, Cheruthony, Kattappanayar and Edamalayar flows to reach Arabian Sea at Cochin. The river is much significant to the state from its economic point of view as it supports industries like tourism, fisheries, irrigation and its vital role in electricity generation as well. But the present scenario of the river to continue its qualitative usage is doubtful from the prevailing and continuing health standard of the river, which is highly affected by the various anthropogenic sources.

METHODOLOGY

The method used for the work involves the splitting of the entire stretch of river Periyar (244 kilometers) into 10 sampling points. Suitable locations were identified and the water samples were collected from the 10 sampling points. Each of the sampling location is around 25km long. This was performed during December 2015. The names of the 10 sampling stations are listed as:

Sl.No	Sampling Points
1	NEAR PERIYAR PARK
2	CHERUTHONI
3	UPPUTHARA
4	VANDIPERIYAR
5	PANAMKUTTI
6	NERIYAMANGALAM
7	BHOOTHATHANKETTU
8	KURICHILAKODU
9	THEKKUMBHAGOM
10	VALIYAPANICKENTHURUTHU

RESULTS AND DISCUSSIONS

Over the entire stretch of River Periyar divided into 10 sampling locations, water samples were collected and various physico-chemical parameters including Color, Turbidity, pH, Acidity, Alkalinity, Total Dissolved Solids, Calcium, Nitrate, were analyzed and the results obtained are discussed as below:

	PARAMETERS	UNIT	DESIRED LIMIT	SAMPLING POINTS									
				1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	Color	Hazen/Pt. Co. Units	5	30	20	5	5	20	10	10	10	20	10
2	Turbidity (NTU)	NTU	1	2.07	1.52	0.60	0.49	5.90	1.49	2.49	1.22	2.74	2.73
3	pH		6.5-8.5	6.67	6.63	6.66	6.60	6.85	7.01	6.87	7.29	6.69	7.74
4	Acidity	µs/cm		8	6	4	6	6	6	8	6	8	Nil
5	Alkalinity	mg/ litre	200	20	20	24	24	20	20	24	18	20	100
6	Total Dissolved Solids(TDS)	mg/litre	500	19.4	28.3	32.4	30.5	31.5	25.3	31.5	22.4	23.2	12300
7	Calcium(Ca)	mg/litre	75	4	6.4	6.4	8	6.4	4.8	8	5.6	8	320
8	Nitrate(NO_3)	mg/litre	45	0.416	0.618	0.800	0.396	0.946	0.66	0.824	0.467	0.447	0.713

Color, being one of the most important physical parameter that bears a desirable limit of 5Hazen units ,was analyzed across the stretch and apart from two sampling stations, all the rest showed deviations from the desirable limit. This is mainly because of the turbulence subjected to the river by run-off from the high lying terrains. The larger deviations from the permissible limit is observed to be the result of various kinds of developmental activities.

Turbidity is also one of the physical parameter that was analyzed across the stretch of river Periyar. It bears a permissible limit of 1NTU. The results showed that apart from two sampling stations, the rest showed a deviation from the permissible limit, which was again due to the turbulence of the river due to considerable runoff from the high lying terrains during the rain.

pH, being the most important chemical characteristics of the river was also analyzed. The desired limit of pH varies in the range 6.5-8.5. The results showed that almost all values taken across the sampling stations lied within the range and showed least deviations. The study on this ecological factor is so important to look for deviations for the growth of aquatic life.

Acidity, is one another property of the river water body being analyzed and the results showed that in six of the sampling stations the result for acidity was obtained positive. This shows a serious trend of the river water body getting polluted in an alarming rate.

Alkalinity, being the ability of water to neutralize acids was also measured and analyzed to know the buffering capacity of water bodies. The permissible limit of alkalinity is 200mg/litre. The results showed that across the 10 sampling stations, no single station raised a value that exceeded the permissible limit.

Total Dissolved Solids(TDS) is one another parameter taken into study. This refers to the inorganic constituents along with certain organic constituents that are dissolved in the water bodies. The permissible limit of TDS in water bodies is 500mg/litre. The results showed that none of the values in any of the sampling station exceeded the permissible limit.

Calcium in water bodies is an indicator of water hardness as the same may be present in the form of Ca^{2+}ions. This property in water is not an effect of a single constituent but the combined effect of dissolved polyvalent metallic ions. The permissible limit of Calcium in river water body is 75mg/litre. The results showed that apart from one of the stations that showed a tremendous deviation from the permissible limit, which lies near the river mouth , all other station points raised values that fall below the permissible limit.

Nitrates are one of the important forms of ammonia that serve as a nutrient for the growth of flora and fauna. This was one another parameter taken into observation and analysis. The permissible limit of nitrates in river is 45 mg/litre. The results showed that none of the sampling stations raised a value that exceeded the permissible limit. That is, the river water body showed a much lesser concentration of nitrates.

