1.1 GENERAL

One of the major challenges of the 21st century is the phenomenal population explosion, the induced competitive and massive exploitation of all the available natural resources and the triggered endanger to the ecosystem of the planet earth and the cumulative challenge to the maintenance and sustainable development of a region. However these challenges are to be met with and in which the science of Geology has an unparallel role to play.

It is because, the geological events that happened in the past and the geologic events that are happening around us today have a direct bearing over the environment more than what we have imagined. So, in the present study deserving importance was given to the tectonic grains of the study area which obviously stand as a testimony for the palaeo, time transgressive and active geological processes. For the said study, geomatics based integrated approach including the aid of modern remote sensing and geophysical studies along with the field based conventional mapping even to the level of microtectonics were used.

In the present contest, it was felt essential to select a suitable study area. Peninsular India has long been considered a seismically stable shield area but, high magnitude and disastrous earthquakes like, the Kutch earthquake (M 7.8) of 1819, the Koyna earthquake (M 6.0) of December 10, 1967, the Broach earthquake (M 5.4) of March 23, 1970, the Latur earthquake (M 6.4) of 1993, the Jabalpur earthquake (M 6.1) of 1997, the Bhuj earthquake (M 7.6) of January 26, 2001 and the Pondicherry earthquake (M 5.5) of September 25, 2001, have changed the long held belief and revised the seismic zonation of part of Peninsular India from moderate to high seismic prone areas according to Bureau of Indian Standards (BIS) 2001.
Keeping this in mind, a regional study was carried out with the help of satellite data. Anomalies from geological, geomorphological, structural – lineament analysis and topographical analysis were corroborated to select a study window bounded by North latitudes 11.25° and 12° and East longitudes 78° and 79°. This study window (Attur valley) covers an area of 9050 sq.km that includes parts of Salem, Namakkal, Dharmapuri, Villupuram, Cuddalore and Perambalur districts of Tamil Nadu state (Fig.1.1).

Having understood the capabilities and the credentials of high resolution satellite based Earth Observation Systems in mapping the earth features and monitoring their dynamics due to spectral, spatial and temporal resolutions credibility and the potentials of Geospatial technology in digital mapping, modelling and visualizing the Earth System Dynamics, LISS- III of IRS-IC and IRS-ID satellite data were used for visual interpretation and preparation of thematic maps in ARCGIS 9.0 platform.

The following research methodology was envisaged with the aim to bring out natural resources and hazard status of Attur valley. Various thematic maps were prepared through remote sensing, geophysical and collateral data and analyzed geomatically to bring out

- Neotectonic and Seismotectonic corridors
- Mineral and water resource potential
- Water quality evaluation
- Landslide vulnerability assessment.

The present study was emphasized to bring out the input of tectonism to the geoenvironmental sustenance and to propose and reinstate the indeclinable role of geology and modern tools of geospatial technology.

Natural resources and the geohazards, which are key components of the geoenvironment, have been an interest and need of mankind throughout history. Exploitation of natural resources occurred locally prior to the
industrial revolution of the 18th century. Since that time, spectacular technological and economic development has led to a large increase in the consumption of renewable and nonrenewable resources. However, the use of natural resources is still non uniformly distributed, and a less than optimal use of the geoenvironment is occurring. A modern approach emphasizing the integrated use of natural resources and the study on geohazards is desirable. A given region/area should be treated as a single multi-component space, like a complex web formed by, and held together with, many threads. This integrated approach is not static but, rather, is a dynamic system which evolves and changes over time. To create such a system, development of new methods of geological research, more effective methods and technologies of natural resources exploitation, understanding of present geoenvironment that is controlled by geodynamic events and sustenance and restoration of geoenvironment is required. The phenomena of geologic processes relating to all the present day synergy of environments and their evaluation will throw light on many interrelated events and conditions on which we are living.

Giving a higher priority to the tectonic framework and reactivated tectonics in the recent past will be a greater justification for the understanding and management of the geoenvironment. An integrated approach starting from regional study with the aid of modern remote sensing and geospatial technology to field based conventional mapping and even to the level of microtectonics will serve the purpose.

The Salem region is a place of hills and mangoes, occupying central part of Tamil Nadu with a chest of minerals and host of many miners. It is one of the best geosystems around the world bridging the low-grade greenstone–granite domain and high-grade granulite facies rocks (Swaminath et al. 1976). In recent years, Ramasamy et al. (1995) have carried out interpretation of satellite images and recorded evidence of possible
Neo-active tectonics in parts of South India, with possible land arching in the Chennai and Ramanathapuram areas.

Obviously, it will be an interesting study to demonstrate the concept of evaluating certain natural resources and natural hazards at the perspective of geodynamic processes operating on the earth over the period.

1.2 PREVIOUS WORK

To get an idea of problem building for the present research, all the available earlier studies were browsed both in India as well as around the world. Special attention was given on how the earlier workers have used lineament anomalies, geomorphic anomalies, geophysical anomalies, etc. towards understanding the recent tectonics of their study area.

1.2.1. International

1.2.1.1 Neotectonics and Seismotectonics

Hobbs (1904) was the first person to coin the word “lineament”. He has studied the lineaments of Atlantic border region and defined such lineaments as rectilinear and curvilinear topographical features and explained that these are the reflections of crustal tectonic features.

Vening Meinze (1947) has interpreted some shear lineaments and attributed them to global stress pattern.

On the basis of the studies carried out in parts of Canadian Shield, Wilson (1948) inferred the lineaments as features associated with epirogenic upliftments.

Kupsh and Wild (1955) have observed that the lineaments of Avonlea area of Saskatchewan as expressions of deep seated faults.

Moody and Hill (1956) have developed a hypothesis of eight directions of wrench faulting and four directions of compressional faulting within a single primary compressive stress of any tectonic regime.

Blanchet (1957) has defined fractures as the generally abundant natural lineation discernible on aerial photographs and explained that these are
mostly related to rhythmic action of earth tides and such earth tides cause fracture systems in a systematic pattern.

**Haman (1961)** has made first time attempt to establish the stress environment responsible for the origin of fold and faults by preparing lineament density and lineament intersection density diagrams.

The fracture systems of the earth were attributed to the extensional deep tectonics by **Badgley (1962)**.

**Gay (1973)** has also similarly propounded that mostly the lineaments are related to vertical tectonic forces rather than horizontal movements.

Late Quaternary fault activities were identified through geologic and geomorphic evidences in Tehran, Iran by **Pedrami (1981)**.

**Marrs and Raines (1984)** have found that the lineaments coincide with facies changes, folds and faults of Powder River basin, Wyoming area and further correlated them with plate tectonics.

**Qiang and Zhang (1984)** have classified the Quaternary faults of Northern China on the basis of rate of displacement and observed a positive correlation between seismicities and high aero magnetic fields. In addition, they further observed that the N–S oriented Quaternary active faults generated the moderate to high intensity earthquakes in the area.

On the basis of their studies in parts of east African rift system, **Berhe and Rothery (1987)** reported that the lineaments control the sedimentation and tectonic evolution.

While evaluating the tectonic evolution of the Fennoscandian – Baltic shield in Denmark, **Liboriussen et al. (1987)** have inferred the curvilinear lineaments to signify Late Cretaceous tectonics.

**Trifonov and Makarov (1988)** hold the view that, especially in interpreting, modern movements of the Earth's crust, one should take into account its tectonic variability, its layering and the deformations exposed at the Earth's surface, which reflect the evolution of deep processes. No less
important is the solution of the opposite problem, i.e., the study of deep tectonic processes, using data on modern movements of the surface. In both cases, analysis of the distribution of types of movement and regions along (active) faults is essential. Active faults in Asia between 20° and 60° are taken as examples.

Campagna and Levandowski (1991) has appreciated the study of wrench tectonics because it serves as the loci of earthquakes, volcanic activities, hot springs, ore deposits and hydrocarbon; and moreover it serves as a major aspect of tectonic analyses of many regions.

Rust and Stewart (1996) have attempted to estimate the slip rate along the active faults of southern California and central Greece.

Mueller and Talling (1997) have carried out exhaustive studies in Wheeler ridge of southwestern California. They inferred that the ongoing active tectonics in the form of N–S compression is causing the E–W rise of the Wheeler ridge. In this process, a series of N–S trending tear faults have also formed which act as wind gaps, main water gaps etc.

The evaluation of seismic potentials of the Kahrizak fault, Tehran, Iran by De Martini et al. (1998) shows that as a consequence of northerly compressive force, there is an upliftment in hills in E–W direction as revealed by drainage anomalies. Again they observed progressive deformation as a result of NW–SE trending right lateral wrench fault.

Kusky et al. (1998) have attributed Fault scarp cutting in the recent alluvium in Sinai Peninsula to recent tectonic movements.

Harbi et al. (1999) studied the Neotectonic faults in conjunction with seismic scenario of the Eastern Tellian Atlas of Algeria and the studies revealed that mostly the transverse faults appear to be Neotectonically active; also have positive correlation with seismicities.

Azzaro et al. (2000) have carried out trenching along Mt. Etna Volcano in southern Italy and brought out the vertical displacement, slip rate, slip per event of the Moscarello faults during the recent period.
Calamita et al. (2000) have carried out correlative studies in between Quaternary faults and seismicity in Umbo – Marachean Apennines of central Italy and found that the NE – SW trending transverse faults of Quaternary age were more prone for seismicities.

From the point of palaeo seismic perspective, Machette (2000) has classified the global faults into active, capable and potentially active faults.

Han et al. (2003) have developed certain newer methodologies for mapping the concealed active faults using drainage density in the North China Plain. On that basis, they have identified a subsurface fault system with NE–SW and NW–SE orientations. They also further found more frequency of earthquakes along such NE–SW faults.

Hodgkinson et al. (2007) have analyzed recent seismicity data to assess spatial correlations between earthquakes and geomorphological features.

Kavak and Cetin (2007) have analysed the LANDSAT TM data of the Golmaramara region of Turkey for linear features and categorised the NNE-SSW lineaments as Neotectonic origin.

Wolfgang et al. (2007) have identified the seismotectonic lineaments of the northern part of the Eastern Alps, the Western Carpathians and the Bohemian Massif by the Correlation between the epicentres of earthquakes and lineaments derived from gravity data.

Barbara Theilen-Willige and George Pararas-Carayannis (2009) have traced the neotectonic movements by drainage and sedimentological patterns or displacements of strata mapped as linear features (lineaments). Causal or preparatory factors influencing earthquake ground intensity that can be derived by remote sensing and GIS methods were represented as layers in Earthquake damage may vary locally, since it depends on the types of structures that are built and the subsurface ground conditions, proximity to faults and fractures, lithology, and the ground water table.
Lala Andrianaivo and Voahanginirina J. Ramasiarinoro (2010) have interpreted the aligned rectilinear valleys, valley walls, ridges, crests, passes or a combination of these features as well as a spatial analysis, helped detect morphological differences in the lineament patterns. The results extracted from processed satellite images, were compared to geoscientific data of their own geological field surveys in a geographic information system (GIS).

Karen Fontijn et al. (2010) studied the volcano–tectonic architecture of the Rungwe Volcanic Province in SW Tanzania, part of the East African Rift System, with integrated remote sensing imagery and found that Tectonic lineaments show two distinct directions, NW–SE and NNE–SSW, consistent with the idea of a current stress regime.

Zamolyi et al. (2010) have indicated on-going active tectonic activity along Late Miocene by the local earthquake record and geomorphic parameters derived from high resolution digital elevation models.

Eirini S. Papadaki et al. (2011) has shown the application of remote sensing technology, a great promise for large-scale geological mapping and investigated lineaments with possible relevance to faults, in Western Crete, Greece using a multi-spectral ASTER satellite image and standard geographic information systems (GIS) techniques. They have carried out fieldwork surveys in selected regions of interest and this applied methodology has contributed in identifying several known large-scale faults in Western Crete, Greece and mapping their potential extension.

