WSN Based Natural Disaster Alert and Analysis System

Mr. VipinKumar R. Pawar
PhD Scholar, Terna Engineering College
Mumbai

Dr. Sudhakar S. Mande
Professor, Don Bosco Institute of Technology
Mumbai

Dr. Imdad Rizvi
Professor, Terna Engineering College,
Mumbai

Abstract:

Sensor is widely used device in technology to measure any physical phenomenon from environment to convert into electrical data. It can be used as an early warning and analysis system for detection of Landslide or any other natural disaster / tragedy. It has been surveyed that landslides are frequently occurring natural hazards in hill or valley terrains, especially in Himalayas and Sahyadri mountains. GIS based remote sensors can play most important role to alert and analyze natural disaster to prevent millions of losses.

INTRODUCTION

Analysis of Natural disaster like Landslides, Earthquakes and Tsunamis are possible but Alert of these disasters before occurrence is more difficult than analysis. WSN plays most important role to get live digital data regarding geological changes like temperature, humidity, rain water intensity. There are three fundamental ways for monitoring natural disasters viz visual, surveying and instrumentation. Ground based visual inspection and sampling of these on regular basis may be one of the effective ways of monitoring the disaster. Surveying includes all type of physical measurements. Instrumentation may include installing equipment for periodic reading of the different monitoring sensors such as inclinometer, strain gauge, rain gauge, clinometers, extensometer, pore pressure sensors etc.

WSN based natural disaster alert system capable to inform the geological changes in digital form and also provides digital and numerical data wirelessly to the control room in real-time with disaster category, its strength, and the exact geographical location (GPS data) and also provides the SMS to concern registered officer for quick decision of rescue operations.

WSN based natural disaster alert system is currently in active state in Nashik, Maharashtra and providing the live geographical information from Kadwa Dam, Ghoti, Nashik, Maharashtra(GPS Locations: 19.768536, 73.793108) and Varwandi Village, Nashik, (GPS Location: 20.069680, 73.837865) for data validation purpose.

Interactive software "VKz GeoInfoSys" (Version: 1.0.0.4) is in active mode to collect data generating from these two locations. It has capability provide live geographical information from sensors available from these two locations. And also message database in MS-Access (for testing mode).

After validation of WSN based natural disaster alert system, near about 630 villages, towns, cities in Sahyadri Mountain areas are covered by these types of Sensor node.

LITERATURE SURVEY

Landslides triggered in rainy season in most mountainous landscapes. Some of these landslides occur suddenly and covers many kilometres of area at high extremely speeds. They can pose grave threats to life and property. Traditionally, prediction of rainfall-triggered landslides has relied mostly on recognition of landslide-prone terrain and identification of rainfall intensities and durations that cause slopes to fail. These empirical methods are important, but they provide no theoretical framework for understanding hot hydrologic processes influence the location, timing and rates of landslide or for anticipating how landslide hazards might change in response to changing climate or land use. Recently, theoretical models have been developed to predict how variations in landslide susceptibility depend on topographic, geologic, and hydrologic land use. (page no 1) [8]

Unambiguous length scale, it is therefore necessary to approximately A by some readily measurable property.(page no 3)[8]

Land sliding involves two basic phenomena, slope failure and postfailure motion,which I analyze sequentially.[8]

Slope Failure: To evaluate the potential for slope failure at diverse locations within a landscape, I use a one -dimensional infinite-slope stability anlaysis,which neglects all forces not resolvable on planes that parallel the ground surface. An infinite slope geometry is a rigorous, lowest-order approximately of a multidimensional landslide geometry if H<< Lowered H is The Prospective slip surface depth and L is the prospective landslide length or width.(page no 9) [8]

Post failure motion: Post failure movement of a translating landslide mass depends, in part, on soil properties that may cause deforming soil to progressively weaken or strengthen. However, the interplay of subsurface hydrology and landslide inertia also plays a role, which is the focus here. For a landslide of arbitrary thickness Z the effect of inertia can be evaluated.[8]

The Himalayas are tectonically active and characterised by steep slopes and high rate of surface erosion. This, combined with heavy rain in the central and east side of Himalayas during the monsoon, poses a high risk for landslides and flash floods. Approximately 83% of Nepla's topography is composed of hills and mountains, making the country prone to landslide and debris flows (DWIDP 2013).(page no 1)

Landslides: Definition- Landslides are a subset of natural processes of mass movement os slope-forming material under influence of gravity. They are composed of bedrock and soil(earth and organic matter debris),and are often classified by the type of movement such as fall, topple, slide, lateral, spread, and flows(ICIMOD 2008).Although landslides occur naturally in Himalayas where techtonic plates moves, there are also clear influences of human activity on their occurrence in Nepal, particularly due to road-building, deforestation, and agriculture practice.(Gerard and Gardner 2001; Petley et al.2007)(page no 2)[9]

Landslides in Nepal : The steep mountains terrain of Nepal combined with heavy monsoon rainfall yields a high risk of landslides each year. Landslide risks have been further exacerbated by the earthquake and subsequent aftershocks, which have destabilized slopes, making the areas affected more susceptible to landslides during the monsoon than usual(Faris and wang 2014).Over 3000 landslide were observed after years combined. Furthermore, the 12 May earthquake reactivated some landslides as well as triggered new landslides .Most landslides tend to occur late in the monsoon period, when the moisture content of the land surface reaches a critical stage (MoHA 2012),with the highest numbers of landslides occurring in July, August, and September.[9]

Landslides are in themselves extremely damaging in the presence of property and people when they bury villages and block roads and trails but they pose risk of additional disastrous consequences when they block rivers or affect critical infrastructure such as supply routes or electricity networks. Landslides are very localised and rarely span over more than one VDC (GRIP 2011).[9]

Sectoral Impacts of Landslides: Health: The primary causes of death during landslides are trauma from direct impact and suffocation from being buried under debris(WHO).Thus, mortality is usually high and injuries few. Mental trauma has been observed in both the short and long-term in survivors.(WHO).

Shelter and NFI: After large landslides, the immediate need is search and rescue of people trapped in debris and emergency shelter for the homeless. People who are still living in unsafe/damaged building are at risk of further building collapse due to heavy monsoon rain,wind,and continuing aftershocks.[9]

Water, sanitation and Hygiene: Destruction of sanitation facilities will result in increased practice of open defection. Drinking water systems are destroyed and contaminated with sediment. Those displaced will need temporary water systems and latrine in temporary settlement sites if not available.[9]

Food Security, Agriculture and Livelihoods: Agriculture is both impacted by, and influences the occurrence of landslide. Inappropriate agricultural practices on steep slopes are thought to increase the frequency of landslide. Irrigation channels are severely damaged or destroyed. Food security is likely to deteriorate due to both decreased food production and decreased access to markets.[9]

Protection: Further destruction and damage of homes from landslides may increase the number of people seeking compensation since the earthquake and those who are not owner of the damaged homes may be left out of the relief allocations.[9]

Flash Floods: Definition: Flash floods are severe flood events triggered by extreme cloudbursts,glacial lake outbursts,or bursting of artificial dams or dams caused by landslides, debris, ice or snow(ICIMOD 2008).These cause more damage than regular floods.(page no 3)[9]

Landslide dam outburst floods: Earthquake and excessive rainfall and snowmelt are the most common triggers for landslide dams.[9]

Mitigation Strategies - Most mitigation measures for landslides and flash flooding are long-term solutions related to watershed management through addressing agriculture, forest cover and other land use patterns.

Early Warning Systems and Continuous Monitoring-

The Department of Hydrology and Meteorology has installed automatic water sensors that monitors water level and normal flow in 27 major rivers.Some of the glacial lakes also had early warning systems in place in case of dam breakage, although it is unclear whether the system is currently functional.

Multiple communication channels to relay warning messages to communities should be mapped out, tested, and refined(Ex.FM radio, text, telephone, megaphone, hand operated sirens).Collation of observations of the distribution, character and impact of landslides from people in the field is necessary to enable continual landslide risk assessment.

Coordination for Rapid Response-[9]

There is little to react to sudden effects of landslide and floods in remote and hard to reach areas.Coordination and communication between govt.humanitarian partners and communities is essential. Local knowledge of landslide prone areas and local history should be tapped into for planning purposes.[9]

Guidance for choosing sites for temporary facilities-Site selection for temporary facilities such as tented health centres, temporary learning centres and shelters should be chosen carefully away from riverbanks and fragile slopes. Avoid areas with piles of large boundaries or other signs of previous landslide. Stay away from steep hill slopes and minimise the angle between a site and the local skyline.(page no 6)

Messaging for Communities at Risk/Personal awareness-[9]

Two-way communication regarding risks should be maintained, and messaging on personal measures that can be taken to reduce risk promoted among both local communities and humanitarian actors delivering aid. Be aware of surrounding, unusual noises, tremors and dust in the air are all possible indication of an earthquake or a landslide. Be aware of decreased river flow and change of colour(in absence of rainfall changes) as it may indicate damming upstream. Earthquake might have changed some landscapes dramatically, so other areas may also be at risk.(page no 7)[9]