The water samples were collected from 10 sampling stationsacross the 244km stretch of the river Periyarand the survey work carried out found the results discussed above. The various physico-chemical parameters were studied and the following conclusions can be made:-

- Most of the results showed large deviations from the permissible range of the various parameters and this indicates the extent of pollution of the river. The obtained values were either much lower than the limit or they didn't fall within the range and values that lied within the permissible limit were very few.
- The pH values obtained showed the pertaining acidic behavior of the river at various locations mainly with the discharge of industrial effluents. Comparing with the BIS norms, 70% of the samples are not fit for drinking. The major conclusion to be made is the policies of government agencies must be made stringent against the disposal of untreated industrial wastes into the river.
- The contamination of river is also accompanied by the change in its temperature. The thermal variations in the river affects the life of aquatic flora and fauna.
- The river being the lifeline of the state is deteriorating in its quality at an alarming rate. This needs the decisions at the authoritative level to work against further deterioration of the river.
- Also prior to any developmental activities in future near the banks of the river, Environment Management
- policies like EIA assessment and related studies must be made to ensure the health of the river and such natural resources. The study can be made as a reference tool for further research works in the related areas that aims in preventing the qualitative degradation of our natural resources.

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Public perceptions upon snakes as risk and vulnerability: A study from Kasaragod district, Kerala

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Human-snake interactions have always been associated with different outcomes. This cross-sectional study was conducted to assess the human-snake interaction and its outcomes in Kasaragod District, northern Kerala. In the context of increased snakebites, natural habitat destruction, and climate change we conducted a study on the rate of human - snake interactions and the rate of conflict, risks, vulnerability and public perception upon snakes from Kasaragod district, Kerala. For the assessment of human - snake conflict we collected snake bite data from different hospitals in and around the district and also gathered the snake bite compensation data of the district from the Kerala Forest Department. From the assessment of gathered data, we noticed that the number snakebite cases increased from 2011 to 2016; many of the participants (66.5%) responded as they will kill all the encountered snakes without any identification because all are venomous and there is only few respondents, that is by 33.5 per cent, they will prefer to release the snakes after the identification. Simultaneously, other than direct killing most of the respondents used kerosene against the snakes which is dangerous to the snakes. Most of the respondents were aware about natural snake repellents and agree with the snake repellency of garlic (61.5%), cow dung (21.5%) and mixture of garlic and asafoetida (40.9%) but in most cases snakes were directly killed. The snakebite compensation details from Kerala forest department also reveals that the number of compensation given in each year is also increased from 2011 to 2016 and for the year 2016, it was 117. So the findings indicates that there is an intense conflict, risk and vulnerability among the human-snake interaction in the Kasaragod district that needs to be managed for the preservation of snake species and natural habitat for creating ecological balance and sustainability in that area.

Introduction

Human activities can threaten the viability of animal populations through a variety of processes, some of them complex (e.g. subtle modifications of habitat structure) and some of them very straightforward (e.g. over-harvesting). For many animal populations living in densely-settled areas, direct killing by humans may be a significant component of the overall effect of human activities on wild populations. Because this aspect of the interaction between humans and wildlife is unlikely to be as important overall as broader-scale processes such as habitat destruction (Dodd, 1987; Caughley & Sinclair, 1994), direct killing of wildlife has tended to attract more attention from community-based "conservation" organizations than from professional scientists.

Human-wildlife interaction that always leads to conflict is a major concern of most people living next to protected areas or when wild animals come in direct contact with humans. Conflict is here defined as any interaction between humans and wildlife that results in negative impacts on human social, economic or cultural life, and on the conservation of wildlife populations, or on the environment (Anon, 2005). Though humans generally try to avoid interaction with reptiles like snakes, they occasionally bear an importance that extends beyond survival and into the realm of culture. Human - snake interactions has always been associated with different outcomes. Human snake encounters with negative results such as animal death, habitat destruction, injuries to people, injuries to wildlife and the like are common (Magige, 2012). Generally, there are more than 3000 species of snakes in the world and they live in both terrestrial and aquatic ecosystems and are predatory carnivores with wide range of prey species (WHO, 2010; Bijees, 2012).