1.2.1.2 Drainage and Fluvial Geomorphic Anomalies and Neotectonics

Bowler and Harford (1966) have analyzed the migratory pattern of Murray river, New South Wales and the diversion and preferential migration of rivers to the Late Pleistocene – Holocene upliftments along N–S faults.

Panizza (1978) has evolved a technique of identifying active tectonic features from various geomorphic anomalies in general and fluvial geomorphic anomalies in particular.
Ouchi (1985) has provided a possible method by geomorphologic evaluation: analysis of alluvial river dynamics and found them to be an appropriate tool for evaluating vertical deformation.

Bull and Knuepfer (1987) have inferred tectonic upliftment in Charwell river basin of New Zealand by using the well defined stream terraces as indicators.

Reid (1992) has demonstrated the repetitive rise and subsidence of long valley Caldera Dome, California, on the basis of river migration, meandering and drainage avulsion.

Chen and Stanley (1995) have brought out the linkages between the Quaternary land subsidence and the related migration of Yangtze river in eastern China.

Smith et al. (1997) have observed that the Okavango river got split up into four channels when crossing a graben and ultimately rejoined after crossing such graben in Botswana.

Harbor (1998) has brought out certain newer information on the interference between the active tectonic upliftments and the fluvial dynamics of the river Sevier, Utah.

Saintot et al. (1999) have observed the multivariate drainage anomalies in Crimea area to be the indicators of surficial and sub surficial active tectonic movements viz: annular, radial and centrifugal drainages indicating the phenomenon of sub surface doming, the rectilinear and deflected drainages suggesting the wrench faulting.

Matmon et al. (1999) have observed Late Pliocene and Pleistocene drainage reversals and attributed the same to tectonic arching along Galilee, northern Israel and further they inferred that the Pleistocene tectonism arched the Galilee region to 200 m above and over a wave length of 40–60 km.
Kusky and El-baz (2000) have inferred the fluvial geomorphology of Sinai Peninsula of northeastern Africa that the most of the drainages have been blocked by the conjugate / shear faults giving rise to palaeo lakes.

On the basis of geological, geomorphological and geophysical data, Maruyama and Lin (2002) have identified the dextral shifting of Pre-Neogene basement rocks to the tune of 16-18 km and Pre-Mio-Pliocene elevated peneplains to the tune of 16–17 km along Arima–Takatsuki Tectonic Line (ATTL) in southwest Japan.

Twidale (2004) has made an exhaustive review on the drainage morphology / pattern and their signatures in understanding the Pleistocene–Holocene tectonic movements. He observed that

- The rivers in central east Australia are mostly controlled by the underlying lineaments / fractures
- The rivers and streams show deflection due to fractures / lineaments and their tectonic activities
- Again that the drainage flow modifications and headward erosions are controlled by tectonic upwarping
- The acute sinuosity in river Murry is directly controlled by the underlying faults.
- The orthogonal, rhomboidal and arcuate pattern observed in rivers and streams in Gawler Ranges, South Australia, is due to the ongoing tectonic movements.
- The rectilinear drainages in Flinders ranges, southern Australia were observed to be due to active faults.

Gábris and Nádor (2007) have observed a major re-arrangement of the rivers governed by local subsidence along the margins of the Great Hungarian Plain led to the development of the present-day drainage system.
Hodgkinson et al. (2007) have proposed the uplift in the coastal region of southeast Queensland since mid-Cenozoic times based on unfit anticipated drainage model and anomalous channel, valley, and escarpment features. Anomalous drainage patterns are suggested to indicate previously unidentified structural features and in some cases relatively young tectonic control on the landscape.

Our results show that structure largely controls drainage patterns in this region, and we suggest that a presently unmapped and potentially active, deep-seated structure may exist parallel to the coast in the northern coastal region. We propose that this structure has been associated with uplift in the coastal region of southeast Queensland since mid-Cenozoic times.

Annamária Nádor et al. (2010) have studied the fluvial history and landscape development of Koros plain, Hungary where they observed the braiding of river and attributing them to huge sediment supply due to neotectonic upliftment of the catchment area.

Zamolyi et al. (2010) have found that the spatial distribution of the pronounced sinuosity variations coincides with the location of Late Miocene and concluded that river sinuosity calculations represent a sensitive tool for recognizing neotectonic activity in low-relief areas. River sinuosity has been used for the detection of vertical movements possibly induced by neotectonic faulting.

1.2.1.3 Topography and Neotectonics

Mountains and all areas of high topography need to be maintained by some sort of dynamic process. If not they will eventually erode and become flat plains. The existence of regions of high topography tells us that some sort of tectonic process must be operating, even if we cannot observe it directly.

People like Burbank et al. (1996), Jackson et al. (1996), Boudiaf et al. (1998), Keller et al. (1998, 1999) have studied the influence of Topography produced by long-term folding forms an obstacle that can affect local
drainage and streams and rivers are often diverted around the ends of the fold. Remnants of the original drainage channels are sometimes preserved as ‘dry valleys’ within the anticlines, which show up as low-points, or ‘wind-gaps’, in the fold topography. Drainage deflections are often interpreted as the result of lateral increases in fold length.

Holbrook and Schumm (1999) holds the view that even the smallest changes in the topography affect the sinuosity of low gradient rivers providing hints on on-going microtopographic changes.

Klaudia Ratzinger et al. (2006) have used SRTM data terrain parameters were extracted from a DEM as shaded relief, aspect and slope degree, minimum and maximum curvature or plan convexity maps and extracted geomorphometric parameters that might be related to Neotectonic based landslide events.

Richard Thomas Walker (2006) has traced the Rafsanjan fault which is clear in both SRTM topography and ASTER satellite imagery. And studied the neotectonic activity and observed a series of anticlinal folds in alluvium run along the northern side of the Rafsanjan fault trace. By topographic profiling he found a height change of up to 10–20 m across the folds and incision of northward-flowing rivers ceases at the northern margin of these folds, indicating that the folds are underlain by southward-dipping thrust faults at depth.

Cameron Wobus et al. (2006) have described in detail a method for exploiting the relationship, in which topographic indices of longitudinal profile shape and character are derived from digital topographic data and tectonic boundaries. The case studies illustrate the power of stream profile analysis in delineating spatial patterns of, and in some cases, temporal changes in, rock uplift rate. They asserted that we can extract quantitative information about tectonics directly from topography.

Paul Kapp et al. (2008) have made swath profiles and topographic analysis for studying development of low angle normal fault systems during orogenic collapse in Tibet.
Raimundo Almeida-Filho et al. (2009) have observed two distinctive topography across the Pirapemas Lineament in Brazil with remarkable smooth topography with sub-parallel to sub-dendritic drainage patterns in north, and a dissected plateau characterized by incised valleys and rectangular drainage pattern occurs southward.

Guido Schreurs et al. (2010) have used SRTM data for the portraying drainage network and extracting lineaments in the process of studying Ranotsara shear zone in Madagascar.

Karen Fontijn et al. (2010) have used the SRTM DEM with georeferenced geological and topographical maps and air photos and they have inspected systematically for tectonic lineaments and alignment of volcanic vents along the lineaments.

1.2.1.4 Tectonic Geomorphology and Neotectonics

Ouchi (1985) has provided a possible method by geomorphologic evaluation: analysis of alluvial river dynamics has been found to be an appropriate tool.

Silva et al. (1992) have advocated the influence of tectonics on morphology and sequences of alluvial fans primarily through an influence on accommodation of spaces.

Blair and Mcpherson (1994) have attributed the spatial difference between fans or group of fans to tectonics and gross topography of the region.

Fabian Jähne and Ralf Freitag (2006) have done remote sensing based lineaments kinematic analysis and terrace analysis of Cape Kamchatka Peninsula and found that a major part of horizontal shortening on the Peninsula seems to be relieved in differential rock uplift along the east coast which was reflected in alluvial fan formation.

Byrdie Renik et al. (2008) have studied the Death Valley area of eastern California and southern Nevada on extreme crustal extension based on the tightest constraints on Death Valley extension from clasts in alluvial-
fan deposits of the Eagle Mountain Formation (15–11 Ma) and their source in the Hunter Mountain batholiths. Hunter Mountain is located 100 km from some of the deposits. Because alluvial fans are usually less than 10–20 km in radius, the remaining separation has been interpreted as tectonic.

Zaitsev and Panina (2011) have identified Neotectonic deformations using structural and morphological analysis of the landforms coupled with the integrated computer-assisted interpretation of multi-scale topographic maps (ranging from 1: 1000000 to 1: 200000) and satellite imagery. A comparison of recent and present day tectonic movements, earthquake catalogues, and heat flow maps allowed the identification of the most intensely deformed and geodynamically active areas in Scythian plate.

1.2.1.5 Geophysical Anomalies and Neotectonics

Turner et al. (1982) have analysed the geophysical lineaments in conjunction with satellite derived lineaments and found positive correlation between the both in Northern Sonora of Mexico.

Lidiak (1989) has used geophysical lineaments for the tectonic modelling.

Drury and Walker (1991) have used geophysical images for bringing out the sub surface geology and structure of the Solway basin, England.

Lee et al. (1991) have observed the concealed basement structures of eastern England in regional Aeromagnetic imagery.

Damaske (1999) has prepared aeromagnetic anomaly map for Queen Maud Land of Antarctica which could be used as first hand information of the region.

On the basis of gravity studies and its correlation with borehole data, Cantini et al. (2001) have inferred the tectonic activity during the Upper Pliocene–Lower Pleistocene in Lower Arno valley, Italy.
Williamson, J.P. et al. (2002) have interpreted magnetic anomalies related to Baltica-Avalonia suture and observed contrast in magnetic crust across the suture.

Nakada et al. (2002) have used gravity anomaly to bring out the zones of aseismic crustal uplifting during the Late Pleistocene time on the basis of negative anomalies in the eastern part of Kyushu, Japan.

2D electrical resistivity tomography has been used by Caputo et al. (2003) to detect and map the Late Quaternary tectonic activity in Tyrnavos Basin, Greece.

Rizzo et al. (2004) have used electrical resistivity tomographic method to identify the Quaternary faults in parts of Apennine chain, southern Italy.

Peters et al. (2005) have used shallow geophysics in conjunction with palaeoseismology and structural analysis to identify and map the zones of Neotectonism in Western Border Fault (WBF) in Upper Rhine Graben, Germany.

Kachentra Neawsuparp et al. (2005) have identified many regional structures of Loei area of Northeastern Thailand by Interpreting of all the processed geophysical data like aeromagnetic data with electromagnetic data, radiometric data, enhanced Landsat images and GIS geological information.

Boyko Ranguelov et al. (2008) have studied the Neotectonics and related seismic hazard of Macedonia. They have used recent seismicity data and GPS data for the measurement of Stress field and other geophysical means to overcome the complexity of stress pattern of the region.

Hernan A. Ugalde et al. (2008) have observed the evidences of basement faults reactivation based on aeromagnetic studies in comparison with the topography.

1.2.1.6 Mineral Resources Evaluation

Badgley (1962) has narrowed the target with the well recognized association of Copper and molybdenum deposits with crackled quartz
monzonite stocks about 1 mile in diameter, their space relationship to lineaments and fracture patterns as in the south western United States.

In a hypothetical example of continental drift in relation to the occurrence of mineral deposits of a type found on oceanic islands, one might apply the evidence advanced by Wilson (1965) on progressive age of islands with distance from spreading centers to the search for matching phosphate and bauxite occurrences on either side of mid-ocean ridges.

The hot brines and recent iron deposits discovered in the Red Sea in 1965 are described by Miller (1966). They occur in an isolated submarine pool more than 2000 m deep.