The gazetteer of the Simla Hill State (Punjab Government 1910) mentioned numerous landslides induced by an earthquake in 1803.These landslips blocked the river Satluj and river Giri and created huge dams. Near village Band role, about 13 km north of Kullu town, where according to a legend a massive landslide buried an entire village(Gardner 2002).The records reveal that 1905 Kangra earthquake induced numerous landslides in the Beas river valley between Kullu and Manali (Punjab govt. 1926).The Tribune, june 10,1935 reported many landslides near Barog on Kalka-Shimla highway that isolated areas of solan and Dharampur from the other markets and led to the shortage of food products. During late 1950s,two landslides occurred five and half kilometres south of Kumarsain in Shimla district on Shimla-Rampur highway, due to heavy rainfall; One in shimla town near Jakhu and various places on Kalka-Shimla highway(The Tribune 18,september 1957).A huge landslip occurred in 1963 on Bilaspur-Chandigarh highway at Gambhar in Bilaspur district. A landslide killed 40 people and injured 16 at Matiana on Hindustan-Tibet(HT) highway in Shimla district in August 1989.Another massive landslide killing over hundred people in Luggar Bhatti area of Kullu district occurred in 1995.As per Govt.of India(2003) nearly 97.42 oercent of the total geographical area of the state is prone to landslide hazard.Over 14 percent and 70 percent area is liable to severe to very high and high risk of landslides. All the districts have over 90% area prone to landslide hazard except Una where it is about 80% of the total area.IN severe landslide hazard risk category Kullu district(33.70%) with one-third area under this class tops the list followed Chanba (33.28%),Solan(29.11%),Mandi(25.01%),BIlaspur(18.91%),Shimla(17.79%),and Kinnaur (13.73%).(page no 2).[10]

The 1970s witnessed 164 incidents of landslides with an annual average of 18.22 events per year,which accounts for 18 percent of the total events that took place during 1971-2009.There was further increase in landslide events during 2000s.which recorded 474 landslides having annual average of 47 events per year, according for over 51% of total events.(page no 3)

The district wise distribution of landslides for the period 1971-2009 shows that there has been continual rise in landslide activities, particularly in post 1980 decades. During 1970s major landslide prone district included Shimla (30.49%),Solan(23.17%),mandi(12.20%),and Kinnaur(10.37%) while in 1980s MAndi 919.35%0,Una(17.74%),Shimla(14.52%) and Solan(11.29%) were the most affected districts.During 1990s Shimla(25.11%), Solan(14.15%), Mandi (12.33%) retained the status of being the most landslides prone districts while chamba (11.87%) emerged as another landslide prone area. Intense and torrential rains are the principal cause of slope failure and majority of landslide in HImachal Pradesh occur during the monsoon season. During 1971-2009,703(76.50%) landslide events occurred during the monsoon season. The pre monsoon showers were also responsible for about 107 (11.64%) events of landslide while winter rains and snowfall during early months of the year cause over 7 percent of total landslide.(page no 4)[10]

Landslide Impact on Human Life: Landslide hazard and its disastrous manifestations have as established history in HImachal Pradesh. There have been numerous devastating incidents of landslides claiming huge numbers of human lives alongside gigantic loss of property, infrastructure and livelihood in the state.The Matiana (Shimla) landslide (1989),Luggar-Bhatti (Kullu) slide (1995) and Nehrukund slide 2008 are some of the worst reminders of misery caused by such events. A total of 525 people were killed in last four decades due to landslides.1971 of towering deaths when 56 people lost to landslides.(page no 6)[10]

Uttarakhand area had suffered an earthquake on 29 March 1999 which caused loosening of rock masses, ground cracks and landslide etc, besides killing more than a hundred people due to collapse of buildings.[11]

The heavy rainfall triggered the landslides through the percolation in the joints and cracks. The rain acts as a lubricant matter that induces the occurrence of landslides. The rainwater percolates through the soil pore space and the cracks and joints of the rocks. The materials also become saturated and these increase the effective weight of the materials. This mechanism reduces the resistance and stability of the parent rocks. In the Darjeeling Himalayas, before the occurrences of the landslide, the average rainfall wasabove 200 mm.The average precipitations in June to July of Darjeeling is 600-800 mm. But at the preceding time of landslide, Kalim pong have faced a torrential downpour of 254.4 mm in just 24 hours. Thus with the addition of heavy rainfall ,the lubricated unconsolidated matter slips down as the subsequent effect of heavy torrential rainfall. This induces the occurrences of landslides at MIrik,Kalimpong,Kurseong and Darjeeling.most of the landslides are the subsequent effect of heavy rainfall.(page no 3) [12]

Anthropogenic activities - The anthropogenic activities are one of the major factors for the recent landslides in the Darjeeling Himalayas. The anthropogenic activity include the continued cutting of the vegetation due to the construction of the multi-storeyed building, roads for communication and tea cultivation. The removal of vegetation reduces the cohesiveness of the soils and the parent body. Thus, is has enhanced the vulnerability of landslides with the addition of heavy rainfall in the surroundings of Mirik. The continues construction of the buildings and roads have accelerated the vulnerability of landslides. Cutting off the natural slope in an unscientific manner reduces the shearing strength of the parent body and increase the vulnerability of landslides. the number of roads is growing.(page no 4)[12]

Landslide is most common phenomena in following areas.

(a) Areas subject to seismic shaking.

(b) Mountains environments with very high relative relief

(c) Unscientific mining/land use areas

(d)Areas of moderate relief suffering severe land degradation

(e)Areas covered with thick sheets of loess

(f)Areas with high rainfall and ill drainage system. (page no 1)[13]

During Landslide the materials like rock, soil, vegetation and existing construction above the land sliding area may move by falling, toppling, sliding, spreading, flowing or in combination of two or more principal types of movement. Some landslide is rapid, occurring in seconds, where as others take some minutes, hours and week and so on. The landslide velocity scale proposed by cruden and Varnes (1996).[13]

Remotely sensed data are used in solving various environment tasks. This technology can be used as an effective aid in natural hazard investigation, as well as for the purpose of environmental planning. Terrain information, such as land cover, geology, geomorphology and drainage could also be derived from it and existing thematic information can be updated to enable the quantification of human interference on the earth's surface. Geographic Information System(GIS),as a computer-based system for data capture, input, manipulation, transformation, visualization, combination, query, analysis, modelling, and output, with its excellent spatial data processing capacity, has attracted sincere attention in natural disaster assessment.(page no 6)[14]

Spatial and temporal thematic information derived from remote sensing, thematic maps and ground-based information needs to be integrated. Several researches have envisaged remote sensing and GIS technologies for LHZ studies. Specifically GIS has the potential of performing Landslide Zonation using various thematic layers. A study has also been carried out(in a part of Garhwal HImalaya Tehri environ) to know the spatio temporal dynamics of landslide using multitemporal remote sensing data (Pandey and Verma, 2007).To study temporal dynamics of landslides, satellite images of LISS-III and LISS_IV sensors for year 1995 and 2005 were used. The total area effected from landslides hazard has been mapped in year 2005 with LISS III data and estimated to 2.93sq.km which is greater than 1.3sq.km of landslide area,mapped in the year 1995 with LISS-III data. In terms of landslide incidence the number of landslides in area increased from 134 during 1995 to 725 in 2005 indicating 81.51 percent of increase in landslide incidence area. The number of landslide occured during 1995 and 2005 were analyzed with reference to mapped terrain parameters to throw light on their genetic distribution in space and time.(page no 7)[14]

Landslide hazard zonation in southern Mizoram was carried out with the aid of geocoded IRS imageries and toposheet (GIS, North Eastern Region,1999).the work resulted in delineation of the entire region into low hazard zone(30%),medium hazard zone was also identified where detailed information regarding geology, tectonics, engineering properties of slope material and land use pattern would be incorporated for evaluation of specific locations .Landslide hazard zonation has been attempted using GIS techniques by manipulation and interrelating geomorphic, geologic and meteorological variants of Lawngtlai area, Which is a known landslide prone area of Mizoram. This methodology involves preparation of different thematic maps, viz. slide incidence map, equal landslide area map, slope, map, drainage map and then merging of two or three themes to generate composite maps.(page no 8)[14]

Study also includes that he approach of GIS based modelling can give good results in the analysis of field-oriental data. The validation results showed satisfactory agreement between the susceptibility map and the existing data on landslide locations. As a result, the success rate of the model (76.2%) shows high accuracy in prediction. Landslide susceptibility index map of study area has been classified into basis of distribution of landslide inventory of the area..It shows the validity of the system adopted to divide the landslide susceptibility index map. Moreover, planning of any project at a local level requirs large scale and more accurate landslide susceptibility mapping. Landslide susceptibility mapping at a small catchment scale covers a lot of information that is necessary for micro level planning. On the basis of landslides susceptibility, use of land for different purpose may also be decided.(page no 11,12) [14]

Monitoring, forecasting and warning of landslides are the essential feature for saving the lives and assets from devastation. There are three fundamental ways for monitoring the landslide viz, visual, surveying, and instrumentation. Each monitoring technique has its own advantages, disadvantages and application range. Ground based visual inspection and sampling of these on regular basis may be one of the effective ways of monitoring the landslides. Surveying includes all type of physical measurements. Surveying equipments such as levels, theodolites, electronic distance measurement (EDM), and total station provide some of the prominent landslide features. However, aerial or terrestrial photogrammetric provides contour maps and cross section of landslides. The compilation of the photogrammetric data enables a quantitative analysis of change in slope morphology and determination of the movement vectors. Instrumentation may include installing equipment for periodic reading of the different monitoring sensors such as inclimeter, strain gauge, rain gauge, clinometers, extensometer, pore pressure sensors etc. The monitoring techniques also can be divided into two groups: geodetic technique, and ii0 non-geodetic technique. Geodetic technique give global information on the behaviour of the deformable landslide while the non-geodetic technique give localized and locally disturbed information without any check unless compared with some other independent measurements. A landslide detection system with the use of a wireless sensor network can detect the slight movements of soil or slope instability due to the several reasons such as dielectric moisture, pore pressure etc. that may occur during a landslide.(page no1)[15]

The wireless sensor network in the laboratory trial follows a two-layer hierarchy lower layer wireless sensor nodes which and collect the heterogeneous data from the sensor and the data packets are transmitted to the upper layer the upper layer collects the data and forwards it to the sink nodes or base radio. The IRIS motes can be programmed as nodes as well as base radio. Experiments with micro-electro mechanical system (MEMS) based Inclinometer .MEMS inclinometer can measure incline and decline positive and negative slopes, respectively. [15]