Snakes, the animal closely associated with the festivals, fears and believes contiguous with the concept of environmental protection and sustainability. That is why the ancients made patches of small forests called sacred groves *(sarppakkavu)* and worshiped snakes as *naga* in Kerala as natural forces. Snakes influenced the life of common men by beneficially as part of its important role in the ecosystem

and place in the food chain. The significance of snakes is mostly unnoticed and killed without identification and considering the entire species as venomous and dangerous to mankind. Accidental snakebites are became a widely distributed hazard but it is not considered as a serious condition. This malignant increase of snakebite accidents and death pointing towards the vast destruction of their natural habitat and failure in the proper management of vegetation. India has over 300 identified species; out of this more than 60 are venomous (Whitaker & Captain, 2008). In Asia, it has been estimated that, about four million snakebites occuring in every year. Approximately50 per cent are envenomed and resulting in annual death of 100,000 victims (Chippaux, 1998). In 2009 World health organization (WHO) considered snakebite as a neglected tropical disease, and the organization found that, India has the highest number of death due to snakebites, around 35000 to 50000 victims in every year (Alirol et al., 2010; Chippaux, 1998). Snakes co-exist with humans in homes, gardens and outhouses but their presence usually goes unnoticed. Snakes are beneficial to humans by killing unwanted insects and rodents in food stores and crops. Apart from the benefits of snakes, the general society is always scared of snakes especially from bite and their general appearances. Fear of snakes is understandable since they are responsible for a number of bites and numerous deaths as well as cases of permanent physical handicap. However, snakes do not ordinarily prey on humans and most will not attack humans unless they feel threatened, trodden or injured, or provoked. Based on previous studies, we conducted a survey on the rate of human-snake interactions and impacts, public perception upon snakes from Kasaragod district, Kerala.

Objectives

- To analyse the rate of snakebite accidents and death rate of Kasaragod district, Kerala.
- To analyse the public perception upon snakes.

Materials and Methods

Study area: Kasaragod is lying at the northern tip of Kerala bounded by the Western Ghats in the east and Arabian Sea in the west. The district has geographical area about 1992 Sq. Kms and 56.25 Sq.Kms of forest area. The climate of the district is classified as warm, humid and tropical.

Study Design and Population: A cross-sectional research design was conducted where sociological data were collected. All people with different age group living in Kasaragod district formed the study population. Randomly selected respondents were administered with structured questionnaire and observational checklist was used to collect information on snakes. Participation in the study was on voluntary bases and depended on willingness to participate in the study and readiness to give the required information.

Data Collection: Data collection was done through questionnaires, key informants interviews and record review of snake bite cases. The study involved extensive field visits and interaction with 340 individuals from the district and collected the primary data regarding the knowledge upon the snakes as risk and vulnerability, misconceptions, etc. Form the survey; we collected the information regarding the frequency of observing snakes in their surroundings, approach towards the snakes when the have seen them, how they treated the snakes when it entered into the home or surroundings and what sort of precautions they have taken to prevent the entry of snakes into the home. Snakebite data of the past 6 years (2011-2016) gathered from hospitals such as Govt. district hospital Kanhangad; Govt. general hospital, Kasaragod; swami mukku, Kankol (Traditional practitioner); Vishachikilsalayam, Pappinisseri; KIMS Nursing home, Kasaragod; Carewell hospital, Kasaragod; & E.K. Nayanar Co-Operative hospital, 4th Mile, and snakebite compensation details from Kerala Forest department includes the year, the compensation given for snakebite accident and death cases.

Results and Conclusion

A total of 340 respondents from different part of the district were involved in the study. It was found that majority of the respondents (64.1%) have encountered the snakes are rarely seen in their surroundings and

34.4 per cent of the respondents observed the snakes frequently. A few of the respondents (1.5%) answered as they don't have any snake encounter in their surroundings (shown in Table 1). Many of the respondents (66.5%) reported that, without any identification of the snakes they will kill them whenever they encountered with them. But according to the opinion of 33.5 percent, they will prefer to release the snakes without harming them after identification (shown in table 1). Other than direct killing, in most cases respondents choose kerosene against the snakes to driving out them from their (respondent's) surroundings, which affects the snakes badly and because of the application of kerosene, the snake may die.

Table 1. Respondents snake encounters

Variable	Category	No. (%) of respondents
Visibility of Snakes	No	5(1.5)
	Rarely	218(64.1)
	Frequently	117(34.4)
Approach towards Snake	Killed the Snake	226(66.5)
	Identified and Released	114(33.5)
Precautions taken	Yes	112(32.9)
	No	228(67.1)
Snake Repellency with Garlic Water	Agree	209(61.5)
	Don't Know	122(35.9)
	Disagree	9(2.6)
Snake Repellency with Cow Dung	Agree	73(21.5)
	Don't Know	219(64.4)
	Disagree	48(14.1)
Snake Repellency with Garlic Water and Asafetida mixture	Agree	139(40.9)
	Don't Know	196(57.6)
	Disagree	5(1.5)
Knowledge about Compensation	Yes	40(11.8)
	No	300(88.2)
Presence of Snake for Healthy Environment	Yes	115(33.8)
	No	36(10.6)
	Don't Know	189(55.6)
Number of Snakes	Decreasing	195(57.4)
	Increasing	59(17.4)
	No Change	78(22.9)
	Don't Know	8(2.3)