On the East Pacific Rise, Bostrom and Peterson (1966) found heat-flow anomalies with enrichment of Fe, Mn, Cr, Pb, Ni, Ba, and Sr.

Schuiling (1967) found that tin belts extend unbroken from one continent to another. The fit of Brazilian and West African deposits is most striking. The source of the tin and its associated elements must be in the crust since the ages of tin mineralization vary within the belts.

A note of caution is sounded by Petrascheck (1968) on wholesale acceptance of separation of metallogenic belts by continental drift. He notes that some areas do not show satisfactory coincidences in time and space or even missing links.

Walker and Bilbin (1968) it appears that each orogenic episode had a growth pattern of early, syntectonic, and late tectonic events. In the early stage, the outer belts of the downf low system contain flysch deposits of the sedimentary arcs with the following mineral deposits.

Jan Kutina (1969) has identified the prospecting net for hydrothermal deposits in Western United States based on regularities in distribution of actual faults and ore veins in the continental area and on the landward prolongation of the big fractures zones of the northeastern Pacific.
In discussing Irish and Arabian geofractures possibly related to rifts, *Russell and Burgess* (1969) observe that the nature of the geofractures will be determined by the interaction of positive pore pressures and the strength parameters of the rocks. It is possible, they believe, that in rift areas high positive pore pressures may be developed due to mantle degassing. Since the mantle is tapped passively by uprises, rather than violently as in downflows.

In the Irish base metal area *Russell* (1969) hypothesizes that vertical fissures he relates to continental drift came up from the upper mantle and deposited lead-zinc ores in Carboniferous limestones at intersections with east-west and northeast-southwest faults of Caledonian trend.

*Barsukov et al.* (1970) note that evidence is accumulating on the importance of abyssal fractures and so-called «through» shatter zones in hydrothermal ore deposition, especially in parts of platforms activated by block tectonics and marked by andesite-basalt magmatism.

*Crawford* (1970) believes that the gold deposits of Kolar, Mysore, India and those of Kalgoorlie, Australia are of the same age and that the gem and graphite deposits such as those of Ceylon may be expected to occur in Southwestern Australia.

According to, *Dietz & Holden*, (1970) the Precambrian sedimentary iron formations of Western Australia and Northeast India may in Gondwanaland once have been much closer.

*Snelgrove* (1971) has suggested a broad target in the search for porphyry copper-molybdenum in the three earthquake zones of Turkey outline a large tectonic plate.

According to *Tuzo Wilson* (1971) the East Pacific Rise may be projected into the Western United States through Arizona and Utah. In this connection (although the exact relationship is not clear at present) the Salton Sea, California, hot brines, containing abnormal amounts of Cu, Ag, K, Li, Sb,
Pb, As, B, Be, Li, Ga, etc., may represent diluted magmatic waters from underlying igneous rocks related to either subduction or rise.

**Walker (1971)** holds that less variety of metallic mineralization and of host rocks is to be expected in spreading centers and the prime source of mineral deposits is the interaction of the down flowing crust and the upper mantle.

People like **Bian, (1980) and Taylor (1984)** have performed the lineament analysis since it facilitates the recognition of different tectonic settings for mineral deposits.

**Katz, (1982)** has applied the lineament analysis technique to mineral exploration and attempts to define the most favorable locations for mineral concentrations on the basis of tectonic environments.

**Floyd F. Sabins (1999)** has used Landsat thematic mapper (TM) satellite images for mineral exploration in two applications: (1) map geology and the faults and fractures that localize ore deposits; (2) recognize hydrothermally altered rocks by their spectral signatures.

**Chan Chiang Liu et al. (2000)** have studied the lineaments based on Landsat images and correlated with the existing geological maps of known hydrothermal mineralization (Cu, Au, Mo, Ni, W and Ti) and the lineament map was verified in the field reconnaissance.

**Billa et al. (2004)** have done a comprehensive continental-scale metallogenic information system for the entire Andes Cordillera, was developed based on original syntheses structured into thematic layers and produced an integrated tool to understand ore deposit localization in the Andes.

**Xianfeng Zhang et al. (2007)** have used the supervised classifier for the first time to classify the 14 channel ASTER radiance data to map gold deposits in Chocolate Mountains, California.
Ladislav A. Palinkaš et al. (2008) have studied the Magmatic ore-forming fluids, related to alkali-type magmatism in the Early Permian ore deposits in the medium-grade metamorphics of the Mid-Bosnian Schist Mts. This which is a part of Alpine–Himalyan system.

Gong et al. (2011) have studied the effects of neotectonic activity in offshore China, where oil/gas fields were partially breached by post-trap peneplanation and faulting initiated earthquake activity and depocentre migration, created new faults and initiated earthquake activity and there are pools with active gas leakage through neotectonic faults and this seems to suggest a dynamic balance between outboard leakage of gas and inboard migration of hydrocarbons.

1.2.1.7 Ground Water Resources Evaluation

Theis (1935) applied the principle of superposition to derive an exact solution for the recovering water levels in a well by summing two drawdowns (s1) caused by imaginary continuation of the original pumping and the other (s2) due to an imaginary injection at the same constant rate. Since then, many have developed simplified methods for estimating transmissivity (T) and storativity (S) from recovery data by approximating the exact Theis solution.

The common assumption in lineament mapping for exploration of ground water is that these features represent vertical zones of fracture concentration (Lattman, 1958).

Walton (1962) presented the analytical methods of aquifer evaluation which formed the basis for numerical approaches.

Lattman and Parizek (1964) interpreted the fractured area from aerial photographs and find out relationship between fracture traces and accuracy of ground water in carbonate rocks.

Prickett (1975) gave a comprehensive outlook on the modelling techniques for ground water evaluation by properly explaining the equations...
of flow, given an overview of the types of analog and numerical method used to prior 1975.

**Van Overmeeren (1981)** showed the use of electrical measurements in mapping boundary conditions in an aquifer system in Yemen.

Simulation of flow in fractured system requires definition of effective values for hydraulic conductivity, storativity and porosity, which are, in turn, determined from aquifer testing (**Gingarten, 1982**).

The hydrogeological analysis of satellite imagery is one of the difficult tasks, because “ground water by its varying nature is not available for direct observation” (**Fransworth et al. 1984**).

Electrical and electromagnetic techniques have been extensively used in ground water investigations because of the correlation that often exist between electrical properties, geologic formations and their fluid content (**Flathe, 1955; Zohdy, 1969; Flathe, 1970; Zohdy et al., 1974; Fitterman and Stewart, 1986**).

**Yin Shuren Xiao Youquan (1988)** have studied that the Neotectonic fractures are of new age, very active, deep in penetration, precipitous in dip angle, occurring equidistantly in plane and marked with a zoning in the section resulting from the faults and fissure formed by neotectonic movement in the earth's crust and hence the neotectonic fractures are in control of the distribution, formation and movement of ground water that their study is of great importance in hydrogeology.

A library of equivalent transmissivities and residence times of single fractures is assembled by solving the steady-state flow for different aperture distributions. The resulting values are then introduced as local parameters in the whole fracture network analysis. Such a local to global procedure requires morphological descriptions of large fracture samples, and important modelling efforts have been made in this field (**Brown, 1987; Tsang and Tsang, 1989**).
Cacas et al. (1990) calculated unfractured rock volumes and permeabilities from field description of fracture apertures, lengths and interconnections.

Many workers have investigated lineaments and geological fracture traces with respect to ground water potential, several with an emphasis on arid or semiarid hard rock areas (e.g. Greenbaum, 1992).

For consistent with channeling evidence within the fracture plane, the modelling process developed by Nordqvist et al. (1992) includes a first stage of analysis which consists in constructing spatially varying aperture fields within an individual fracture plane.


Bruel et al. (1994) have studied the fractured aquifer system to show how the shortest, weakly connected joints can be removed and replaced in the system by an equivalent parameter. These efforts can save computer time or enlarge the modeled rock volume. Moreover, this approach may be helpful in addressing the troublesome up-scaling problem in discontinuous media.

Chi and Lee (1994) have used remote sensing and GIS in diverse geological set up for the demarcation of ground water potential zones in Kochang Korea.

Most geophysical techniques have been used for ground water characterization but once again it is with the electrical and electromagnetic methods that the greatest success has been shown in directly mapping and monitoring contaminated and clean ground water (Van Dongen and Woodhouse, 1994).
Some of the workers have demonstrated that the use of electrical resistivity techniques for citing wells and boreholes in crystalline basement aquifers (Beeson and Jones (1988), Hazell et al. (1988), Barker et al. (1992), Olayinka and Barker (1994).

Teeuw (1995) had used IDRISI GIS for processing of satellite images to assess the reliability of interpreted lineaments, and create maps showing the individual lineament, aerial extent of interconnected lineaments and targets for ground water borehole.

Budkewitsch et al. (1994) and Karnieli et al. (1996) published different algorithms for lineament extraction from digital images and aerial photographs respectively.

Sandar (1997) applied a probabilistic approach for ground water exploration, using Bayesian statistics in hard rock setting of Botswana and Ghana. In his study, the lineaments, vegetation anomalies, drainage, and bedrock geology are integrated into GIS environment and produced posterior probability map.

Edet et al. (1998) used black and white radar imagery and aerial photography and defined the hydrological and hydrogeological features. They delineated the ground water potential as high, medium and low in the cross river state of southeastern Nigeria.

Chang Pixing Ma Zhiyuan (1998) have studied the relationship between neotectonic movement and ground water resources and he reiterated that Neotectonic movement is key to the development of drainage, and the distribution of ground water, shifting and storage of ground water, the hydrogeochemical characters as well as their variation are controlled by the neotectonic movement.

conducting azimuthal surveys. This method was successfully used to assess the directional variation in hydraulic conductivity of glacial sediments.

Several workers have adopted remote sensing techniques to delineating ground water potential zones in hard rock terrains (Boeckh, 1992; Greenbaum, 1992; Gustafsson, 1993; and Saraf, 1998).

Zakir et al. (1999) describes fractal plot and fractal analysis as an optimizing technique for preparation of lineament density maps.

The GIS technology provides an alternative for efficient management of large and complex databases (Bernhardsen, 1999).

Bailey and Halls (2000) used multi-spectral satellite imagery in Precambrian crystalline areas to derive maps that reflect differences in vegetation growth between dry and wet seasons, asymmetric patterns across lineaments, identified dykes from aero magnetic data to find out ground water accumulation zone as a dyke controlled phenomena.

Shahid et al. (2000) used seven themes such as lithology, geomorphology, soil, water level fluctuation, drainage density, slope and surface water body to evaluate ground water potentiality. They had given an equation for the spatial analysis of these seven themes. GWPI= (Lw Lr + Gw Gr + Sw Sr + Rw Rr + Ow Dr + Ew Er + Ww Wr ) / Lw. Where, Wi represents weight of a theme and r represents rank of a feature in a theme.

Dinger et al. (2002) tried remote sensing and field techniques to locate fracture zones for high yield water wells in the Appalachian Plateau, Kentucky.

Detailed surveys of these methods can be found in Chapuis (1992), Banton and Bangoy (1996), Chenaf and Chapuis (2002). Estimating the hydraulic characters of water bearing layers is an essential part of ground water studies. The most effective way of determining these characteristics is to conduct and analyse in-situ hydraulic tests.
Characterizing the permeability at a regional scale where fracture distributions are heterogeneous, can be aided by defining hydrostructural domains. Such an approach uses regional-scale structural data to divide aquifers into structural domains (Ohlmacher, 1999; Martin and Tannant, 2004).