Landslide causes significant changes in the Earth’s natural environment. It is relatively local event; therefore, non-geodetic monitoring technique might help more significantly.WSN is also emerging, reliable and inexpensive technology and is capable of presenting the real time monitoring over a long distance and inhospitable terrains. A multi functional

IRIS mote interfaced to wireless module has been used to sample the heterogonous data with digital sensors in the present paper. Analyzing the data produced by the system, one can monitor the landslide movement, acceleration and subsequently remedial measure can be taken.(page no 2)[15]

Traditionally landslide mapping has relied on visual interpretation of aerial photographs and intensive field surveys. However, for mapping of large areas, those methods are time consuming; creating a gap that remote sensing has been increasingly filling. Due to restrictions in spatial resolution. Traditional optical satellite imagery such as acquired by the Landsat Thematic Mapper (TM),has limited utility for landslide studies. More recently, high-resolution images and Light Detection and Ranging (LiDAR)elevation derivatives have started to offer an alternative way for elective landslide mapping. Most research works, however, have been focusing on pixel-based analysis. For example, Boghuis employed unsupervised image classification in automated landslide mapping using satellite pour observation de la Terre 5 (SPOT-5) imagery. McKean and Roaring also successfully delineated landslide features using measures of surface roughness from LiDAR digital terrain model (DTM).With increasing spatial resolution, however, pixel-based methods have fundamental limitations in addressing particular landslide characteristics allow landslides to be further assigned to different type classes and other features of similar appearance to be discarded. Such method focusing on features instead of pixel are the basis of object-oriented analysis(OOA). [19

OOA, which is based on image segmentation and subsequent classification of derived image primitives, represents a more advantageous approach for analyzing high-resolution data because image pixels can be meaningfully grouped into networked homogeneous objects and noise consequently reduced. Moreover, OOA offers a potentially automated approach for landslide mapping, with a consideration of spectral, morphological and contextual landslide features supported by expert knowledge.(page no 1)[19

Image segmentation with scale optimization -

Image segmentation defines the building blocks for object-oriented image analysis and to ease further analysis, should aim at meaningful delineation of targeted real-world objects. However, considering the complex characteristics of landslides, including land cover variance, illumination difference, diversity of spectral behaviour and size variability it is difficult to delineate each individual landslide as a single object .Notwithstanding this difficulty, over and under segmentation can be reduced by means of a multi scale optimization approach. The multi resolution segmentation based on fractal net evolution approach (FNEA) implemented in Defines Cognition was employed for the initial segmentation, parameterized according to the specific need of event-based rapid mapping of landslides and incorporated in a multiscale optimization routine. FNEA requires the user to define weights for input layers (bands) as well as a scale parameter that defines the maximum allowed heterogeneity within individual segments. Catastrophic slope failures typically remove the vegetation and result in high ratios between the red and NIR bands. These bands are also the least affected by atmospheric effects and were assigned equal weights.(page no 3)[15]

While developing the prototype, some important statements declared by Dr. Manish that, “How to deploy WSNs,” Although having much theory written still currently lacks of practical guide,. WSN has enabled a more convenient early warning system and secondly, WSN provides a system able to learn about natural phenomena of natural disasters.[121]

Each landslide behaves differently; Factors playing strong role in landslide occurrence include slope subsurface factors such as, The type of soil and its properties, soil layer structure, the depth of soil to bedrock, the presence of quartz or other mineral veins, and the depth of water table, among other and slope surface factors such as the type of foliage and vegetations, the topographical geography, human alterations to the landscape and the amount, intensity and duration of rainfall.[121]

Many factors contribute to the instability of slopes, but the main controlling factor are the nature of soil and underlying bedrock, the configuration of slope, the geometry of slope, the ground water conditions.[121]

In India, The main landslide triggers are intense rainfall and earthquakes. Landslide can also be triggered by gradual process such as weathering, or by external mechanism such as,

1. Undercutting of slope by stream erosion, wave action, galciars, or human activity such as road-buildings
2. Intense or prolong rainfall, rapid snowmelt, or sharp fluctuations in ground water levels
3. Shocks or vibrations caused by earthquake or construction activity

4. Loading on upper slopes
5. A combination of all these

Fig.02 Field Deployment of WINSOC Node With MiniatureAntenna

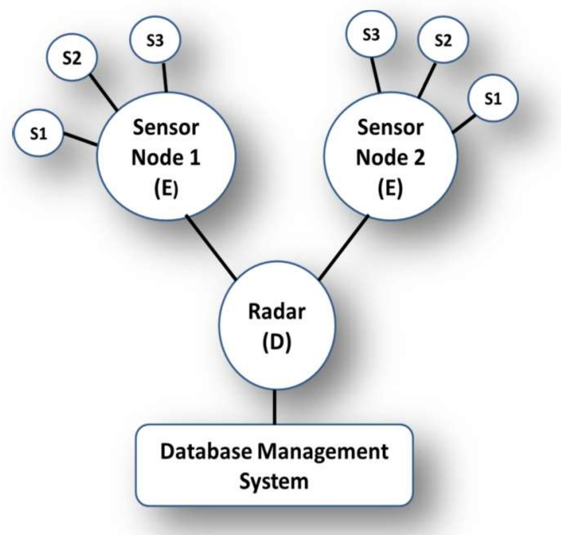
EXISTING SYSTEMS

1. Rescue 21-: Rescue 21[14] is an advanced maritime computing, command, control, and communications (C4) system designed to manage communications for the United States Coast Guard. Rescue 21 will provide the United States with a 21st-century maritime command, control, and communications (C3) system that encompasses the entire United States. By replacing outdated technology with a fully integrated C3 system, Rescue 21 improves on the NDRS with the following enhancements: interoperability, direction-finding equipment with 2 degrees Root Mean Square of accuracy, enhanced clarity of distress calls, simultaneous channel monitoring, upgraded playback and recording feature for distress calls, reduced coverage gaps, and supporting Digital Selective Calling (DSC).

2. AMVER[15] or **Automated Mutual-Assistance Vessel Rescue System-: AMVER** is a worldwide voluntary reporting system sponsored by the United States Coast Guard. It is a computer-based global ship reporting system used worldwide by search and rescue authorities to arrange for assistance to persons in distress at sea. With AMVER, rescue coordinators can identify participating ships in the area of distress and divert the best-suited ship or ships to respond. Participating in AMVER does not put ships under any additional obligation to assist in search and rescue efforts, beyond that which is required under international law.[15]

3. Global Maritime Distress and Safety System (**GMDSS**)[15]-: **GMDSS** is an internationally agreed-upon set of safety procedures, types of equipment, and communication protocols used to increase safety and make it easier to rescue distressed ships, boats and aircraft. GMDSS consists of several systems, some of which are new, but many of which have been in operation for many years. The system is intended to perform the following functions: alerting (including position determination of the unit in distress), search and rescue coordination, locating (homing), maritime safety information broadcasts, general communications, and bridge-to-bridge communications. Specific radio carriage requirements depend upon the ship's area of operation, rather than its tonnage. The system also provides redundant means of distress alerting, and emergency sources of power. Recreational vessels do not need to comply with GMDSS radio carriage requirements, but will increasingly use the Digital Selective Calling (DSC) VHF radios. Offshore vessels may elect to equip themselves further. Vessels under 300 Gross tonnages (GT) are not subject to GMDSS requirements. The Medical Priority Dispatch System (MPDS) is a way of categorizing and prioritizing EMS incidents. The MPDS assigns a number-letter-number format code to each type of incident. The first number (one of the numbers 1 through 32) indicates the category of the incident (e.g., breathing problem). The letter (one of the letters A through E) indicates the priority of the incident. Letter "A" indicates the lowest priority incident and "E" indicates the highest priority incident, however not all letters are used within each category. The second number indicates the subcategory of the incident. The MPDS codes are also commonly referred to as "Clawson Codes" because the MPDS categorization system was originally designed by Dr. Jeff J. Clawson.

SYSTEM OVERVIEW



Early warning system can reduce the maximum losses of landslide hazard. It may possible using Remote Sensing Technology.

The potential measure of early warning system includes,

A. Land owner education on natural warning sign and self evacuation

B. Low level early warning systems: Which includes visual observation by resident in risk areas?

C. Active monitoring of rainfall and land slope changes using instruments.

D. Forwarding necessary information to residents in risk areas.

E. Deployment of mobile radar to monitor areas of concern during major event.

High level event system consists, sensors connected to alarm places in all areas with a high risk of potential landslide.[13]

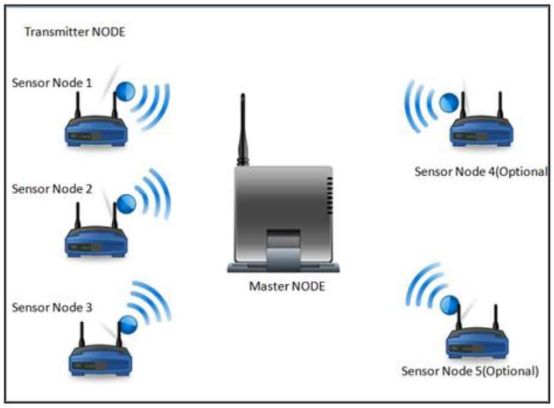


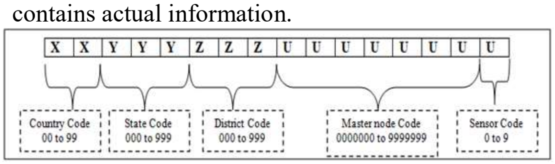
Fig. 2 Stat Topology of sensor network

The System is the combination of Hardware contains Sensor Node, Master Node & Receiver Node and Software for data base management for current event analysis. For the Microsoft Windows XP, Windows 7 or Windows 8 Operating system, Visual Basics 6 platform is used to development of Database management system.