Simultaneously, in Kasaragod district it was found that 174 people were bitten by snakes in the study area for the year 2011. And there is an alarming raise in the snakebite risks and for the year 2016, 335 cases were reported (shown in Table 3). However, most of the respondents were not concern about this risk and vulnerability among the human-snake interaction. Because from the 340 respondents, only 112 (32.9%) were taken the precautions to reduce the snakebite risk, whereas 228 (67.1%) respondents were not bothered about the risk of the snakebite and they do nothing to be safe from the snakes. Most of the respondents agree with the snake repellent activity of garlic (209 or 61.5% agreed), cow dung (73 or 21.5% agreed) and mixture of garlic and asafoetida (139 or 40.9% agreed) and in the most cases of snake encounter, direct killing is happened. And even from the total 340 participants, only 40 respondents (11.8%) were aware about the snakebite compensation given by Kerala forest department. These all pointing towards the absence of snake awareness programs with respect to misconceptions and scary public perception upon snakes and unawareness regarding the risk, reasons and solutions.

Table 2. Total number of reported snakebites.

Year	Total number of Snakebite cases
2011	174
2012	228
2013	273
2014	203
2015	285
2016	335

The result of the chi-square test shows that there is a strong association between the opinion on the presence of snake for healthy environment and the number of snakes. Most of the respondents agreed the healthy environmental condition and frequent encounter of snakes. That is the number of snakes present in the environment is directly proportional to the healthy environment.

Table 3. Chi-Square tests for association of Presence of Snake for Healthy Environment with Number of Snakes.

Presence of Snake for Healthy Environment * Number of Snakes						
Response		Number of Snakes				Total
		Decreasing	Increasing	No Change	Don't Know	
Presence of Snake for Healthy Environment	Yes	67	22	26	0	115
	No	19	9	4	4	36
	Don't Know	109	28	48	4	189
Total		195	59	78	8	340

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	19.461	6	.003
Likelihood Ratio	16.936	6	.010
Linear-by-Linear Association	0.427	1	.514
N of Valid Cases	340		

When analyzing the snakebite compensation details from Kerala forest department, the number of compensation given in each year is also increased from 2011 to 2016 and for the year 2016, it was 117 (shown in Table 4).

Table 4. Snakebite compensation data from Kerala forest department, Kasaragod

Snakebite compensation data from Kerala forest department, Kasaragod			
Year	Compensation for -		Total No. of Compensation
	Death Case	Snakebite Accidents	
2011	1	0	1
2012	4	4	8
2013	9	46	55
2014	4	60	64
2015	2	78	80
2016	6	111	117
Total	26	299	325

The findings show that there is an intense conflict, risk and vulnerability among the human-snake interaction. If this situation continues and the risks being unremarked, the snakebite will become one of the major disaster of the district. That will compel the common man to consider the snake as the main enemy and promote the direct killing of snakes. That finally leads to the extinction of that reptilian species from the district and will become the uncontrollable hazard by the disproportionate increase of rats, pests and outbreak of epidemic diseases.

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Seasonal variability of zooplankton species in the Kavaratti lagoon of Lakshadweep Archipelago, India

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Kavaratti is one of the coral lagoons having major primary productivity in the Arabian Sea. The distribution of zooplankton communities were studied along with the environmental influencing factors through in-situ survey and water sampling analysis. Samples were taken from various locations of the study area during pre and post monsoon for the year 2014 and 2015.The growth of zooplankton communities are mainly response to availability of nutrients and primary productivity (Phytoplankton) and their spatio- temporal dynamics. The result reveals that the zooplankton assemblages of copepods are dominated in major parts of the area at the rate of 38.35%.Their communities contain the following species *Accrocalanus gibber, Nannocalanus minor* and *Acartia danae.* Maximum concentrations of species diversity were found during premonsooon and summer that shows a positive correlation with salinity and sea surface temperature. Silicate and nitrate loadings having a significant contribution in determination of copepodan distribution. The Pearson correlation analysis shows a significant impact of nitrate, temperature and salinity on zooplankton growth and productivity. Hierarchial cluster analysis also proves above the result. The pattern of silicate loading (7.5 to 9.2 µmol L^{-1}) in associate with higher salinity and lower sea surface temperature is considered as favorable condition for higher productivity of zooplankton in the study area.