Erhen Sener et al. (2005) made a case study on ground water investigations in Burdur, Turkey. The investigation was carried out using thematic maps such as annual rainfall, geology, lineament density, land use, topography, slope and drainage density. The investigation revealed that the areas Askeriye, Bugduz, Gelincik, Taskapi and Kayaalu were seemed to be important from the ground water potential point of view.

Elijah Ayolabi et al. (2005) has opined that the prospecting for ground water is essentially a geological problem and geophysical approach is dependent on the mode of the geological occurrence of water.

Amin Shabhan et al. (2006) determined the recharge potential areas in Occidental Lebanon using the parameters lineament, drainage frequency density, lithologic character, karstic domains and land use/land cover. By the analysis they found that highest recharge potential was found around 57 % of the study area in terrain with very high to high recharge rate values where a considerable amount of precipitated water was allowed to percolate into the subsurface rocks.

Semere Solomon and Friedrich Quiet (2006) studied the ground water potential in the central highlands of Eriteria using GIS, Remote sensing, Digital Elevation Model (DEM) and field work analysis and found that ground water potential was very good in basaltic layers overlaying lateritized crystalline rocks, flat topography with dense lineaments and structurally controlled drainage channels with valley fill deposits.

The data generated through GIS can be updated and can be used for planning and development of ground water (Shaban et al. 2006).
Last two decades many scientists have effectively carried out the three-dimension transport model and flow models (Ophori and Toth, 1989; Gomboso et al., 1996; Merkel and Friedrich, 2005; Hardyanto and Merkel, 2007).

**Hsin-Fu Yeh et al. (2009)** assessed the ground water recharge potential zone in Chih-Pen-Creek basin in eastern Taiwan using lithology, land use/land cover, lineaments, drainage and slope. The weights of the factors contributing to ground water recharge were derived using aerial photos, geology maps, a land use database and field verification. The resultant map of the ground water potential zone demonstrates that highest recharge potential area was located towards the downstream region in the basin because of the high infiltration rates caused by gravelly sand and agricultural land use in these regions.

**1.2.1.8 Water Quality Evaluation, Hazardous Ions Zonation Mapping and Detection of Controlling Lineaments**

**Lawerence and Upchurch (1982)** carried out factor analysis for ground water quality data to relate those data to specific hydrologic process in upper Floridan aquifer near Live Oak. R-mode factor analysis was carried out to separate the chemical variables. Four factors which represent different chemical process were identified and their relative impact was determined and the processes were 1. Regional dissolution of the aquifer limestone, 2. Dissolution and ion exchange in the discontinuous and semi permeable layer that overlies the portion of the aquifer, the 3rd and 4th were due to recharge from local, urban and agricultural runoff.

**Chen-Wuing et al. (2003)** applied factor analysis for assessing the ground water quality in a black foot disease area in Taiwan. Based on the factor analysis a two factor model was suggested. Factor 1 (seawater salinisation) includes electrical conductivity, total dissolved solids, chloride, sulphate, sodium, potassium and magnesium and factor 2 (arsenic pollution) includes alkalinity and arsenic. The authors finally concluded that the over
The extraction of ground water was the major cause of ground water salinisation and arsenic pollution in the coastal area of Yun-Lin, Taiwan.

**Syeda Azeem Unnisa and Khalilullah (2004)** studied the impact of industrial pollution on ground and surface water quality in Kattedan industrial area. They found that both the surface and ground water was polluted and they were not suitable for drinking as the effluents from the industries were discharged without treatment. The water can be used for irrigation under special circumstances.

**Seddique and Ahmed (2004)** studied the urban and industrial pollution in the aquifers of Narayanganj town, Bangladesh. The study reveals that the shallow aquifers had higher dissolved solids due to industrial and densely populated areas. Quality of deeper aquifer was seemed to be better when compared with shallow aquifer.

**Bahattin Centindag and Nail Unsal (2004)** studied the ground water quality along the ground water flow path in unconfined aquifer in Hankendi plain, Elazig, Turkey. The study resulted that the concentration of TDS, EC and water quality of water are related to ground water residence time. The ground water condition is chemically suitable for drinking and agricultural purposes.

**Elijah Ayolabi and Folashade Oyelayo (2005)** assessed the pollution of ground water due to dumpsite in Lagos state, Nigeria. Geophysical and hydrochemical analyses were done in the study area. Based on the geophysical tests, depth to resistivity map was produced to show the extent of pollution. The hydrochemical results from ground water and surface water shows very high values of conductivity, total dissolved solids, total suspended solids, alkalinity, total hardness, calcium and iron.

**Kortatsi (2006)** analysed the chemical characteristics of ground water to study the relevant water-rock interactions which leads to poor ground water quality in the Accra plains of Ghana. The results revealed that the
ground water quality was good for drinking only along the foothills of the Akwapin Togoland ranges.

**Charkhabi and Sakizadeh (2006)** assessed the spatial variation of water quality parameters in the most polluted branch of the Anzali wetland in Northern Iran. Samples were collected for four consecutive seasons in nine stations. The samples were analysed for eleven parameters and the results of the factor analysis revealed that agriculture and urban activities were the major pollutant sources.

**Olobaniyi and Owoyemi (2006)** analysed the chemical facies of ground water in the Deltaic plain sand aquifers of Warri, western Niger delta, Nigeria. The results obtained from the analysis were subjected to R-mode factor analysis and three factors were extracted in which factor 1 includes potassium, sodium, chloride and electrical conductivity which reflected the signature of saline water intrusion, factor 2 includes magnesium, calcium, bicarbonates and pH which represented the process of rainwater recharge and water-soil/rock interaction and factor 3 includes sulphate which was related to the dissolution of sulphides from interstratified peat within the geological formation. From the results the authors demonstrated the effectiveness of factor analysis in sorting out ambiguous hydrochemical process.

**Najafpour et al. (2008)** applied multivariate statistical analysis for evaluation of temporal/spatial variation of Shiroud river which discharges to the southern part of Caspian sea, Iran. A total of 16 parameters of water quality were monitored for 12 months at 8 sites. Factor analysis resulted that the first factor comprised of electrical conductivity, total dissolved solids, calcium ion and temperature levels, second factor called the water quality indicator comprised of silicate, dissolved oxygen and pH levels and third factor called phosphate pollutant comprised of total phosphorous and orthophosphate. Additional factors were affected by nutrient flow rate and general water quality.
1.2.1.9 Landslide Hazard Evaluation

Slopes need to be considered as continuously changing complex systems which is main causative for landslides (Carson and Kirkby, 1972).

Slope gradient is a critical factor controlling the distribution of landslides, as failure will only occur on slopes exceeding the critical angle for the materials to be moved (Thomas, 1974).

Landslides are complex phenomena, whose time-space distribution results from an interaction of numerous factors: geological, geomorphological, physical and human interference (Varnes, 1978).

Landslides are short lived phenomenon but which can cause extraordinary landscape changes and destruction of life and property. Landslides in the strict sense denote the rapid movement of sliding earth material, separated from the underlying stationary part of the slope by a definite plane of separation (Coates, 1981).

Fuller et al. (1981) Prepared a Landslide zonation map with the following classes like areas of recent landslides, areas of older landslides, areas buried by debris flow colluvium and alluvium, areas of rockfall potential and area of little or no landslide potential, for a part of Utah province.

In his studies conducted in Weber river bank, Gill (1981) has used geological structures, climate aspects, landslide characteristics, lithology, hydrology and seismicity data for landslide hazard zonation.

The real cause of landslide involves the progressive weakening of slope materials by slow natural process such as weathering and tectonic uplift. The immediate cause or triggering mechanism is a local short duration drop in the stability of a slope due to rainfall or ground shaking from earthquake (Costa and Baker, 1981).

The slope evolution to stable or unstable form is typically controlled by numerous geomorphological, physical and manmade processes (Crozier, 1986).
**Hutchinson, (1988)** defined Landslides as a broad range of different types of motion whereby earth material is dislodged by falling, sliding or flowing.

**Duque et al. (1991)** prepared the slope stability classes, using various factors such as lithology, structure, slope etc and further predicted the future behaviour of the terrain with regards to slope processes.

**McKeaen et al. (1991)** used the fuzzy sets to map potential slope failure. In 1991, **Niemann and Howes** done digital terrain model for slope stability.

Digital Elevation Models (DEM) provides a rapid and objective evaluation of morphologic parameters useful in the development of preliminary slope stability hazard maps (**Niemann and Howes, 1991**).

**Juang et al. (1992)** used the fuzzy sets to map slope failure potential. **Van Westen (1994)** has brought out a review article to depict the status of landslide hazard zonation studies all over the world.

GIS can be applied for the generation of Digital Elevation Models (DEM) for quantitative analysis of topography (**Gao, 1993**) and landslide hazard zonation (**Terlien et al., 1995**).

Introduction of GIS into landslide research has greatly enhanced the ability in collecting and analyzing landslide data (**Wang and Unwin, 1992; Hansen et al., 1995; Mark and Ellen, 1995**)

**Leroi (1996)** discussed about the objectives, tools and development of Landslide hazard – risk maps on various scales.

Landslides are variable in intensity and in the nature and in form: rotational, translational, composite, complex, rock falls, mudslides, debris flows (**Dikau et al., 1996**).

**Mertens and Lambin (1997)** used temporal remote sensing data to prepare the deforestation risk zones which have a high value for implementing development projects to mitigate the adverse effects of deforestation. Several works proves that integration of GIS with remote
sensing data has provided a useful tool to assess and estimate potential landslide hazards.

The reason is that following heavy rainfall an upwardly concave slope has more water and retains it longer. At intermediate elevations, slopes tend to be covered by a thin colluvium, which are more prone to landslides. The boulder slopes are associated with the highest number of failure events, including the most catastrophic. But most of the landslides were found to have taken place in loose bouldery colluviums (Wong et al., 1997).

Al-Homoud and Masant (1998) adopted the geological, topographical, rainfall and geotechnical parameters as the basis for the classification of terrains in terms of their stability and a classification system was proposed. The major parameters in the classification are geologic formation, dip, average annual precipitation, slope inclination and topography. Each factor has been assigned a rating to indicate its relative contribution to the overall stability according to engineering judgment and past experience.

Burton and Bathurst (1998) on their studies on landslides showed that landslides triggered on forest slopes release such energy and mass that a debris flow nearly always develops. This usually scours all the material in its path and continues to move down slope until the gradient falls below that needed to maintain flow.

Landslides occur when the motivation forces exceed the resisting forces. Factors such as vegetation cover, slope angle and slope forming materials also influence the susceptibility, and severity, of slope failure. Landslide may be shallow or deep-seated one depending upon the depth of bedrock, weathering material and soil properties. Rainfall, soil properties and morphology are major factors controlling shallow landsliding (Crosta, 1998).

Several reports with diverse GIS database, compiled primarily from existing maps and aerial photographs can be used to construct a model of slope stability (Rowbotham and Dudycha, 1998).
Geomorphological research on landslides was carried out by Pasuto and Silvano (1998) in Italian dolomites and they have proposed a territorial subdivision based on homogeneous units and defined them as landslide units.

According to Scheidegger (1998) landslides are result of sudden change in long-term response caused by minute changes in the initial conditions. The term geomorphology has a broad meaning which includes landforms, slopes, drainage etc.

Studies by Brunsden (1999) shows that GIS database compiled with existing digital maps and aerial photographs can be used to describe the physical characteristics of landslides.

Franks (1999) examined natural terrain landslides and concluded that a sparsely vegetated slope is most susceptible to failure that was originally occurring.

Studies by Franks (1999) reveal that as the distance from drainage line increases, landslide frequency generally decreases. This is due to the fact that terrain modification caused by gully erosion may influence the initiation of landslides. Run-off associated with thunderstorms also influence landslide occurrence in a large scale because the water follows artificial ‘preferential flow’ channels rather than following natural path.