DATA FRAME

WLASN Protocol was developed for local level data interchange purpose between two systems, And Also developed for communication between Master Node & Local Rescue Service Providers, like POLICE, AMBULANCE, and FIRE BRIGADE.

Characteristics of Data Frame chosen in such way that data frame contains unique information regarding Source of the data & the pattern of the data contains actual information.



EXPERIMENTAL ANALYSIS

As per the industrial as well as residential area protection, the model of Rescue caller was designed for standard working as follows, but, this model was designed only for demonstration.

For actual consumer product, lots of redevelopment and adjustment was required so, I have remodified this project as below,

After Initialization, when any sensor detects the problem, then it rapidly indicates the data and sent to master node.

Master node suddenly raises the alarm and sends SMS contains IMNIN and sensor code to Receiver Node installed at POLICE, FIRE BRIGADE & HOSPITAL immediately.

Receiver node suddenly switches on the alarm and Send Serial Data to via RS 232(JTAG Protocol) while receiving the SMS come from Master node.

As shown follows, the database management system developed in VB 6 suddenly indicates the information of respective customer like country, state, city, name of customer, emergency contact number, address from which accident is detected,

Windows OS based analysis System

Window OS based VKz GeoInfoSys version1.0.0.4 has been developed for live updates of natural disasters worldwide.

Fig.3 Dashborad of VKzGeoInfoSys Software

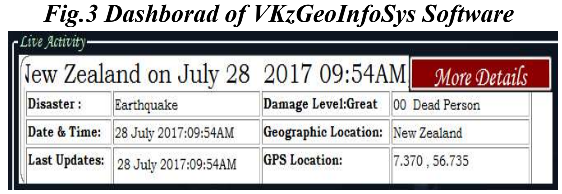


Fig.5 Live Natural Disaster alerts

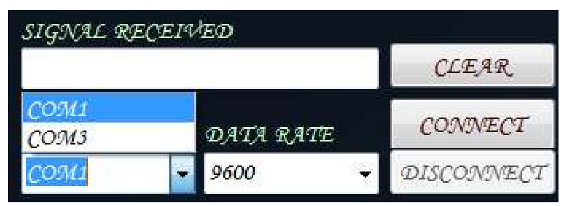


Fig.5 External Hardware connection for live streaming

Fig. 6 Event Details after getting confirmations

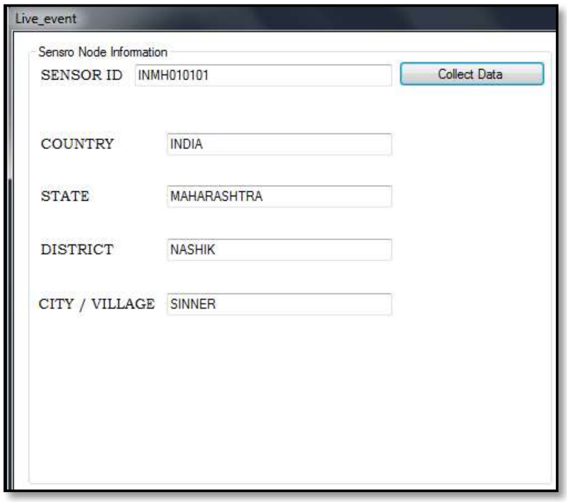


Fig.7 Event Locations

Fig. 8 Event Graphical Map Location

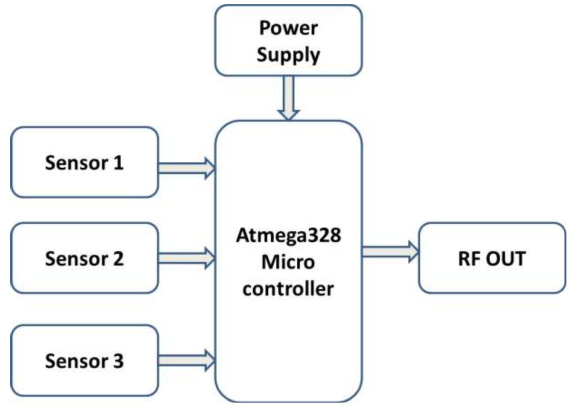
OUTCOMES OF RESEARCH

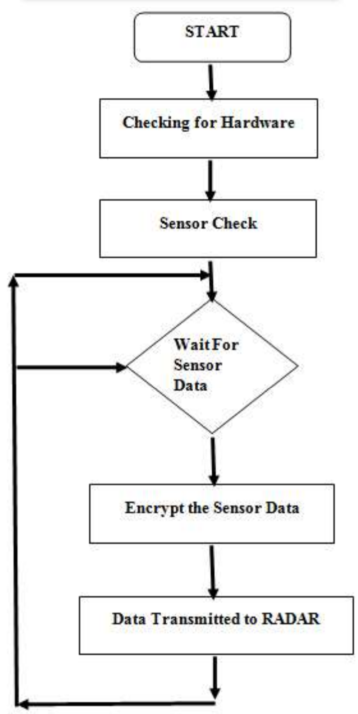
Authorised government body can analyse the current status of geographical areas include temperature, soil moisture, tilt condition and all other relative information with each and every moment so that, If any suspicious activity triggered by sensor the, instant messages can be transferred to Authorised government body and nearby people.

IMPLEMENTED SYSTEMS

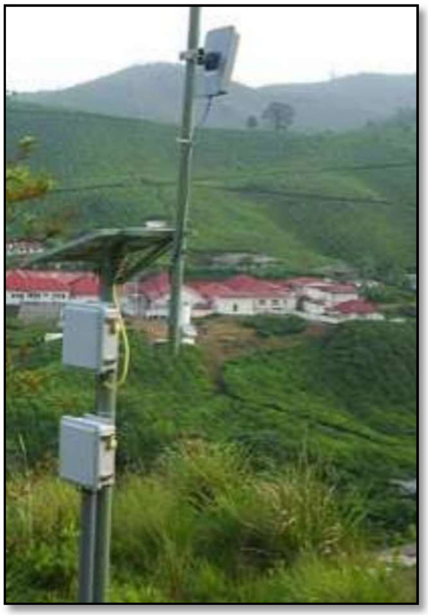
Sensor Node:

A sensor node, also known as a mote, is a node in a Sensor network that is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network.





Sensor Flowchart



Encryption Process:

Serially data collected from the no of sensors which is connected to the sensor node.

Microcontroller will collect all the data and store it into the temporary register.

Then address verification is done from which location data is collected. And also in that location which sensor node gives that data is identified. After that data is isolated which activity is done in that location. That data is need to transmit securely that's why key is applied to that data. Normal data is converted into the symbolic form because of Unauthorized person cannot collect that data. By applying key again process on that data store it in temporary register and transmitted to the radar.

Radar:

A radar system consists of a transmitter producing electromagnetic waves in the radio or microwaves domain, a transmitting antenna, a receiving antenna and a receiver and processor to determine properties of the object(s). Radio waves from the transmitter reflect off the object and return to the receiver, giving information about the data. Encryption data is get at radar.

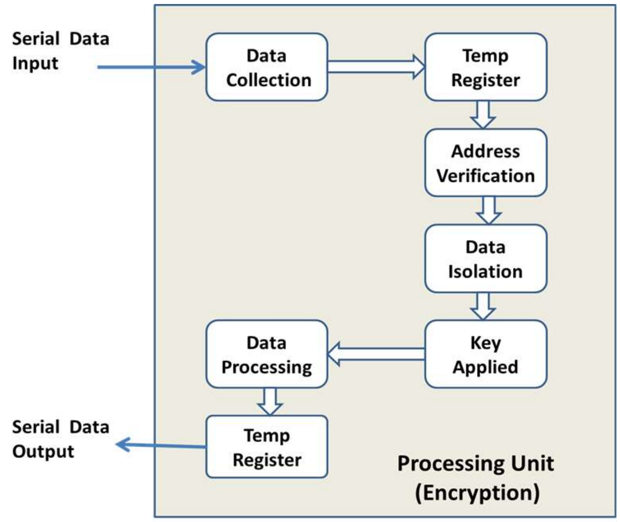


Fig3.1.1b. Encryption Process

At receiver side decrypted that data and get original information. And send it to master computer or node.

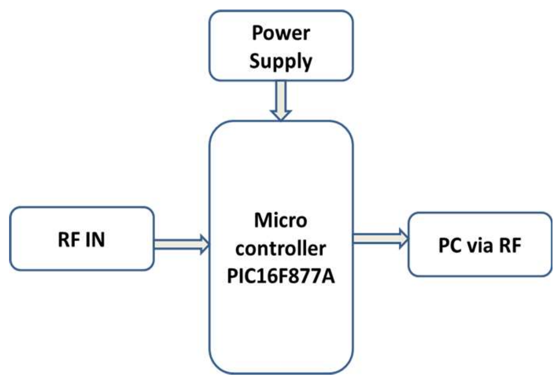


Fig 3.1.1c. Receiver Section

1) **RF IN**: Encrypted data transmitted by the sensor node is recives at receiver side by using radio frequency.
2) **Microcontroller**: At receiver side we have also used a microcontroller PIC16F877A. Microcontroller continuously monitors the RF in signal. If RF gives any information or signal then controller process on that data or signal that is decryption process. That decrypted data is send to the master node by using the wireless protocol that is Bluetooth.

At receiver side Decryption process is done which is explaining below.

Decryption Process:

Serially data collected from the RF in. Radar will detect the data. Microcontroller will collect all the data and store it into the temporary register. Process on that data. Collected data is in the symbolic form that's why again applied a key to that data to get it into the original form. After that data is isolated which activity is done in that location. Then address verification is done from which location data is collected. And also in that location which sensor node gives that data is identified. That data store it in temporary register and collect all the data. And it send to the master node or computer.