Key words: Zooplankton, Copepods, Lagoon

Application of geospatial technology in landslide vulnerability analysis – a case study of Devikulam high range in Idukki district, Kerala, India

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Abstract

Landslides are destructive agents which has the capacity in modifying and changing the landscape Asmelash Abay Hagos (2012). Landslides are a frequently occurring geologic hazard in Idukki region. Rock fall, rock slide, debris fall, creep and debris flow are some of the notable landslide types occurred due to slope failures. This catastrophic activity sometimes become a vulnerable agent which affects the normal life in several ways. Debris sometimes block the roads and supply lines making serious causalities, increased sedimentation in major reservoirs and sometimes induced flood. Incessant rainfall and unscientific land use practices are the main reason for landslide vulnerability in this area. However, Knowledge of landslide location, lithology and morphology will reduce their impacts. Central government (National Institute for Disaster Management) and the Kerala State are Disaster Management Department are attempting to identify potential landslide vulnerable zones in an effort to anticipate and lesser damage to life and property. The main objective of this study is to evaluate the landslide susceptibility and prepare maps of Devikulam taluk using various landslide associate spatial data. The landslide susceptibility map is prepared based on 'rank sum' methods in GIS platform. This study area is prone to various types of landslide and landslide generated vulnerabilities. Landslides will continue to be a vulnerable hazard in Devikulam taluk, Idukki district.

Key Words: Landslide, Disaster, Rank sum method, GIS and Devikulam

Introduction

Landslides are simply defined as down slope movement of rock debris and/or earth under the influence of gravity. This sudden movement of material causes extensive damage to life, economy and environment NIDM (2014). Heavy rainstorms, cloudbursts, earthquakes, floods, cyclones and haphazard human activities are the main factors which triggered landslides. After Himalayan range, Western Ghats are the next serious land slide hazard prone area. Ever increasing population, deforestation, human developmental activities over unstable slope such as unscientific road construction, faulty slope management practices, ignoring natural features increased intensity of landslides are increasing risk to human life, buildings, infrastructures and environment. A comprehensive study of hazard and risk evaluation of landslide prone areas of high ranges conducted by experts has found Kumbanpara, Neriyamangalam, Machi Plav, Munnar, Adimali, Karadipara, Lockhart and Ambalachal are potentially dangerous localities. They conclude that, though incessant rainfall is the reason for landslide hazards unscientific land use practices also the main reason for such vulnerability in Idukki (The New Indian Express, May 26, 2012).

During the south west monsoon season (June-September) landslides are common problem almost every year. The combination of mountain terrain, deforestation and excessive rainfall sometime one day rainfall reached upto 92.66 mm (The Hindu, June 5, 2013) is most conducive to mass wasting. Almost 90% of all landslides are caused by heavy downpour in the study area and act as a lubricant which increases pressure in soil and rock debris and allowing them to flow down as semi solid and liquid.

Number of major and minor landslides are occurred in and around the study area create tremendous damage. More number of landslides identified in Cochin-Munnar NH 47 especially on the either side of Cheeyappara waterfall, Pallivasal, near old Munnar and Machipilavu.

Munnar is a famous tourist destination which attracts people from different parts of the world. So, the traffic density is always high in NH 47. Heavy downpour sometimes triggered landslides and cut off

Munnar from Cochin and put tourist people into great pressure. In 2013, June 25 seven people Killed, many houses damaged and cultivated area swept away due to landslides in Adimaly, Machipilavu areas from June 1 (The Hindu, June 25, 2013), In the same year 5 people killed and more than 10 people trapped including two foreign tourist and more than 20 vehicles were trapped under the 30 feet thick mud, huge rocks and trees (The pioneer, 06 August 2013). In 2005, Seven people killed and one missing near Munnar (The Hindu, July-26, 2005) are some of the few example shows the severity of landslides in the study area. So comprehensive landslide management is essential one in the study area.

Central government and state disaster management department conduct various research studies to control landslide hazards in Cochin-Munnar NH 47 and other parts of study area. Among the various techniques adopted in landslide hazard zone identification, Geospatial techniques with the incorporation of geographical data such as slope, land use/ land cover, lithology, geomorphology, road buffer using weighted overlay techniques (rank sum method) will bring fruitful result with high accuracy and minimum expenditure.

Study Area

The area selected for the present study is Devikulam Taluk of Idukki district in the state of Kerala is located on the eastern slopes of Western Ghats (Fig.1). The study area stretches between the latitudes of $9^0 56'56''$N to $10^0 21'29''$N and longitudes of 77^0 48' 31''E to $77^0 16'14''$E covers an area of 1140 Km^2 and is inhabited by 177621 persons with a literacy rate of 138527 (Census Report, 2011). June and September which are the months of south-west monsoon recorded at least two third amount of rainfall. Average annual rainfall in the rain fed regions ranges from 3,000 to 8890 mm and in the Marayur region it goes as low as 1270 mm (Satis Chandran Nair, 1994). Physiographically the study area is diverse in nature. Fluvial action is dominant one in the leveling up processes. Narrow ridges, steep slopes, cascades, spur, wooded narrow valley, open grassy summits etc,. are the major fluvial erosional features in Munnar plateau.