Zêzere et al., (1999) emphasized the role of lithology in landslide occurrence. The authors identified 55% of landslide occurrence on marls and marly limestone which covers only 18% of the study area in Lisbon.

The important factors that are responsible for landslides are geographical location, topography, rainfall intensity, the predominant soil and the urbanization/settlement form (Smyth and Royle, 2000).

The ability of GIS in the engineering analysis of the slope stability by incorporating the spatially varying data of ground elevation, soil properties etc., is shown by several workers (Wu and Latif, 2000).
Landslide hazard assessment can provide much of the basic information essential for hazard mitigation through project planning and implementation (Dai et al., 2001).

Lee and Min (2001) showed that lithology have much importance in landslide occurrence in Yongin, Korea and his study area is characterized by granite gneiss, quartz mica schist and biotite gneiss, of which probability of landslide occurrence is high in granite gneiss.

Enhanced landslide activity following deforestation produces a progressive increase in the triggering threshold due to regolith stripping and bedrock exposure (Brooks et al., 2002).

Dai and Lee (2002) revealed that the morphology of a slope influences direction and amount of surface runoff or subsurface drainage which probably affect the susceptibility of a slope to landslide.

Afforestation has the double aim of both reducing the ratio of erosion of the soil and minimizing the visual impact of vegetation poor zones. But in Spain, studies conducted by Linares et al. (2002) found that it has negative effects and cause the slope relatively unstable.

Zhou et al. (2002) proposed statistical spatial analysis approach to study the relationship between landslides and causative factors. Reports indicate that steep terrain, deep weathering, heavy rainfall and intensive cutting and platforming of the landscape by man collectively contribute to frequent occurrence of landslides. Moreover, the role played by artificial structures was significant in triggering and controlling many of the shallow slope failures. As a result of urbanization, there was a serious change in vegetation cover resulted in the marked increase in the incidence and severity of landslide events. Deforestation has resulted in environmental degradation, erosion and recurrent slope failure.

Hofmeister and Miller (2003) followed an approach based on the readily derived topographic attributes and addressed a range of parameters
necessary for debris flow hazard assessments, including identification of zones of initiation, transport and deposition.

Zones susceptible to failures were assessed by Baillifard et al. (2003) using five criteria (1) a fault, (2) a scree slope within a short distance, (3) a rocky cliff, (4) a steep slope, and (5) a road. The model yielded a rating from 0 to 5, and gave a relative hazard map.

Renato Fontes Guimaraes et al. (2003) applied a physically based model for the topographic control on shallow landsliding (SHALSTAB) to two catchments in Rio de Janeiro. They ran the model for all combinations of reasonable cohesion, bulk density, and friction angle values and compared model predictions to mapped landslides scars.

Moeyersons et al. (2004) identified the combination of slopes at the head of the slides and surface drained to it, and inferred that it is a promising tool to discriminate the hydrologically induced landslides from the tectonically seismically induced one.

Lulseged Ayalew et al. (2004) Studied six landslide-controlling parameters namely lithology, slope gradient, aspect, elevation, and divided the area into five classes of landslide susceptibility. They found high scale of susceptibility in mid-slope mounds and also in weak rocks such as sandstone, mudstone and tuff.

Lee et al. (2004) have analyzed the Landslide hazard areas and mapped the same, using the controlling parameters (such as slope, aspect and curvature of the topography, Texture, materials, drainage, effective soil thickness from the soil database and type, age, diameter and density of timber from the forest database etc). The results of the analysis were verified using the actual landslide location data. The validation showed satisfactory agreement between the hazard map and the landslide incidence.

Saro Lee and Biswajeet Pradhan (2006) has mapped landslide hazards and risk analysis of Penang Island, Malaysia using landslide-occurrence factors employing the probability-frequency ratio model.
Suhaimi Jamaludin and Ahmad Nadzri Hussein (2006) has developed slope assessment systems in Malaysia to predict the likelihood of landslide occurrence.

Cardinali et al. (2006) used the information derived from a recent landslide event to test the contribution of geomorphology over landslide hazards and prepared a risk map for the village of Sugano. They also demonstrated multiple landslide scenario viz (i) rapid and very rapid landslides, (ii) Soil slides, (iii) Debris flows and (iv) Debris avalanches.

Frank Weirich and Leonhard Blesius (2007) has used an overlay model approach in which several map layers were combined by some arithmetic rules to determine the potential for sliding in an area of Santa Monica, California, USA, along the Pacific Coast Highway.

Ali Yalcin (2008) have used the analytical hierarchy process (AHP), the statistical index (Wi), and weighting factor (Wf) methods to locate the landslides associated with the climatic conditions, geologic, and geomorphologic characteristics of the Ardesen region.

Nora Tassetti et al. (2008) has monitored and assessed landslide hazards by remote sensing data processing and GIS spatial analysis and developed the model giving indications about the relevant factors influencing slope instability using Spatial Decision Support System (SDSS) for land management.

Mehrnoosh et al. (2009) has evaluated the landslide susceptibility and the effect of landslide-related factors at Marzan Abad in Iran, using the Probabilistic–Frequency Ratio (PFR) model, geographic information system (GIS) and remote sensing data.

Clerici et al. (2010) has used the ‘Conditional Analysis’ multivariate statistical method to evaluate Landslide Susceptibility (LS) in an area of the Italian Northern Apennines. By overlaying Inventory Landslide Map and landslide relate factor map with the map of the elements at risk, namely, settlements, roads, and streams, the spatial risk in the area was assessed.
1.2.2. National

1.2.2.1 Neotectonics and Seismotectonics

Raiverman et al. (1966) have prepared the fracture pattern map of Cauvery basin and they observed similarity with tectonics of Deccan traps and doubted for their possible Post Tertiary origin.

Vaidyanadhan (1967) has inferred that the southern Indian Peninsular in general was subjected to epirogenic uplifts since Jurassics.

The concept of rift valley was propounded by Yelur (1968) for the Narmada lineament zone.

Gubin (1969) has postulated a series of peripheral faults in South India through which the Nilgiris, Palani and Anamalai hills have risen and Palghat region has undergone subsidence.

Vaidyanadhan et al. (1971) have recorded evidences for the time transgressive and repetitive reactivation of lineaments in southern Peninsular India.

Rubke (1974) has brought out for the first time a detailed picture on Lesser Himalaya and the Neo–Active faults too.

Srinivasan (1974) considered the Attur Valley as a rift zone between Shevaroys-Chitteri-Kalrayan and Kolli- Pachchai hill massifs and attributed its origin to ongoing N–S compressions.

The publications by NGRI (Anon 1975 and Anon 1978) have brought out significant information on the seismicities in Indian Peninsula and their relation to transverse fault movements.

On the basis of the coincidences between the geothermal springs and lineaments, Guha (1977) has observed a number of active faults in Bihar and West Bengal.

Umesh Chandra (1977) has prepared Seismicity status of peninsular India from a detailed consideration of the historical as well as recent
earthquake data, and a catalog of earthquakes from the earliest time throw 1974 that occurred within the region, 5°N – 28°N, and 67.5°E - 90°E.

**Das and Ray (1977)** have interpreted the lineaments of entire Deccan traps of Maharastra and part of Madhyapradesh and found that these are related to post trappean tectonics.

**Vemban et al. (1977)** have identified that many faults in Tamil Nadu are active and seismogenic.

On the basis of their studies in Gondwana basins, **Ahmed and Ahmed (1977)** have identified the regional faults in Peninsular India were formed due to anticlockwise rotation of Indian plate.

**Ahmed and Ahmed (1980)** have again presented a picture on the Late Mesozoic faults with an overall fan shape in Arabian Sea. They further observed that these fan faults are progressively younging towards north.

**Drury and Holt (1980)** have interpreted Attur Valley lineament as a branch of curvilinear shear system, which incorporates Moyar-Bhavani, Palghat-Cauvery lineaments.

**Powar and Patil (1980)** on the basis of the Landsat imagery lineaments concluded that the Deccan volcanics has undergone a N–S compression and E–W cymatogenic arching.

**Suryanarayan (1982)** has brought out the Neotectonic picture of Dun valley from lineaments derived from satellite images and aerial photographs.

**Peshwa (1983)** has observed that most of the lineaments reflect the neotectonic pulses along them on the basis of the Landsat imagery interpretation in Koyna area.

**Drury (1984)** has interpreted the E–W, NNW–SSE and NNE–SSW trending dyke systems in parts of Tamil Nadu and from the same he has visualized the Crustal doming.

**Bakliwal and Ramasamy (1987)** have brought out the regional frame work of all the lineament systems for entire Rajasthan and Gujarat on
1:5,00,000 scale and inferred that the ENE–WSW lineaments are tectonically active on the basis of their coincidence with seismicities and geothermal springs.

_Ghosh and Singh (1988)_ have attributed that the structures and geomorphic anomalies of the northwestern part of the Indo-Gangetic plains to the northward tilting of Bundelkhand region due to the reactivation of Narmada lineament.

_Choudhary and Srivastava (1989)_ have propounded a hypothesis that the over turning in Assam Himalayas are due to northerly movement of Indian plate.

_Thakur (1989)_ has inferred that the lineaments of Himalayan region in general reflect the Neo–Active tectonic movements and hence seismogenic.

On the basis of the coincidence between the earthquake occurred 30° due north of Trivandrum and NE–SW to ENE–WSW trending lineaments, _Singh and Venkatesh Raghavan (1989)_ have observed that this is because of the reactivation of these lineaments in the area.

_Nair (1990)_ has prepared detailed structural trendline and lineament maps for the entire Western Ghats of Kerala and observed that most of the NNW–SSE lineaments are related to Indian Plate movement.

The most of the fracture systems in southern Gujarat were attributed to the northeasterly movement of the Indian plate by _Alavi and Merh (1991)_.

_Ranadhir Mukhopadhyay and Khadge (1992)_ have identified ENE–WSW trending major depressions in central Indian Ocean basin to Post Cretaceous tectonics.

_Ramasamy (1995a)_ has analyzed the lineaments in the Deccan volcanics of southern Saurashtra and from the same he identified a series of E–W to ENE–WSW oriented horsts and grabens and attributed to post collision tectonic of India.
Gupta et al. (1997) have reported the recent Jabalpur earthquake of May 22, 1997 was related to ENE–WSW faults.

Ramalingeswara Rao, B. (2000) has studied the historical seismicity and deformation rate in the peninsular shield.

Valdiya (2001) has observed a series of peripheral faults in South India, from which he inferred that the Nilgiris, Palani and Anamalai hills have risen and Palghat region has undergone a subsidence.

Gupta (2003) reiterates that Remote sensing data can be used to map factors that are related to the occurrence of higher earthquake intensities and earthquake-induced secondary effects, such as liquefaction or landslides.

Ramasamy (2006a) has observed that the Indian Peninsula in general and its southern part in particular has been prone for younger earth movements and seismicities. He presented a clear picture on the active tectonics of South India based on a large number of anomalies visibly displayed by the tectonic, fluvial, coastal, and hydrological systems in remote sensing and ground based datasets/observations. He indicated the two E–W trending ongoing tectonic (Cymatogenic) archings along Mangalore–Chennai in the north and Cochin–Ramanathapuram in the south with intervening cymatogenic deep along Ponnani–Palghat–Manamelkudi.

Stacey Martin and Walter Szeliga (2010) have evaluated eight thousand three hundred thirty-nine intensity observations for earthquakes that occurred on the Indian subcontinent and surrounding plate boundaries from the seventeenth century to the present. They characterize 570 earthquakes, more than 90% of which occurred in the past two centuries. They summarize these data graphically in the form of a spatially averaged intensity map for the subcontinent, a map that emphasizes the features of many previously published earthquake hazard maps for the Indian plate, but which more faithfully depicts regional amplification and attenuation. They
also estimated the probable return time for future damaging shaking in five of India’s largest cities.