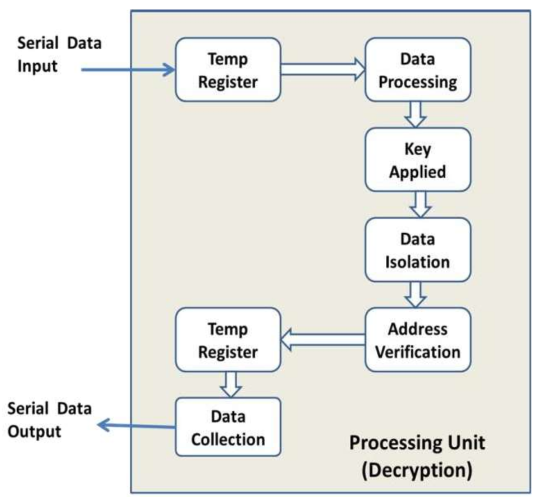


Fig 3.1.1d. Decryption Process

3) Power Supply: It is used to supply the power to the entire system. We use 5V battery supply.

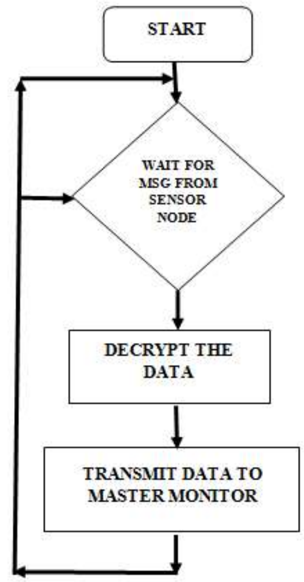
4)PC via RF: All the information is stored at the master node or computer. For communication between radar and the master computer we again use a radio frequency or a Bluetooth protocol.

Features of Radar System

1) Power consumption: 12watt/hour

2) Encryption: Standard ceaser chipper encryption to encrypt the original data for secure communication.

3) Communication range can be increase or decrease by changing RF prototypes.



Radar System Flowchart

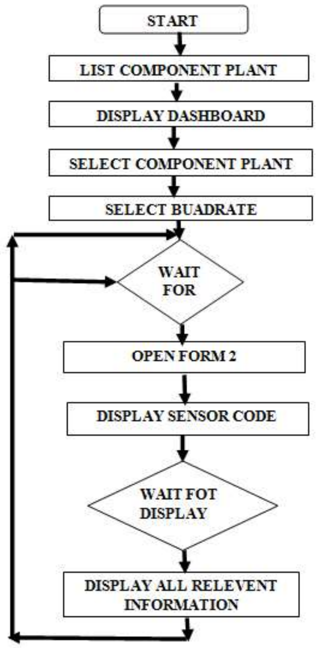
4) Pre-alert of earthquake, landslide and other natural disaster can monitor and analyze by system itself.

5) Live broadcasting and alerting possible by using standard receiver system.

6) Data rate: standard 9600 can be increases up to 1Gbps

7) Number of dada enter communication or cross connection due to TDMA protocol.

8) Can be work on 24/7 hours so any time data can be receive and modify.



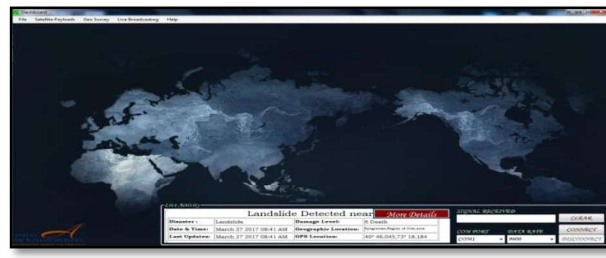
VKz GeoInfoSys Flowchart

8.1 RESULT

VKz GeoInfoSys Launch board

VKz GeoInfoSys Dashboard

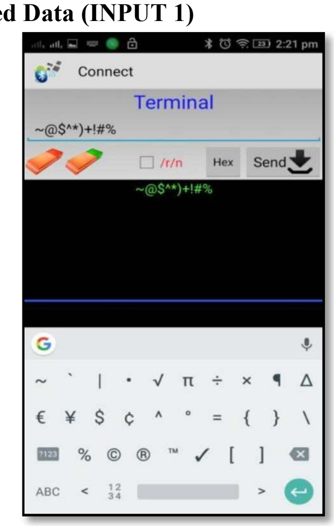
VKz GeoInfoSys RADAR Configuration



VKz GeoInfoSys Live updates

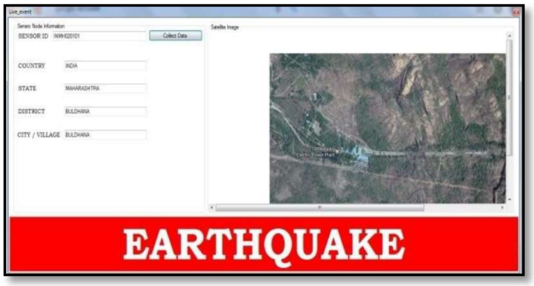
VKz GeoInfoSys satellite Live data

Encrypted Data (INPUT 1)



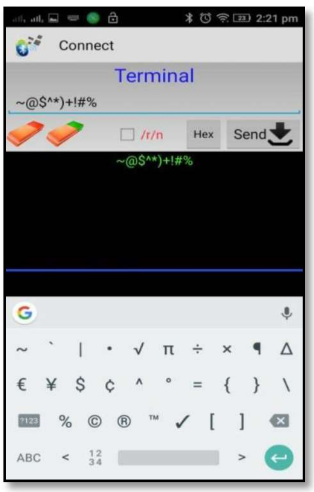
Encryption Process(Case 1)

Dcrytpted Data (OUTPUT 1)



VKz GeoInfoSys Detail information about disaster (Earthquake)

ENCRYPTED Data (INPUT 2)

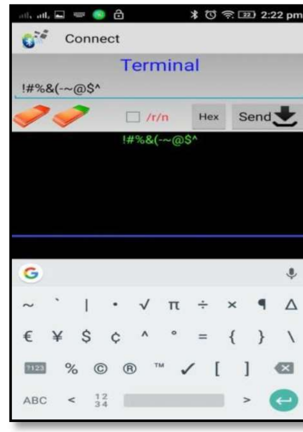


Encryption Process(Case 2)

Dcrypted Data (OUTPUT 2)

VKz GeoInfoSys Detail information about disaster (Landslide)

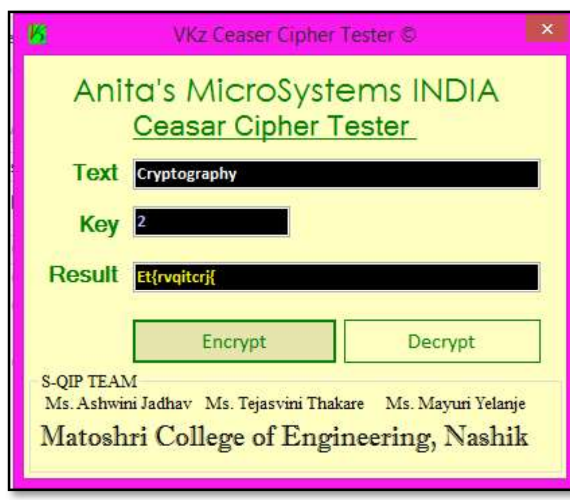
Encrypted Data (INPUT 3)



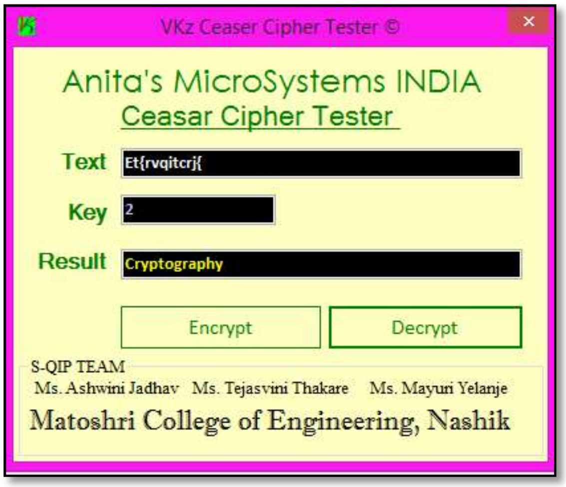
Encryption Process(Case 3)

Decrypted Data (OUTPUT 3)

VKz GeoInfoSys Detail information about disaster (Ordinary alert message)



Special Software developed for Encryption validation



Special Software developed for Decryption validation

Lots of garbage data can be interface due to digitization of data communication to secure the important data from hackers or to protect leakage of information transmitted. System required encrypted data to that hackers cannot analyze the data even often reception of secure encrypted data.To enhance the security in wireless sensor network ceaser cipher(symbolic) in the best method for cryptography. Due to simplest method of encryption and decryption simple encryption key can unlock the encrypted data and original data can be get.