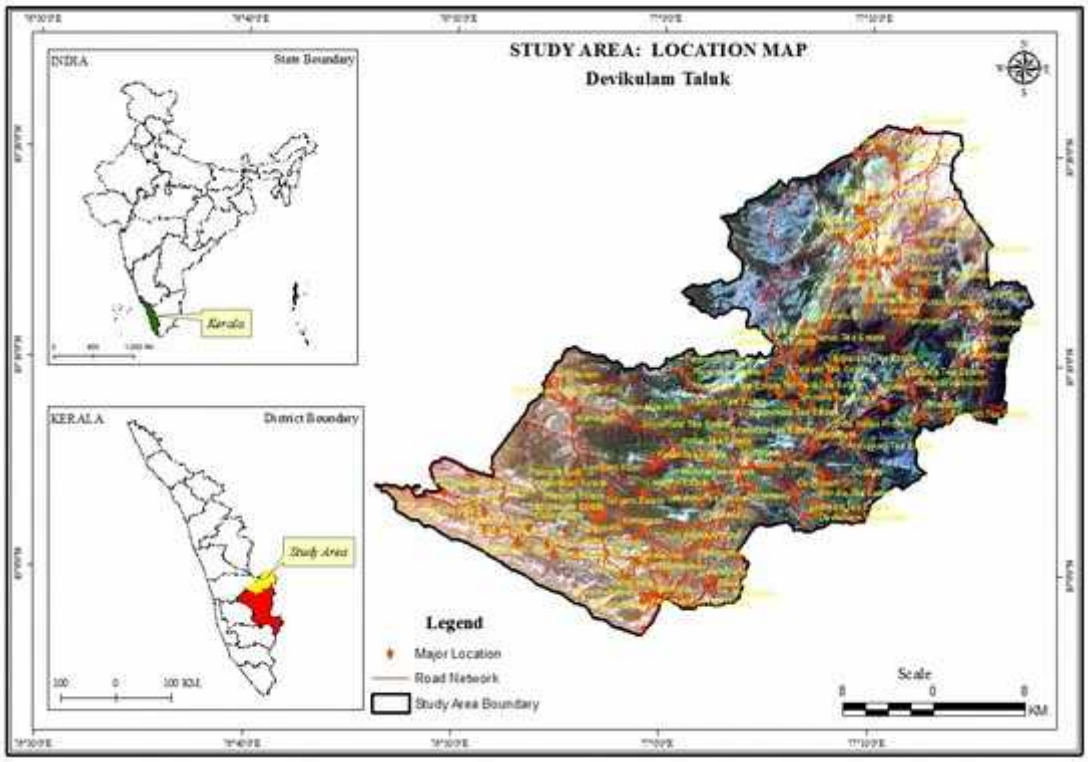

Fig: 1 Study Area Map.

Fig 2: Landslide in Munnar Colony (Source: The Hindu, July 26, 2005).

This region is covered by riparian forest, scrub forest, paddy fields, deciduous forests. Adimali is a foot hill region of Munnar plateau situated in the south eastern direction. In Adimali before 1980, the main crops under cultivation were rice as well as pepper and cardamom. Now almost 90% of the paddy fields have been modified for other purposes such as residential land, rubber plantations and banana fields. The study area was drastically changing since 1879. Munro in partnership with two brothers named Turner acquired a concession of land for the purpose of developing Cinchona and other plantations Speer. S.G (1953). In order to cater to the aspiration of the masses, the land use pattern of the study area was totally modified. Due to food shortage and famine (1941-44), the government opened forest lands on an emergency basis for food cultivation. The narrow paddy fields in mannamkandam, Vellathuval, Marayur and other villages which lay scattered in between the hill slopes had acted as the major source of food production. Orginally paddy fields were rich in fertility and the supply of water. When people started cultivation on the steep side slopes, without proper soil conservation measures, the eroded soil got deposited in the paddy fields and cultivation become difficult and less profitable Mani. K, (2011). Most of the native flora and fauna of Devikulam have disappeared due to severe habitat fragmentation resultant from the creation of the plantation. The annual mean temperature is also gradually increasing due to some climatic phenomena Suresh.S et.al, (2015) but it is mainly because of land cover changes. Frequent flood also occurred in this study area. Historically in 1896 and 1924 heavy flood struck Munnar and adjacent areas causing more damage Speer. S.G (1953). Frequent removal of Eucalyptus plantations, Tea plantations, heavy rainfall and rapid increase of land use mainly for settlement etc,. provoke this area for landslide vulnerability.