**Sharmili Parthasarathy and Vaishali Rajendra Kumar (2011)** have done remote sensing and GIS based seismic sub-zonation in north-western Tamil Nadu by considering the factors like, fractures/lineaments, history of Earthquakes, and magnitude of earthquakes, Peak Ground Acceleration (PGA) and lithology. The result is a map indicating subclasses / areas with high, moderate and low probabilities of seismicity within zones II and III of the north-western districts of Tamil Nadu.

**Mayshree Singh et al. (2011)** have developed a seismotectonic model for South Africa by bringing together, digitally, several data sets like geology, geophysics, stress, seismicity, neotectonics, topography, crustal and mantle structure and anisotropy in a common GIS platform.

### 1.2.2.2 Drainage and Fluvial Geomorphic Anomalies and Neotectonics

The anomalous compressed meandering observed in river Yamuna in Agra region was explained to be due to ongoing active tectonics of Great Boundary Fault and the related ENE–WSW spectrum of lineaments by Bakliwal and Sharma (1980).

**Yashpal et al. (1980)** on the basis of remote sensing and archaeological data, have brought out a vast spread of palaeochannels in Gaggar basin of northwestern Rajasthan and demonstrated them to be the traces of Lost Sarasvati river.

The rectilinear pattern and regional deflections of river Brahmaputra were attributed to fault systems of NE–SW, NW–SE, E–W and N–S orientations by **Murthy and Sastri (1981)**.

**Suryanarayan and Prabhakar Rao (1981)** have observed drainage reversals in northern Tamil Nadu along N–S lineaments and suspected a tectonic wedging along N–S trending lineaments.
Prasannakumar and Mathai (1982) have doubted for possible tectonic movements along Bhavani lineament on the basis of certain changes in Bhavani river near Mukali area.

Rajaguru and Kale (1985) have observed five phases of fluvial activity since Middle Pleistocene in the upper parts of Krishna, Bhima and Godavari rivers of western Maharastra.

Ramasamy et al. (1992) have observed the northerly migration of Swarnamuki river in the north and southerly migration of Palar river in the south to a probable E-W land arching in Chennai area.

On the basis of drainage anomalies in Luni - Jawai plains of Rajasthan, Amalkar (1988) has inferred Neotectonic activities along NE-SW lineaments / faults.

Barooah and Bhattacharya (1989) have demonstrated that the Brahmaputra valley has a number of horst and graben structures of Quaternary period.

Ganapathy and Merh (1989) have observed various fluvial anomalies in Sheturnj river in Saurashtra Peninsula and attributed them to the sea level changes and the compressed meanders to tectonism.

Philip et al. (1989) have analysed the hierarchical changes in the courses of Ganga and Barhigandak rivers in middle Ganga basin and attributed the same to the ongoing tectonic movements.

The entrenchment of river Tawi and deep gorges at the exit of river Tawi in Jammu and Kashmir was explained to be the effect of Late Pleistocene tectonic activity by Ganjoo (1990).

Narasimhan (1990) has observed clockwise rotational migration of river Palar and explained it to be due to possible doming in parts of northern Tamil Nadu.
Ramasamy *et al.* (1991) have analyzed the lineaments of entire western India in conjunction with migratory pattern of many western Indian rivers and brought out a number of active faults.

Radhakrishna (1992) has identified extensive rejuvenation of river Cauvery near Sivasamudram area (south of Bangalore) and inferred N–S trending cymatogenic arching in the area.

Pant *et al.* (1992) have observed recent sinistral and dextral strike-slip movements along NNW–SSE trending Kaphlikot-Ramari and Ghatia Gad faults from drainage deflection and dextral shifting of colluvial fill of Badiyakot landslide in the Loharkhet area, Kumaun Himalaya.

Vaidyanadhan and Ghosh (1993) have observed anomalies in the rivers of Andhra Pradesh and brought out Neotectonic scenario of the area.

Harbor *et al.* (1994) have brought out active tectonic windows from the fluvial anomalies of Indus river.

Ramasamy and Balaji (1995) have observed phenomenal preferential and anomalous migration of Palar, Ponnaiyar, Cauvery, Vaigai and many rivers in Tamil Nadu and attributed the same to the Pleistocene arching and complementary deepening with E–W orientation.

Singh *et al.* (1996) have identified active tectonism with sinistral movements along NNE–SSW lineaments and dextral movements along NW–SE lineaments from the varied riverine anomalies in Indo-Gangetic plains. From the above they resolved the northerly compressive force related to the post collision tectonics.

Ramasamy and Karthikayan (1998) have interpreted a Holocene graben in between Pondicherry in the northeast and Kambam valley region in the southwest in Tamil Nadu on the basis of varied fluvial geomorphic anomalies.

Valdiya (1998) has observed various drainage anomalies in Bangalore peneplains and on the basis of that he has interpreted a number of Holocene uplifted faults to the tune of 300 – 400 m.
Rachna Raj et al. (1999) have studied the ravines in the Lower Mahi valley, Gujarat and from the fluvial anomalies they doubted for pulsatory tectonism during the Pleistocene period.

Ramasamy and Ramesh (1999) have inferred possible sinistral strike slip movements along the NE-SW fault during 1930–1992 AD on the basis of modifications of eyed drainage in river Coleroon in the area east of Tiruchirappalli.

Sharma and Rajamani (2000) have observed contrast in weathering profiles in upper reaches of Cauvery catchment and doubted for ongoing periodic land upliftments.

Ramasamy and Kumanan (2000) have demonstrated land subsidence in Tiruchirappalli area on the basis of mega eyed drainage in river Cauvery.

Sinha-Roy (2001) has visualized many NW–SE and NE-SW faults bounded horst and graben structures in Banas river basin in Rajasthan on the basis of longitudinal river profile morphology.

Valdiya (2001) has observed that the N-S tectonically active faults have blocked many river systems in upper reaches in Cauvery river and created ponded streams.

Valdiya and Kotlia (2001) have observed a lot of fluvial geomorphic evidences like dismemberment and dislocation of Late Quaternary fluvial terraces, lacustrine flats and colluvial cones, ponding of streams, etc. and attributed them to Late Quaternary tectonic movements or reactivation in Kumaun Lesser Himalaya region.

Rachna Raj et al. (2003) have observed active tectonism along ENE–WSW and NNE–SSW faults on the basis of varying drainage anomalies in Karjan river basin of Lower Narmada valley in western India.

Jain and Sinha (2005) have identified a number of fluvial geomorphic anomalies like compressed meandering, knick points in longitudinal profiles,
channel incision, anomalous variations in sinuosity, sudden change in river flow direction, river flow against local gradient and related flooding in adjacent areas, water logging, etc. in Baghmati river, north Bihar plains, eastern India and attributed all to active block faulting.

**Ramasamy et al. (2006a)** have carried out regional interpretation of drainage anomalies viz: deflected drainages, eyed drainages and anomalous compressed meanders in parts of South India and from the same identified the active faults with vertical and transverse tectonic movements.

**Ramasamy (2006b)** has carried out remote sensing based interpretation of all the deltas of Tamil Nadu viz: Proto Palar, Palar, Ponnaiyar, Cauvery, Manimuttar and Vaigai rivers and identified the perceptible preferential migration in these rivers in their deltaic regimes, and therefrom he has brought out tectonic arching and subsidence, block faulting and transverse fault movements in the Middle–Late Holocene period.

**Ramasamy et al. (2006b)** while interpreting the palaeochannels in Cauvery delta of Tamil Nadu, observed northerly rotational migration of river Cauvery and attributed the same to the ongoing upliftment of Pattukottai–Mannargudi Mio-Pliocene Sandstone in the south atleast since last 6000 years onwards.

**Nupur Bose et al. (2009)** have done a detail study on migratory trends of the Kosi and indicate that neotectonism and local isostatic adjustments are active in the heavily faulted river basin.

**Ramasamy et al. (2011)** have studied the drainage characteristic pattern in parts of South India and anomalous characters have been inferred to be the indications of dominantly the Eustatic and Isostatic changes. They comprehensively mapped some of drainage anomalies like deflected drainages, eyed drainages and compressed meanders and evolved the tectonic scenario therefrom. This study brought out the scenario of active tectonism along N–S block faults and NE–SW sinistral and NW–SE dextral strike slip faults.
1.2.2.3 Topography and Neotectonics

Patel and Sarkar (2010) have extracted geomorphic features, the nature of altimetric distribution, relief aspects, patterns of lineaments and surface slope, topographic profiles and their visualisation, correlation between geology and topography, hypsometric attributes and finally, the hierarchy of terrain sub-units and terrain character of part of the Chotonagpur plateau and the Dulung River basin therein using SRTM data.

Duarah and Sarat Phukan (2011) have analyzed SRTM DEM-derived longitudinal profiles, valley profiles, valley asymmetry, hypsometric integral values SRTM (Shuttle Radar Topographic Mission) along with earthquake data for neotectonic activities in the eastern Himalayan tributary of the Brahmaputra.

1.2.2.4 Tectonic Geomorphology and Neotectonics

Chamyal et al. (1997) have studied the one of the world’s largest alluvial fan Narmada Alluvial fan with largest axial length of 23km. He attributed the erosion of the alluvial fan to a major episode of tectonic re-activation of pre-existing lineaments which is responsible for the re-confinement of the feeder channel and hence prevents the fan aggradation.

Kumanan et al. (2007) have studied various geomorphic anomalies like wider flood plains and level of dissection of plateaus in addition to eyed drainages, compressed meanders and radial drainages in predicting the seismic vulnerability mapping of Western Ghats.

Philip and Virdi (2007) have studied the morpho-structural details using remotely sensed data along with selected field investigations in delineating new traces of active faults like fault scarp, sag ponds, in the Pinjaur Dun of the northwestern Frontal Himalaya.

Pradeep K Goswami et al. (2009) have interpreted the satellite imagery, Digital Terrain Models (DTMs) and field data for the identification and mapping of various morphotectonic features in the densely forested and cultivated Piedmont Zone in the Kumaun region of the Uttarakhand state of India. Morphotectonic analysis reveals that the fan morphologies and
aggradation processes in the area are mainly controlled by the ongoing tectonic activities.

1.2.2.5 Geophysical Anomalies and Neotectonics

Qureshy (1964) on the basis of various geophysical anomalies has brought out a number of peripheral faults in parts of Tamil Nadu and inferred that the northern Nilgiri massif and the southern Anamalai and Palani hill region of Western Ghat are uplifted with intervening subsidence along Palghat.

Kailasam (1975) on the basis of integrated geophysical surveys, has observed that the southern part of the Indian Peninsula is constantly subjected to vertical epirogenic movements from Late Proterozoic to present day.

Kailasam et al. (1976) have brought out the possible linkages between the water percolation from the Koyna reservoir and their movements along the deep seated faults on the basis of deep electrical resistivity sounding in Deccan trap region.

Tectonic features of Cauvery basin was brought out by Balakrishnan and Sharma (1981) using Bouguer gravity anomaly map.

On the basis of the series of gravity highs and lows along Narmada valley, Qureshy (1981) has observed pulsatory tensional and distensional forces.

Reddy and Ramakrishna (1981) have identified the geophysical anomalies related to recent tectonic movements in parts of Great Indian Desert.

Qureshy (1982) has utilized the regional gravity and magnetic map of India to bring out the tectonic framework of the Indian subcontinent. The framework was well correlating with surfacial lineaments deciphered from Landsat data. Further he has also deciphered zones of tectonic rejuvenation from gravity and magnetic anomalies.
**Ramachandran (1987)** on the basis of lineaments interpreted from Landsat, Aeromagnetic, Bouger gravity and ground geological data, identified basement ridges in Pattukottai – Mannargudi, Pondicherry – Cuddalore and Thanjavur areas and depression in Ramanathapuram–Palghat region.