REFERENCES

[1] Hu yang and Fuzhong Weng,"*Correction for On-Orbit ATMS Lunar Contamination*",IEEE Transaction on Geoscience and Remote Sensing,Vol:54, No.4, April 2016

[2] Michael Spencer and Fawwaz Ulaby,"*Spectrum Issues Faced by Active Remorte Sensing"*,IEEE Geoscience and Remort Sensing Magazine,0274-6638/16@2016IEEE

[3] Guo Huadong,"*Remote Sensing in China :Techniques and Application* ", Institute of Remorte Sensing Applications chineseAcadamy of Sciences Beijing 100101, 0-7803-3836-7/97/1997 IEEE

[4] Qin-HuoLiu and Xiaowen Li and Liang-Fu Chen,"*Field Campaing For Quantitative RemoteSensing in Beijing",* a) LARSIS,institute of remote sensing application ,chinese Acadmy of Sciences ,Beijing 100101,beijing b)REsearch Center forRemote Sensing and GIS,Beijing Normal University,Beijing 100875,China. c)Center for Remote Sensing Boston University ,Boston,MA 02215,USA , 0-7803-7536-X 2002IEEE

[5] Zhang Qijuan and Zhang Renhua , "*Combination Between Remote Sensing and Ecosystem Observation Network in China* ", a) HeadQuarters on remote sensing of chinese academy of sciences b)Institute of Geography ,chinese academy of sciences , 0-7803-3836-7/97 1997 IEEE

[6] Penny Masuoka,Richard Andre,Don Roberts,Gary Gackstetter,Pote Aimpun,Shilpa Hakre,Judi Chamberlin, "*A Remote Sensing And GIS Course For Student In Public Health*", Department Of Preventive Medicine And Biometrics,Uniformed Services University Of the Health Sciences,NASA's Goddard Space Flight Center,Greenbelt,Maryland 20771(301)614-6524. 0-7803-6359-0/00/2000 IEEE

[7] Qulin Tan,JiaoJiao Gao,Xiaofang Li., "*APPLICATION OF SAR VREMOTE SENSING DATA TO LITHOLOGICAL MAPPING:A CASE STUDY IN RAILWAY GEOLOGICAL SURVEY"*, Photogrammetric &Remote Sensing,School Of Civil Engineering,Beijing Jiaotong Univercity,Beijing,100044,China.978-1-4244-395-7/09/2009 IEEE

[8] Beibei Wang,Kun Yang,Lei Yuan,Yanhui Zhu., "*Construction of multi-Source Remote Sensing Data Geodatabase Based on Urban Establishment up at Mountains*", 1.Yunnan Normal University,School of tourism and Geography Science,Cartograpy and Geographic information system,Kunming China 2.Yunnan Normal University,information of Yunnan Normal University School,Kunming China 3. GIS Technology Research Center of Resource and Environment in Western China of Ministry of Education,Kunming China

[9] Haizhen Zhang,Jian Jiao,Junxiao Hu,Dapeng Yan,Xin Li,Sheng Gao,Qiming Zeng, "*DESIGN OF ONE-STOP AND ON-DEMAND REMOTE SENSING INTEGRATED SERVICES PLATFORM"*, Institute of RS and GIS Peking University ,Beijing,100871,China, 978-1-4799-5775-0/14/2014 IEEE

[10] "*Impacts of Mobile Radar and Telecommunication System on Earth Remote Sensing in the 22-27GHz Range* ", 1.NOAA Enviromental Technology Laboratory 325 Broadway Boulder CO 80303 2.Department of Atmospheric Oceanic & Space

Sciences and Electrical Engineering and Computer Science University of Michigan 3.Institut fur Hochst frequenz technik und Elektronik(IHE) University of Karlsruhe Impacts of Mobile Radar and Telecommunication System on Earth Remote Sensing in the 22-27GHz Range

[11] Raffaella Guida, "*Introduction of Podcasts in Remote Sensing Education"*, Surrey Space Center, University of Surrey,Guildford,UK, 978-1-4244-9566-5/10/2010 IEEE

[12] Victor Raizer,"*MULTISENSOR DATA FUSION FOR ADVANCED OCEAN REMOTE SENSING STUDIES*", Zel Technologies,LLC,Fairfax,VA 22032,USA, 978-1-4799/1114-1/13/2013 IEEE

[13] Werner Alpers,Heng Wang-Chen and Lim Hock, "*Observation of Internal Waves in the Andaman Sea by ERS SAR* ", 1.Institute of Oceanography,University of Hamburg 2.Center for Remote Imaging,Sensing and Processing Faculty of Science National University of Singapore, 0-7803-3836-7/97/1997 IEEE

[14] Peter Ritter,Hermann Ricken,"*ProSmart German preparatory programme for the industrial utilization of next-generation satallite remote sensing data*", Deutsches Zentrum fur Luft-und Raumfahrt DLR, 0-7803-5207-6/99/1999 IEEE

[15] Jian Kang,Rui Jin,Xin Li, "*Regression Kriging-Based Upscaling of Soil Moisture Measurment from Wireless Sensor Network and Multiresource Remote Sensing Infomation Over Heterogeneous Cropland"* , IEEE GEOSCIENCE AND REMOTE SENCING LETTERS, vol.12,NO.1.JANUARY 2015

[16] Zhu MinHui, "*Research and Development on Synthetic Aperture Radar System in China*", Insitute of Electronics,Chinese Academy of Science, 0-7803-3836-7/97/1997 IEEE

[17] Reginald A.Blake and Janet Liou-Mark , "*RESEARCH EXPERIENCES IN SATELLINTE AND GROUND -BASED REMOTE SENSING :A MODEL FOR PREPARING THE NEXT GENERATION OF REMTE SENSING UNDERGRADUATES*", New york city college of techology ,CUNY, 978-1-4799-7929-5/15/2015IEEE

[18] S.V.K.Shastry,B.N.Mishra,Pramod.V.B,R.Renuka , "*Surface Charge monitor payload of GSAT-2 spacecraft* ", ISRO satellite center

[19] Guoqing Zhou and Daiyong Wei, "*Survey and Analysis of Land satellite remte sensing applied in highway transpotations infrastructure and system engineering* " , 1.Department of civil engineering and technology, old Dominion University 2.Virginia Tech Transportation Institute(VTTI) ,Department of civil and environmental engineering ,Virginia polytechnic institute and state university 3. state key laboratory of remote sensing science ,beijing Normal university , 978-1-4244-2808-3/08/2008 IEEE

[20] muhammad mazhar ullah rathore , anand paul ,awais ahmad ,Bo-Wei chen ,bormin huang and wen ji, "*Real -time Big Data Analytical Architecture for Remote sensing application* ", Vol.8,NO.10,october2015

[21] Qingping chi,Hairong yan,Chuan Zhang,Zhibo pang and li Da Xu , "*A Reconfigurable Smart Sensor Interface for Industrial WSN in IoT Environment* ", Vol.10,No.2,may 2014

[22] Konstiantinos Alexandris ,George Sklivanitis and aggelos Bletsas," *Reachback WSN connectivity :Non -Coherent Zero-Feedback Distributed Beamforming or TDMA Energy Harvesting ?* ", Vol.13,NO.9,september 2014

[23] Filip Barac,Mikael Gidlund,Tingting Zhang ," *Ubiquitous ,Yet Deceptive :Hardware -Based Channel Metrics on Interfered WSN links* ", Vol.64,NO.5,may 2015

[24] Anatoliy Platonov and ievgen Zaitsev, "*New Approach to Improvement and Measurement of the Performance of PHY Layer Link of WSN*", Vol.63,No.11,November2014

[25] Ioannis Glaropouios,Marcello Lagana,Viktoria Fodor and Chiara Petrioli, "*Energy Efficient COGnitive MAC for Sensor Networks under WLAN Co-existence"*

[26] Ruqiang Yan,Hanghang Sun,and Yuning Qian, "*Energy -Aware Sensor Node Design With Its Application in Wireless Sensor Networks*", Vol.62,No.5,May2013

[27] Zaixin Lu,Wei Wayne Li,Miao Pan ," *Maximum lifetime scheduling for target coverage and data collection in wireless sensor networks."*

[28] Kevin Dorling,Geoffrey G. Messier,Stefan Valentin and Sebastian Magierowski., " M*inimizing the Net Present Cost of Deploying and operating Wirwless Sensor Networks*", vol.12,NO.3,SEPTEMBER 2015

[29] Irfan Al-Anbagi,Melike Erol-Kantarci,Hussein T. Mouftah, "*Delay-Aware Medium Access Schemes for WSN-Based Partial Discharge Measurement"*, IEEE TRANSACTION ON INSTRUMENTATION AND MEASURMENT, vol.63,NO.12,DECEMBER 2014

[30] Wei Chen,Ian J. Wassall, "*Cost-Aware Activity*

Scheduling for Compresive Sleeping Wireless Sensor Networks", DOI.10.1109/TSP.2016.2521608 IEEE

[31] Paco Lopez-Dekker ,Marc Rodriguez-Cassola,Francesco De Zan,Gerhard Krieger,Alberto Moreira, "*Correlating Synthetic Aperture Radar (CoSAR)"*, IEEE TRANSACTION ON GEOSCIENCE AND REMOTE SENSING, vol.54,NO.4,April 2016

[32] xiao Xiang Zhu,Sina Montazeri,Christoph Gisinger,Ramon F. Hanssen,Richard Banler, "*Geodetic SAR Tomography*", IEEE TRANSACTION ON GEOSCIENCE AND REMOTE SENSING, vol.54,NO.1,JANUARY 2016

[33] Jianwen Ai,Yong Xue,Yingjie Li,Jie Guang,Ying Wang,Linyan Bai, "*A DYNAMIC GRID WORKFIOW FOR REMOTE SENSING QUANTITATIVE RETRIEVAL SERVICE*", 1.State Key Laboratory of Remote Sensing Sciences,Jointly Sponsored by the Institute Of Remote sensing Application,Chinese Academy of Sciences.2.College Of Resources Environmental Sciences Northeast Agricultural University.3.Department Of Computing,London Metropolitan University.4.Graduate University Of Chinese Academy of Sciences., 978-1-4244-3395-7/07/2009IEEE

[34] Andrea Castagnetti, Alain Pegatoquet,Trong Nhan LE,and Michel Auguin, "*A Joint Duty-Cycle and Transmission Power Management for Energy Harvesting WSN*", DOI 10.1109 / TII.2014.2306327,IEEE

[35] Mustapha Reda Senouci,Abdelhamid Mellouk,and Khalid Assnoune, "*Localized Movement-Assisted Sensor Deployment Algorithm for Hole Detection and Healing*", IEEE Transaction Parallel And Distributed System., Vol.25,No.5 May 2014