Aims and Objectives

The primary objective of the study is to identify landslide vulnerability in Devikulam Taluk through multilayer overlay “rank sum method” technique in geospatial technology platform.

Methodology

To calculate the land slide vulnerability, Rank Sum Method (RSM) techniques were adopted. This study used nine parameter namely drainage density, soils, land use land cover, slope, geology, geomorphology, NDVI, Road density and lineament density (Table.1). Each layer was reclassified and weight were assign on the basis of influence on landslide. For instance, the chance of landslide will be more in steep slope areas assign high values whereas landslide is less in gentle slope areas assign less value. Similarly for the remaining other factors such as soil, drainage density, geology, geomorphology, land use and slope of perform important role and weights were assigned according to relative importance (Table.2). Where wj is the normalized weight for the j^{th} criterion, n is the number of criteria under consideration (j=1,2,3,….n), rj is the rank position of the criteria. Each criterion is weighted (n-rj+1) and then normalized by the sum of weights, that is, ε (n-rj+1).

Table: 1 Landslide Parameters

Sr. No	Parameter of criteria	Straight Rank (rj)	Weight (n-rj+1)	Normalized weight (wj)	Criteria weight (%)
1	Slope	1	9	0.2	20
2	Vegetation Cover	2	8	0.18	18
3	Soil	3	7	0.16	16
4	Drainage Density	4	6	0.13	13
5	Land Use/Land Cover	5	5	0.12	12
6	Road Density	6	4	0.09	9
7	Geomorphology	7	3	0.06	6
8	Geology	8	2	0.04	4
9	Lineament Density	9	1	0.02	2
N = 9	Sum		45	1.00	100

Results and Discussions

The landslide susceptility map of Devikulam taluk has been workout using remote sensing data and generation of various supported triggering parameters in GIS environment e.g: Soil, land use/Land Cover, drainage density, road density, lithology and geomorphology. In addition to that field verification has been done for the past and present landslide occurred locations. The field data and the prepared landslide vulnerability map generated through the spatial information technologies matched almost 90% accuracy. The landslide map was classified into five zones. i.e. very high vulnerable zone, high vulnerable zone, moderate vulnerable zone, low vulnerable zone and very low vulnerable zone (Fig:4). The result shows around 50% area come under high to very high landslide prone area. Nearly 36% area falls on medium landslide susceptible region. The most landslide occurrence area are very close to National Highway-49 (Munnar to Cochin)can be attributed to the instability caused by the vertical excavation, which were made for road and buildings. The leveling of the slope for the NH construction resulted in steepening slopes caused unstable slopes. These conditions were aggravated when unscientific and unplanned house construction was undertaken in the vicinity of the NH. It should be noted that 5th August 2013 incessant rainfall triggered numerous landslides in Devikulam taluk, resulting in death of 14 people, damaged roads and value properties. The intensity of damage restricted to development of cracks in walls, due to land slip steep face is formed behind the house and infront of the house unconsolidated removed material were dumped, etc. According to the result, Ozhukatadam, Irumpupalam, Adimalai, Kallarkutti, Valpara, Nemakad, Pottamedu, Guderale, Vattavada, Tirthamalakudi and Kilandur area deciphered high landslide possible areas. So, care should taken to construct the new houses only in the original soil and the soil dumped area is only suitable for setting a garden and not for construct building. However, due to the tourism industry, the land cost is going up, the middle and low class people have less land to built home and sometime unstable slope area has forcely removed and filled by unconsolidated filled soil. These changing scenario and lack of awareness on the slope stability has resulted in locations selection which are really unsuitable for housing. The main criteria which is taken into consideration is maintain the proximity to main road and avoid unstable slope.