The crustal structures of Tamil Nadu, brought out by **Reddy et al. (1988)** on the basis of aeromagnetic data, have shown increase in crustal thickness towards north and northwest.

**Singh et al. (2001)** have carried out resistivity sounding in the epicentral region of Bhuj earthquake of 26 January 2001 and inferred a low resistivity layer especially in the liquefaction sites and further they observed that along this site most of the houses were sunk, whereas elsewhere the damage pattern was totally different.

**Anand et al. (2002)** on the basis of ground magnetic survey have identified the coastal structures in Mahanadi delta.

**Anand and Mita Rajaram (2002)** have studied the aeromagnetic high amplitude signature associated with eastern and flatness of western Dharwars and correlated with the iron rich metasediments in the east and gneiss in the west.

**Balaji and Ramasamy (2005)** have developed a new technique of creating GIS images from the resistivity data of various depths from ground level for the interpretation of basement folds and faults.

**Mishra, D.C. and Vijaya Kumar (2005)** have studied the evidence for Proterozoic collision from airborne magnetic and gravity studies in southern granulite terrain, India.

**Singh and Jimmy Stephen (2006)** have studied the Moyar Bhavani Salem Attur shear zones and Palghat- Cauvery shear zones using resistivity sounding technique and found these shear zones were characterized by low resistivity even at greater depths like >2500m.
Ram et al. (2007) on the basis of aeromagnetic anomalies have divided Chhattisgarh basin into the northern low anomaly zone and the southern high anomaly zone and brought out the geology of the basin.

Murthy et al. (2010) on their recent geophysical studies, delineated land–ocean tectonics (LOTs) over the eastern margin, associated with moderate seismicity as a result of the compressional stress acting on the Indian Plate. They have attributed coastal seismicity due to the reactivation of the pre-existing tectonic lineaments extending offshore represents a potential natural hazard.

1.2.2.6 Mineral Resources Evaluation

Blanford (1858; 1862) studied the geology and structure of the Nilgiri Hills and the Cretaceous rocks of South Arcot and Tiruchirapalli Districts.

King W and Bruce Foote (1864) contributed to the knowledge of geology of Tiruchirapalli, Salem and South Arcot Districts.

In the 1870s William King examined the Wynad Gold occurrences and investigated artesian wells in Pondicherry - Cuddalore area.

Holland (1893) investigated the iron ores in Salem District.

Middlemiss (1896) examined the Chalk (magnesite) Hills near Salem and corundum occurrences in Salem and Coimbatore Districts.

The classic work of Holland (1900) on the charnockite of St.Thomas Mount and Pallavaram near Madras is well known.

Holland (1901) contributed an article on the eleolite-syenite and corundum-syenite in Coimbatore District.

Hayden and Hatch (1901) examined the Wynad Gold Field and the auriferous localities in the erstwhile composite Coimbatore District.

Krishnan (1942) investigated bauxite deposits in the Shevaroy Hills and he summarized the work carried out by GSI in Memoir Volume No.80 of the Geological Survey of India (1951). And similar contribution was made by Aiyengar who compiled the work of State Mines and Geology, Madras, in
the book 'Minerals of Madras State' (1964). *Crawford* (1970) also notes that diamantiferous diatremes in India are closely related to carbonatites.

**Rao (1977)** have prepared a neotectonic and geomorphic map was prepared from Visual Interpretation of LANDSAT imagery of Eastern Ghats-Godavari delta area on scale 1:1,000,000 on spectral bands 5 and 7 and discussed the importance of some of these major and minor lineaments for sedimentation, oil migration and localization of ore bodies.

Migmatite occurring extensively in Vellore, Tiruvannamalai, and Villupuram Districts around Tiruvannamalai – Gingee – Tirukkovilur is another example of regional migmatisation of granulite facies of rocks at different stages culminating in homophanous granite (*Sugavanam et al.*, 1976a, 1978).

**Sugavanam et al.** (1976b, 1978) has observed Group of ultramafic and ultrabasic rocks (σA) occur as small bodies, near around Torappadi, Thenmudianur, Manmalai, Tiruvannamalai and Mamandur were considered to be intrusive into precursor rocks of Charnockite Group and later deformed and metamorphosed along with the host rocks under granulite facies conditions.

**Balasubrahmanyan et al.** (1979) have dated the early Proterozoic granite is recognised around Gingee, Tiruvannamalai and Tirukkovilur as 2254Ma.

**Ramasamy et al.** (1993) have studied the spectral response of the 29 different minerals and optimized the spectral bands for identifying minerals using Landsat TM data, SPOT and IRS data.

This restricted development of epidote-hornblende gneiss in the zone of alkaline activity implies possible hydrothermal activity generated during the extensional tectonics at the early stage of alkaline plutonism (*Gopalakrishnan, 1994a*).
Gopalakrishnan and Subramanian (1990), Gopalakrishnan, (1994a) observed that the epidote-hornblende gneiss zone also includes areas where large-scale carbonisation, marked by siderite-ankerite permeation into the older rocks has taken place during the alkaline activity.

The Hogenakkal and Pikkili Syenite complexes have yielded ages of 1994Ma and 2371Ma respectively (Natarajan et al., 1994; NGRI, 1994).

Geochronological and isotope studies done by Pandey et al. (1993) and Ghosh et al. (1996) of Sankari-Tiruchengode granites indicate that they were emplaced during Late-Proterozoic/Early-Palaeozoic times. Rb-Sr dating of the leucogranite (trondhjemites) of the Sankari-Tiruchengode pluton has yielded whole-rock isochron ages of 534±15 Ma and 479 ± 12Ma whereas the pink pegmatoidal granite of the same pluton, however, has yielded a younger age of 390±40Ma (Nathan et al., 1994).

The chemical attributes of these dykes suggest that they were emplaced in a continental tectonic setting. The available K-Ar ages for the mafic dykes of Tamil Nadu are clustering around 1700Ma (Radhakrishna and Mathew Joseph, 1993; Sarkar and Mallick, 1995) indicating that they were emplaced during a major extensional tectonic regime in the Southern Peninsular Shield.

The Salem Ultramafic Complex has also yielded an isochron age of 808 ± 18Ma (Reddy et al., 1995). Although the Sivamalai silica undersaturated syenite-carbonatite complex was earlier dated 1020 ± 670Ma (Crawford, 1969) recent studies have shown that it was also emplaced contemporaneously (623 ± 21 Ma) with the plutons mentioned above (Subba Rao et al., 1994).

Bhaskar Rao et al. (1996) have dated the Sittampundi Ultrabasic and Mettupalaiyam Ultramafic complexes as 3000-2900Ma by Sm-Nd systematic.

The mafic dykes show textural characteristics of dolerite, gabbroic / basaltic variants are not uncommon. The mineral assemblages of these dykes indicate quartz-gabbro / quartz–dolerite composition with minor variations
to olivine-gabbro/dolerite. Petrochemical studies indicate that the majority of these dykes are quartz normative tholeiites, while olivine-dolerite dykes show basaltic komatiite chemistry *(Krishna Rao and Nathan, 1999).*

**Deans and Powell (1968); Morolov et al. (1975); Krishna Rao and Nathan (1991); Anil Kumar and Gopalan (1991); Miyazaki et al. (2000)** have placed the time of emplacement of the Elagiri, Koratti, Samalpatti and Pakkanadu complexes alkaline plutons has been well constrained by different isotopic systematic around 700 and 900Ma.

*Nathan et al. (2001)* have studied the occurrence of two major periods of granitic activity – one during Late-Archaean to Early Palaeo-Proterozoic and the other during Neo-Proterozoic times. The granites of older event are restricted to the northern part of Tamil Nadu i.e. North of Moyar – Bhavani – Attur Lineament (MBAL) while the younger Pan-African event is widespread in the terrain south of MBAL.

The Maruda Malai, Vanji Nagaram and Pudukkottai granites have yielded Rb-Sr isochron ages of 619 Ma, 620Ma and 531Ma respectively *(Nathan et al. (2001).*

The geochemical signatures of these granites broadly characterise them as A-type granites emplaced in a “Within Plate” tectonic setting *(Nathan et al., 2001).*

Sanjeevi *(2008)* has done the spectral unmixing of hyperspectral satellite image data for targeting and quantification of mineral content in limestone and bauxite rich areas in southern India. He observed 16 cappings (including the existing mines) by integrating various geological and geomorphological parameters that control limestone and bauxite formation.

**1.2.2.7 Ground Water Resources Evaluation**

Estimating the hydraulic characters of water bearing layers is an essential part of ground water studies. The most effective way of determining
these characteristics is to conduct and analyses in situ hydraulic tests. One of the early records of pumping tests on a large scale in India was done by Vincent and Sharma (1978).

Karanth and Prakash (1988) have observed that the transmissivity values (T) obtained by slug-tests are more than pump-test values for low T values, and that they vary from negligible up to a factor of about three for higher T values.

Gupta et al. (1989) have referred that ratioing, principle component analysis (PCA) contrast stretching and filtering are used for remote sensing data interpretation for ground water exploration.

Ballukraya and Sharma, (1991) have conducted the yield fluctuation in the pre- and post- monsoon periods of an observation well and it is often found advantageous to use recovery, rather than drawdown, measurements for estimating aquifer parameters. An equation, derived from Cooper-Jacob's (1946) is suggested for estimating storativity using residual drawdown measurements from an observation well.

The electrical resistivity method can be used to confirm the relation between the structure and secondary porosity present in the rock (Anbazaghan, 1993).


Krishnamurthy et al. (1996) have used remote sensing and GIS in diverse geological set up for the demarcation of ground water potential zones in Marudiyar river basin, in Tamil Nadu, India.

Kamaraju (1996) has considered the input information on ground water characteristics of various parameters as descriptive form should be converted into “ground water favorability index” (GWFI) values. The
conversion carried out by rating the ground water characteristics of the parameters in terms of representative numeric modelling.

Pradeep Raj et al. (1996) have conducted hydrogeological tests in dug wells located in the crystalline rocks, estimated a range of T values from 26.5 to 56.36 m²/d, for the weathered zone based on the interpretation made using the Papodopulos and Cooper method (1967).


The favorable site for ground water exploration can be identified through aerial and satellite data and compared with the results obtained from resistively data (Ramasamy et al., 1996; Saraf and Chaudhary, 1998; Anbazhagan et al., 2000).

Ramsamy and Anbazhagan, (1997) and Nagappan and Ramasamy, (2005) have successfully applied GIS integration analysis for mapping of fractured aquifer system in central part of Tamil Nadu for charactering the aquifer behaviors.

Nag (1998) describes Remote Sensing techniques as a tool for morphometric analysis, which can be used in finding perspective zones for ground water exploration.

Anbazhagan et al. (2000) and Anbazhagan and Saranathan(2000) have the opinion that Mapping of linear features from remote sensing data has been an integral part of many ground water exploration programs in hard rock terrain.

Shahid et al. (2000) have used seven themes such as lithology, geomorphology, soil, water level fluctuation, drainage density, slope and surface water body to evaluate ground water potentiality. They had given an equation for the spatial analysis of these seven themes.GWPI= (Lw Lr + Gw Gr + Sw Sr + Rw Rr + Ow Dr + Ew Er + Ww Wr ) / Lw. Where, Wi represents weight of a theme and r represents rank of a feature in a theme.
Pratap et al. (2000); Srivastava and Bhattacharya (2000); Sarkar et al. (2001); Subba Rao et al. (2001) and several other workers in India have used the satellite imagery to interpret the lineaments for ground water exploration.

Anbazhagan et al. (2001) describes the influence of lineament on specific yield, transmittivity and static water level, while comparing the aquifer parameters with lineaments derived from remotely sensed data in Kinzig basin, Germany.