[36] Ben Wu,Bhavin J.Shastri,Member,IEEE,Prateek Mital,Member,IEEE,Alexander N.Tait,andPaul R.Prucnal,Fellow,IEEE., " *Optical signal processing and stealth Transmission for privacy"*, Princeton University,department of Electrical Enggineering., DOI 10.1109 /JSTSP.2015.2424690,IEEE

[37] SAMIUL HAYDER CHOUDHURY, MD.NIAZUL ISLAM KHAN, "*A Study Of The Limitation Of Existig Earthquake Disaster Management System In Bangladesh And A Novel Semi-Centralized Tier-Based Earthquake Disaster Management System Proposition*", 1.Department of Electronic System,Aalborg University,Denmark 2.Department of Communication, Technology,University of ULM,Germany

[38] Malcolm E. Baird, " T*he Phases of Emergency Management*", Intermodal Freight Transportation Institute(ITFI) University of Memphis

[39] cees van westen ," *Remote Sensing For Natural Disaster Management* ", International institute for aerospace survey and earth science ,ITC, the netherlands division of applied geomorphological surveys , vol.XXXIII,part B7

[40] luiz A.manfre ,eliane hirata ,janaina B.silva ,Eduardo J.shinohara ,mariana A.Giannotti,ana paulaC. larocca and jose A.quimtanilha, "*An Analysis Of Geospatial Technologies For Risk And Natural Disaster Management"*, polytechnic school of the university of sao paulo. ISSN 2220-9964

[41] Geneva, Switzerland, *"International Federation of Red Cross and Red Crescent Societies*", IFRC. World Disaster Report 20112011

[42] kees van westen and robert soeters,manfred F.buchroithner, "*potential and limitations of satellite remote senseing for geo-disaster reduction* ", 1.international institute for aerspace survey and earth sciences (ITC) enschede,Nl 2. institute for cartoghaphy ,dresden university of technology ,germany., vol.XXXI,part B6

[43] Thomas, D.S.K.; Eturĝay, K.; Kemeç, S.1. .; Rodríguez, H., Quarantelli, E.L., Dynes, R., Eds.; Springer: "*The role of Geographic Information System/Remote Sensing in Disaster Management"*

[44] Maccann, D.G.C.; Cordi, H.P*."Developing International standards for disaster preparedness and response"*, 1. 2011, 3, 48–51.

[45] Fritz, H.M.; Okal, E.A. Socotra Island, Yemen, "*Field survey of the 2004 Indian Ocean tsunami*", 46, 107–117.

[46] Mansourian, A.; Rajabifard, A.; Valadan Zoej, M.J, "*SDI Conceptual Modeling for Disaster Management*". In Proceedings of the ISPRS Workshop on Service and Application of Spatial Data Infrastructure,

[47] Lee, S.; Choi, J. ,"*Landslide susceptibility mapping using GIS and the weight-of-evidence model.*", 18, 789–814.

[48] Gorsevski, P.V.; Jankowski, P., "*Discerning landslide susceptibility using rough sets*."
32, 53–65.

[49] Pradha, B. , "*Remote sensing and GIS-based landslide hazard analysis and cross-validation using multivariate logistic regression model on three test areas in Malaysia*.", 45, 1244–1256.

[50] Chung, C.F.; Fabbri, A.G.; van Westen, C.J. 1st ed.; Carrara, A., Guzzetti, F., Eds.; Kluwer *"Multivariate Regression Analysis for Landslide Hazard Zonation*" . In Geographical Information Systems in Assessing Natural Hazards, pp. 107–142.

[51] Varenica, J.M.; Vucetic, D. ,"*Multi-Temporal Data Integration for Detection of Changes Regarding Landslides in Serbia*.", In Proceedings of Gi4DM Annual Conference, Antalya, Turkey,

[52] Tralli, D.M.; Blom, R.G.; Zlotnicki, V.; Donnellan, A.; Evans, D.L. ," *Satellite remote sensing of earthquake, volcano, flood, landslide and coastal inundation hazards*.", *59, 185–198.*

[53] Stumpf, A.; Kerle, N. , "*Object-oriented mapping of landslides using Random Forests. Remote Sens.*" *115, 2564–2577.*

[54] Nóbrega, R.A.A.; O'hara, C.; Vijayaraj, V.; Olson, G.A.; KIM, S.; Quintanilha, J.A.; Barros, M.T.L., , "*Extracting and Classifying Bare Soil Erosion Risk Areas in an Urban Basin Using Object-Oriented Technologies*" , High Resolution Imagery, and Elevation Data. In Proceedings of 2006 AWRA Spring Specialty Conference: GIS and Water Resources IV

[55] Ming-Chun Tang, Hao Wang, Tianwei Deng "*Compact Planer Ultra-wideband Antennas with Continuously Tunable, Independent Band-Notched Filters*", IEEE Transaction on antenna and propagation, 2016

[56] Consuegra, D.; Joerin, F.; Vitalini, F.; Carrara, A., Guzzetti, F., Eds, "*Flood Delineation and Impact Assessment in Agricultural Land Using GIS Technology.*", In Geographical Information Systems in Assessing Natural Hazards, pp. 177–198.

[57] Kovar, K.; Natchtnebel, H.P. HydroGIS , "*Application of Geographic Information Systems in Hydrology and Water Resources Management",*

[58] 7. Al-Sabhan, W.; Mulligan, M.; Blackburn, G.A. , "*A real-time hydrological model for flood prediction using GIS"*, 27,9-32

[59] Lupo, F.; Reginster, I.; Lambin, E.F., "*Monitoring land cover changes in West Africa with SPOT Vegetation*", 22, 2633–2639.

[60] Sakamoto, T.; Nguyen, N.V.; Kotera, A.; Ohno, H.; Ishitsuka, N.; Yokozawa, M, "*Cambodia and the Vietnamese Mekong Delta from MODIS time-series*.", Remote Sens. Environ 109, 295–313

[61] Yuhaniz, S.S.; Vladimirova, "*An onboard automaticchange detection system for disaster monitoring.*", 30, 6121–6139

[62] Wikantika, K.; Sinaga, A.; Hadi, F.; Darmawan, S., "*Quick assessment on identification of damaged building and land-use changes in the post-tsunami disaster with a quick-look image of IKONOS and Quickbird*", *28, 3037–3044.*

[63] Yang, M.D.; Su, T.C.; Hsu, C.H.; Chang, K.C.; Wu,. , "*A.M. Mapping of the 26 December 2004 tsunami disaster by using FORMOSAT-2 images", 28, 3071–3091*

[64] Belward, A.S.; Stibig, H.-J.; Eva, H.; Rembold, F.; Bucha, T.; Hartley, A.; Beuchle, R.; Khudhairy, D.; Michielon, M.; Mollicone, D.. , "*Mapping severe damage to land cover following the 2004 Indian Ocean tsunami using moderate spatial resolution satellite imagery*", 28, 2977–2994

[65] Butenuth, M.; Frey, D.; Nielsen, A.A.; Skriver, H. , "*Infrastructure assessment for disaster management using multi-sensor and multi-temporal remote sensing imagery*." *,32, 8575–8594*

[66] Di, B.; Zeng, H.; Zhang, M.; Ustin, S.L.; Tang, Y.; Wang, Z.; Chen, N.; Zhang, B.: , "*Quantifying the spatial distribution of soil mass wasting processes after the 2008 earthquake in Wenchuan, China",* 114, 761–771

[67] Wu, F.; Yu, B.; Yan, M.; Wang, Z. , "*Eco-environmental research on the Wenchuan Earthquake area using Disaster Monitoring Constellation (DMC) Beijing-1 small satellite images.*", *31, 3643–3660*

[68] Kohiyama, H.; Hayashi, N.; Maki, M.; Higashida, H.; Kroehl, W.; Elvidge, C.D.; Hobson, V.R. , "*Early damaged area estimation system using DMSP-OLS night-time imagery*.", 25, 2015–2036.

[69] Watanabe, M.; Yonezawa, C.; Iisaka, J.; Sato, M , "*ALOS/PALSAR full polarimetric observations of the Iwate–Miyagi Nairiku earthquake of 2008.", 33, 1234–1245*

[70] Kwan, M.-P.; Ransberger, D.M, "*Detection of transport network obstructions caused by major disasters.*", *34, 179–188*

[71] Chrysoulakis, N.; Herlin, I.; Prastacos, P.; Yahia, H.; Grazzini, J.; Cartalis, J.C., "*An improved algorithm for the detection of plumes caused by*

natural or technological hazards using AVHRR imagery." ,108, 393–406.

[72] Gitas, I.Z.; Polychronaki, A.; Katagis, T.; Mallinis, G., "*Contribution of remote sensing to disaster management activities: A case study of the large fires in the Peloponnese, Greece*.", 29, 4885–4885

[73] Veraverbeke, S.; Hook, S.; Hulley, G., "*An alternative spectral index for rapid fire severity assessments." ,123, 72–80*

[74] Hastaoglu, K.O.; Sanli, D.U., "*Monitoring Koyulhisar landslide using rapid static GPS: A strategy to remove biases from vertical velocities*.", 58, 1275–1294.