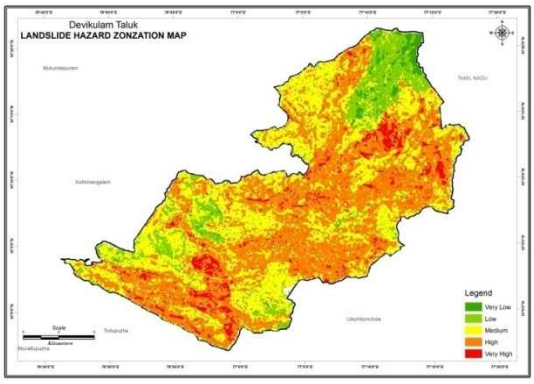

Fig: 4 Landslide hazard Map

Table: 2 Weightage Calculation for landslide Parameters

Erosion Parameters	Sub- class of parameters	Class Weightages	Per cent Of Influence
Slope	0 – 3 % Little or none	1	20
	4 – 9% Gentle	2	
	10 – 15% Moderate	3	
	16 – 30% Steep	4	
	31 – 60% Extremely Steep	5	
	>60 % Excessively Steep	6	
Vegetation Cover	Bare Soil / Waterbody	3	18
	Mixed Vegetation	2	
	Thick Vegetation	1	
Soil	Anamudy Series - Amrithamedu, Iruttukanam	80	16
	Pampadumpara Series - Elappara, Amritamedu	64	
	Thommankuthu Series - Peringasseri, Velur, Venmani	48	
	Venmani Series - Velur, Adimali, Pampanar, Nadukani	32	
	Chinnar Series	16	
Drainage Density	Very High	4	13
	High Density	3	
	Medium Density	2	
	Low Density	1	
Land Use	Cultivated Land	7	12
	Rock Outcrop	6	
	Settlement	5	
	Plantation	4	
	Open Scrub	3	
	Forest	2	
	Waterbody/River	1	
Road Density	Low	1	9
	Medium	2	
	High	3	
	V.High	4	
Geomorphology	Barren Valley	6	6
	Highly Dissected Denudational Slope	5	
	Valley Fill	4	
	Escarpment	3	
	Plateau	2	
	Tanks and Waterbody	1	
Geology	Limestone	10	4
	Granite	9	
	Granite Gneiss	8	
	Quartzite	7	
	Charnockite	6	
	Calc Granulite	5	
	Graphite	4	
	Hornblende-Biotite Gneiss	3	
	Biotite Gneiss	2	
	Waterbody / River	1	
Lineament Density	Low	1	2
	Medium	2	
	High	3	
	V.High	4	

Table: 3 Landslide Category

SI.No	Category	Area	Area in %
1	Very Low	25.63	2.29
2	Low	131.80	11.76
3	Medium	402.55	35.91
4	High	496.46	44.29
5	Very High	65.26	5.82

Conclusion

Satellite remote sensing and GIS are extremely useful tools in data acquition and analysis for landslide hazard quantification, risk reduction, planning and post disaster management. The results and findings of the present study can help the developers, planners and engineers for slope management and all land use planning at regional scale. From the research it can be concluded that remote sensing & GIS and rank sum methods are highly suitable for regional scale landslide susceptibility analysis. In order to optimize the methodology and results we can use high resolution satellite remote sensing products and more number of observation stations should be installed in complex terrains to monitor the rainfall patterns and associated increase of pore water pressure in the region for further investigation.

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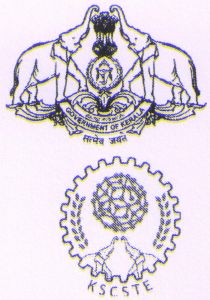

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Sharing Kerala's constant endeavourers in supporting developmental Schemes the Science & Technology Programme of KSCSTE is in the process of various creative Schemes in the Science sector. KSCSTE is now looking at the future by providing world class research and implementing globally accepted quality parameters pertaining to the State's overall development.

RESEARCH AVENUES, FELLOWSHIPS & SCHOLARSHIPS

- *Emeritus Scientist Scheme for senior Scientists*
- *Doctoral & Post-Doctoral Fellowships*
- *Fellowships in Science writing & Science Communication*
- *Prathibha Scholarships for Students opting Science learning*

FINANCIAL SUPPORT FOR PROJECTS

- *Grant for Research Projects in emerging areas of Science (SRS Scheme), Technology (ETP Scheme) & Environment (E&E Scheme)*
- *Project for School and College Students*
- *Individual and collaborative projects in Engineering & Environment areas*
- *Industry linked biotechnology Schemes*
- *Intensive programmes for Innovators of Rural Technology(RTP Programme) and Biotechnology*
- *SARD Scheme focusing activity specific areas*
- *Innovation & Technology Development(TDAP)and Patent Information Centre*

PROMOTIONAL PROGRAMMES

- *Kerala Shastra Puraskaram for eminent scientists*
- *Science Literature Award*
- *Back to Lab Programme for Women*
- *Vocational skill oriented reinstated training [VSORT]*
- *Tech Fest, Green Corps, Eco Clubs*
- *Sasthra Poshini & Sasthra Bhodhini*

POPULARISATION PROGRAMMES

- *Science Popularization Programme*
- *Support for Seminar, Symposia and Workshop*
- *National Science Day, National Technology Day, World Environmental Day, Ozone Day etc.*

KSCSTE is also spreading the activities to the following areas:

- *Technology Transfer*
- *Science City*
- *Scientific Management Training*
- *Innovation Warehouse & River Rejuvenation Projects*
- *Video Production on Science Awareness*