[75] binti Tuan Sarif, S.S.; Shintarou, T.; Takayama, S. , "*GPS Implementation in Sensing Node Network System for Landslide Disaster."*

[76] Calterra, S.; Cesi, C.; Maio, C.; Gambino, P.; Merli, K.; Vallario, M.; Vassalo, R., "*Surface displacements of two landslides evaluatedby GPS and inclinometer systems*", 61, 257–266

[77] Yang, M.; Rau, R.-J.; Yu, J.-Y.; Yu, T.-T, "*Geodetically observed surface displacements of the 1999 Chi-Chi, Taiwan, Earthquake.", 52, 403–413*

[78] Diaz-Delgado, R.; Pons, X., *"Spatial patterns of forest fires in Catalonia (NE of Spain) along the period 1975–1995: Analysis of vegetation recovery after fire. For. Ecol. Manage*.", *147, 67–74*

[79] Giardino, M.; Perotti, L.; Lanfranco, M.; Perrone, G, "*GIS and geomatics for natural disaster management and emergency relief: A proactive response to natural hazards*." , Appl. Geomatics, *4, 33–46.*

[80] Barbieri, W.D.; Ferreira, C.C.; Saito, M.S.; Saussen, M.T., "*Desastres Naturais e as Anomalias de Precipitação para a Região Sul do Brasil."*

[81] Marcelino, E.V.; Goerl, R.F.M., "*Distribuição Espaço-Temporal de Inundações Bruscas em Santa Catarina (Período 1980–2003).",* In Proceedings of Simpósio Brasileiro de Desastres Naturais, Florianópolis, Brazil, pp. 554–564

[82] Hardy, D.; Frew, J.; Goodchild, M., "*Volunteered geographic information production as a spatial process"* , *26, 1191–1212*

[83] Ostermann, F.O.; Spinsant, L. A , "*Conceptual Workflow for Automatically Assessing the Quality of Volunteered Geographic Information for Crisis Management*." , In Proceedings of the 14th AGILE International Conference on Geographic Information Science, Utrecht, The Netherlands

[84] Sui, D.S.; Goodchild, M., "*The convergence of GIS and social media: Challenges for GIScience*." , *25, 1737–1748*

[85] Goodchild, M.F., "*GIS and disasters: Planning for catastrophe." ,* 30, 227–229

[86] Roche, S.; Propeck-Zimmermann, E.; Mericskay, B., "*Issues and perspectives of volunteered geographic information.*" , doi: 10.1007/s10708-011-9423-9.

[87] Goodchild, M.F.; Glennon, J.A., "*Crowdsourcing geographic information for disaster response"*, *3, 231–241*

[88] Sui, D.Z, " *The wikification of GIS and its consequences: Or Angelina Jolie's new tattoo and the future of GIS."* , *32, 1–5.*

[89] Elwood, S.; Goodchild, M., "*Researching volunteered geographic information: Spatial data, geographic research, and new social practice*." , 102, 571–590

[90] Goodchild, M.F, "*Citizens as Voluntary Sensors: Spatial Data Infrastructure in the world of Web"*, *2, 24–32.*

[91] Goodchild, M.F, " *Citizens as Sensors: the world of volunteered geography*.", *69, 211–221*

[92] Rajabifard, A.; Feeney, M.; Williamson, I.P., "*Developing Spatial Data Infrastructure to Facilitate Disaster Management."*, In Proceedings of GEOMATICS'83 Conference

[93] Zhou, Y.; Liu, G.; Fu, E.; Zhang, K.. "*An Object-relational prototype of GIS-based disaster database"*, *1, 1060–1066.*

[94] Ajmar, A.; Perez, F.; Terzo, O., "*WFP spatial data infrastructure (SDI) implementation in support of emergency management.*", 59. 37, 1097–1104.

[95] Agosto, E.; Dalmasso, S.; Pasquali, P, "*Rapid WebGIS Development for Emergency Management.*" , In Proceedings of Gi4DM Annual Conference

[96] Groeve, T.; Stollberg, B.; Vernaccini, L., "*Appropriate Mapping Tools For International Situation Rooms.",* In Proceedings of Gi4DM Annual Conference

[97] Molina, M.; Bayarri, S.A., "*multinational SDI-based system to facilitate disaster risk management in the Andean Community.",* 59. 37, 1501–1510

[98] Snoeren, G.; Zlatanova, S; Crompvoets, J.; Scholten, H, "*Spatial Data Infrastructure for Emergency Management: The View of the Users*.", Presented at the Third International Symposium on Gi4DM, Toronto

[99] Wang, Y.; Gong, J.; Wu, X., *"Geospatial semantic*

interoperability based on ontology."

[100] Masaaki Shikada,Yoshihiko Suzuki,Takashi Kusaka,Shintaro Goto, "*An application of GIS information and Remote sensed data for Extraction of landslide",* IEEE, 0-7803-3836

[101] Friis-Christiansen, A.; Ostländer, N.; Lutz, M.; Nernard, L., "*Designing service architectures for distributed geoprocessing: Challenges and future directions*.", 11, 719–818

[102] Neuvel, J.M.M; Scholten, H.J; Brink, A, "*From spatial data to synchronised actions: The network-centric organisation of spatial decision support for risk and emergency management",* 5, 51–72

[103] Bharosa, N.; van Zanten, B.; Janssen, M.; Groenleer, M, "*Transforming crises management: Field studies on the efforts to migrate from system-centric to network-centric operations*.", 5693, 65–75

[104] Craglia, M.; Annoni, A., "*INSPIRE: An Innovative Approach to the Development of Spatial Data Infrastructures in Europe. In Research and Theory in Advancing Spatial Data Infrastructure Concept*s", pp. 93–105

[105] Craglia, M.; Goodchild, M.; Annoni, A.; Câmara, G.; Gould, M.; Kuhn, W.; Mark, D.; Masser, I.; Maguire, D.; Liang, S.; Parsons, E, "*Next-generation digital earth*.", 3, 146–167.

[106] Rajabifard, A.; Williamson, I.P.; Holland, P.; Johnstone, G., "*From Local to Global SDI Initiatives: A Pyramid Building Blocks."*, In Proceedings of the 4th GSDI Conference

[107] Rajabifard, A.; Williamson, I.P., "*Anticipating the Cultural Aspects of Sharing for SDI Development."*

[108] Li, J.; Chapma, M.A. Zlatanova, S., Li, J., Eds, "*Terrestrial Mobile Mapping towards Real-Time Geospatial Data Collection."*, In Geospatial Information Technology for Emergency Response; pp. 103–119

[109] Zhang, Y.; Kerle, N. Zlatanova, S., Li, J., "*Satellite Remote Sensing for Near-Real Time Data Collection.",* In Geospatial Information Technology for Emergency Response; pp. 75–102.

[110] Kerle, N.; Heuel, S.; Pfeife, N.;, "*Real-Time Data Collection and Information Generation Using Airborne Sensors.",* In Geospatial Information Technology for Emergency Responsepp. 43–74.

[111] Silva, X.J.; Marino, B.T., "*A geografia no apoio à decisão em situações de emergência*.", 1–14.

[112] Mustafa Neammah Jeur,Biswajeet Pradhan And Mahyat Shafapour Tehrany, "*Manifestation Of Lidar-Derived Parameters In The Spatial Prediction Of Landslides Using Novel Ensemble Evidential Belief Functions And Support Vector Machine Modelsin Gis*", IEEE, 1939-1404

[113] Ruiqing niuXeling wu, Dengkui yan, Ling peng Ai and junhuan peng, "*Susceptibility assessment of landslides triggered by the lushan earthquake,April 20,2013,china*", IEEE, 1939-1404

[114] R.marschallinger,F.Zobl, "*Development of simulation-supported long range B-vlos RPAS mission planning for remote sensing alpine disaster operations management*", IEEE, 978-1-4799-5001

[115] Thomas blasche, Bakhtiar feizizasdeh and Daniel holbling, "*Object base image analysis and digital terrain analysis for locating landslide in the urmaia lake basin,Iran*", IEEE, 1939-1404

[116] Lee,s.Ryu,j.Min,k.won,j, "*lopment and apllication of landslde susceptibility analysis techniques using geographic information system."*, IEEE, 0-7803-6359

[117] Ramji Dwivedi,prabal varshney,Ashutosh Tiwari,Avadh bihari narayan,Onkar Dikshit, "*Monitoring of landslides in Nainital,Uttarakhand,India:validation of PS-InSAR results*", IEEE, 978-1-4799-6652

[118] Ting Li,Yuan Tian,Chenchao Xiao,Wengyi Zhao, "*Slope location-based landslide vulnerability assessment",*

[119] PVSP prasada Raju and J. saibaba., "*Landslide hazard zonation using remote sensing and geographic information system techniques-A case study of pithoragarh Area,U.P*", IEEE, 0-7803-5207

[120] gao ke chang, CUI peng,Li yung, "*GIS-based assessment of landslide hazards of Wanahou in Three Gorges region*", IEEE, 0-7803-9050

[121] D.Maneesha Vinodini Ramesh, "*wireless sensor network for disaster monitoring"*

[122] Kavitha Muthu and Maria Petrou, " *Landslide hazard mapping using an Expert system and a GIS"*,IEEE, 0196-2892

[123] Mubushar Hussain,Mudassa hassan arsalan,Kashif siddiq,Bushra naseem,Uzma Rabab, "*Emerging Geo-Information Technologies for natural disaster management in pakistan:an overview*", IEEE, 0-7803-8977

[124] Kwang-Hoon Chi,No-wook park,Kiwon lee, "*Identification of landslide area using remote sensing data and Quantitative assessment of landslide hazard*.", IEEE, 0-7803-7536

[125] S.lee,J.choi,U.Chwae and B.chang, "*Landslide*

susceptibility analysis using Weight of evidence", IEEE, 0-7803-7536

[126] Cao hongyang,Yang Renshu,Shan Xinjian ,Guo weiying, "*An application research on the landslide interpretation based on the technology of remote sensing three dimention visualization"*, IEEE, 0-7803-8742

[127] Li Jiahong,LI Jing,Chen Yunhao, "*Monitoring and Evaluating pali river landlside in Tibet based on RS and GIS"*, IEEE, 0-7803-9050

[128] V.Naydenova,E.Roumenian,Gmkanev,L.Filchev,K .Stefanov, "*Investigating the stream network changes and landslide processes in Open coal minning areas using remote sensing methods*", IEEE, 1-4244-1057

[129] G.venkatachalam,M.S.Nagesha and G.R. Dodagoudar, "*Landlside modelling using remote sensing and GIS"*, IEEE, 0-7803-7536