Senthil kumar and Elango, (2001) and Elango, (2005) have done numerical modelling simulation was carried in Palar river basin, Tamil Nadu, India to get the aquifer characteristics and behaviour based on aquifer parameters, basin boundary and flow conditions.

Thangarajan (2001) has approached a discrete fractured network model (DFN) in a hard rock region.

In areas where hard rocks have low primary porosity, the intersections of secondary structural features are crucial for productive ground water wells. Structural features in hard rock terrain are often visible on remote sensing data as topographic, drainage, vegetation, or soil tonal anomalies (Kumanan and Ramasamy, 2003)

Chakraborthy and Paul (2004) have identified the potential ground water zones in the Baghmundhi block of Purulia district of West Bengal using morphometric and hydrogeomorphic analysis and concluded that ground water occurs at shallow depths under water table condition within the weathered mantle, fractured hardrock and the narrow zone of unconsolidated sediments, along major river valleys. High fluctuation of water table was observed mostly from valley fills to weathered pediments.

Ravi Shankar and Mohan (2005) have made an attempt to identify favourable zones for the application and adoption of site specific artificial recharge techniques for augmentation of ground water using GIS based hydrogeomorphic approach in the Bhatasa and Kalu river basins of Thane.
district, in western Deccan volcanic province and designed a suitable ground water management plan for a basaltic terrain.

Sanjeev Kumar et al. (2006) have delineated the ground water prospect zones in Tehsil Jhalarpatan, Jhalawar district, Rajasthan using the parameters geology, geomorphology, structures, lineaments, slope, land use/land cover and digital elevation model by using overlay technique and concluded that ground water prospects were controlled by the lineaments / joints. Ground water potential in the area was categorized into good, moderate, limited and poor and based on this categorization, the depth of the wells were recommended for drilling.

Trivedi et al. (2006) was using various thematic maps like geology geomorphology, hydrogeomorphology, soil and land use / land cover studied the geo-environmental aspects of Rajghat dam project.

Prasad et al. (2007) have integrated different thematic maps such as geology, geomorphology, slope, drainage density and lineament map to interpret for potential ground water areas in hardrock terrains of Nalgonda district of Andhra Pradesh. The most favourable zones for ground water were interpreted as good and very good zones. Ground water yield data supported that number of high yield wells lie in the favourable zones which are derived from GIS.

Srinivasarao Yamani (2007) has used the application of GIS for identifying suitable ground water zones for irrigation and drinking in Chittoor area, Andhra Pradesh, India and found that 30.06 % of the area were suitable, 67.45 % of the area were moderately suitable and 2.45 % of the area were unsuitable for domestic purpose and 46 % of the area were suitable, 53.36 % of the area were moderately suitable and 0.64 % of the area were unsuitable for irrigation purpose.

Thakur and Raghuwanshi (2008) have prepared various thematic maps such as geological, geomorphologic and lineament maps. The integrated hydrogeomorphology map was prepared to assess the ground
water resources using remote sensing technique in and around Choral river basin, Indore and Khargone districts, Madhya Pradesh and revealed that ground water potential was moderate to poor in buried pediplains, plateaus, denudational and residual hills, good to moderate in structural hills, lineaments/faults and narrow gorges. The ground water prospects are good in alluvial plains, Valley fills and meandering channels.

**Raghu, and Venkata Swamy (2009)** have made an effort to address the problem encountered by assessment, exploration and management of water resources using integrated remote sensing based techniques in a prominent pilgrim centre, Vemulawada in Karimnagar district, Andhra Pradesh by using High-resolution IRS-IC merged (PAN+LISS-III) satellite data and hydrogeomorphological /ground water prospects map was prepared by visual interpretation techniques.

**Amit Singh et al. (2010)** have focused on underlying natural processes (such as tectonic activity) that play a major role in shaping the hydrogeoenvironment in a long run and Structural changes associated with tectonic activity mainly affect the subsurface features associated with any terrain, affecting the flow and accumulation of water, which ultimately affects the ground water recharge.

### 1.2.2.8 Water Quality Evaluation and Hazardous Ions Zonation Mapping and Detection of Controlling Lineaments

**Karthikeyan et al. (1996)** have observed the prevalence of dental and skeletal fluorosis and fluoride in drinking water varied from 3.8 to 8.0 ppm, consisted of four villages of Ayodhyapatnam block of Salem district. They recorded significantly high Community Fluorosis Indices (CFI) values among both children (3.56) and adults (3.72).

**Chadha (1999)** has proposed a new diagram for geochemical classification of natural waters. The proposed diagram differs from Piper and expanded Durov diagram. A comparison between the diagrams indicated
that the new diagram satisfies the classification of natural water and it can also be used for the hydro geochemical studies.

**Radu et al. (2001)** have used data from five river basins of Walloon region, Belgium and created a hydrogeological geographic information system database which facilitates the ground water vulnerability analysis and hydrogeological modelling for the basins.

**Singh et al. (2001)** have studied the quality of ground water and their impact on soil in 58 villages of Chirawa block of Jhunjhunu district and the results showed that EC of irrigation water has non significant correlation with EC of soil and weak positive correlation with pH of the soil. A positive correlation was found in SAR (0.53) and Residual Sodium Carbonate (RSC) (0.47) of irrigation water with pH of soil.

**Hemalatha et al. (2001)** have created a two parameter weibull distribution model to evaluate the quality of ground water in Cauvery delta, Tamil Nadu, India. The model resulted that the cation parameters were not uniform in the study area.

**Jayashri Jagtap et al. (2002)** have assessed the quality of Purna river for irrigation purpose in Buldana district, Maharashtra. The assessment was carried out in three seasons premonsoon, monsoon and postmonsoon. The results based on SAR, percent sodium and RSC indicates that water is of good to permissible quality as per BIS standard for irrigation.

**Rajmohan et al. (2003)** have analysed the major ion correlation in ground water of Kancheepuram region, Tamil Nadu, India. The results indicated that most of the parameters had good correlation. It also showed that silicate weathering reaction is the main source for high concentrations of major ions.

**Mishra et al. (2003)** have studied the quality of water for drinking and irrigation in and around the mines in Keonjhar district, Orissa, India. The results show that the water is suitable for drinking and irrigation.
Anbazhagan and Archana Nair (2004) have prepared a ground water quality map for Panvel basin, Maharashtra, India. The chemical analysis showed that the samples exceed the limits for chloride, hardness, TDS and salinity. By integrating various thematic maps and spatial analysis, a pictorial representation of ground water which was desirable and undesirable for drinking and irrigation was created.

Patel and Desai (2005) have studied the quality of ground water for irrigation in 10 villages of Surat district, Gujarat, India based on SAR, RSC, percentage sodium, Kelly’s ratio and electrical conductivity.

Mise and Nagaraj (2006) have assessed the quality of ground water in Gulbarga city using GIS technique in order to supply pure water. Various thematic maps were created and using GIS overlay technique. It was concluded that the poor quality of ground water was primarily due to hardness.

Freeda Gnana Rani (2006) has studied the hydrogeochemistry of ground water in Thirumanur area, Tamil Nadu, India. The results were compared with the limits prescribed by Indian Standard (IS) Indian Council of Medical Research (ICMR) and World Health Organization (WHO). The comparison showed that few samples exceeded the limits for nitrates and total hardness.

Ravi Saini et al. (2006) have studied geochemical characteristics of ground water in Saharanpur, Uttar Pradesh, India. The water samples were collected during January and April 2003 and the samples were analysed for various parameters. The results show that the carbonate content was the major problem in this area which leads to scale formations.

Minakshi et al. (2006) have assessed the quality of ground water for irrigation in Rupnagar district of Punjab, India by spatial distribution. The quality was based on the values of electrical conductivity and residual sodium carbonate. The results indicated that maximum area (46.7%) in Kharar
block and minimum area (8.5%) in Anandpur Sahib block were marginally sodic waters.

Harikumar et al. (2007) have assessed the status of fluorosis in northwestern districts of Tamil Nadu using community fluorosis index where it varies from as high as 55-81% in Dharmapuri, Krishnagiri and Salem.

Mishra and Srivastava (2008) have analysed the quality of ground water of Tulsipur town at Indo-Nepal border using ground water samples at three different depths 10-12 meter, 20-25 meter and 30-35 meter using Water Quality Index (WQI). The results based on WQI revealed that the quality of ground water was on the border line of fair to very poor and therefore it was not fit for human consumption until it was properly treated to remove the pollutants.

Shankar and Balasubramanya (2008) have evaluated the quality indices for ground water of Whitefield industrial area in Bangalore which was determined by collecting thirty ground water samples in and around the industrial area. Water Quality Index (WQI) was calculated based on ten parameters. The WQI ranged from 11.58 to 495.07 with an average of 69.95. The analysis revealed that the ground water samples in general can be considered fit for human consumption.

Tambekar et al. (2008) have analysed the quality of water in Purna river basin in Akola and Buldhana district of Vidarbha region based on WQI. A total of 260 samples were analysed for different physio-chemical parameters. The study revealed that the samples were within the permissible limits prescribed by WHO and IS standards for drinking except for salinity, chloride, nitrate, phosphate and conductivity. Based on WQI it was concluded that the drinking water was 80% safe and 20% unsafe for drinking and domestic purposes in salinity affected villages of Vidarbha region.

Madhumitha Das (2009) has identified the effluent quality indicators for use in irrigation using factor analysis. Effluent quality factors (grouping)
and effluent attributes were identified using principal component analysis on 23 chemical attributes from 20 different industrial units. The analysis resulted that the salt type, salt stress, heavy metal impact and potassium effect were identified as most critical factors.

Rajankar et al. (2009) have assessed the water quality of ground water resources based on water quality index in Nagpur region of India. Twenty two different sites were selected in postmonsoon, winter and summer season. The water quality index was calculated using National Sanitation Foundation information system. The results revealed that the underground drinking water at almost all the sites was highly polluted

Ramakrishnaiah et al. (2009) have assessed the quality of ground water using water quality index for Tumkur taluk in Karnataka state of India. Calculation of the water quality index was based on 12 parameters and the range of WQI was between 89.21 and 660.56.The high value of WQI was mainly due to the high values of iron, nitrate, total dissolved solids, hardness, fluorides, bicarbonates and manganese. The authors concluded that the ground water of the area needs some degree

Amit Singh et al. (2010) have focused on changes in ground water In Yamuna basin as well as surface water resources with respect to underlying natural processes (such as tectonic activity) that play a major role in shaping the hydrogeoenvironment in a long run especially affects the subsurface geochemical composition. Studying these effects is not easy as the changes associated can be very subtle, spread over a large landscape.

Prasanna et al. (2010) have assessed the major ion chemistry and suitability of water for domestic and drinking purposes of Gadilam river of Tamil Nadu.

1.2.2.9 Landslide Hazard Evaluation

Dave and Joshi (1988) have prepared a hazard zonation map for Nayar basin of Garhwal Himalaya and also assessed the risk involved, by analysing the factors like landuse, human activity and slope stability factors.
Jagannath Rao and Mukherjee (1989) have brought out some techniques for the control of rock slope failures and also discussed about its management needs and application impetus for Nainital area. The need of field and laboratory data input before analysis and application of remedial measures were also emphasized by them.

Anbalagan (1992) has derived a classification system which combines past experience of causative factors and their impact on landslides and this classification was called the landslide hazard evaluation factor (LHEF).

Choubey et al. (1992) have developed a landslide hazard zonation mapping technique using Landuse categories as input parameters for Uttar Kashi and Tehri districts.

Gairola (1992) has brought out the landslide hazard zonation and risk assessment maps of Alakananda Valley. The tectonic factor was considered as an important triggering parameter by him.

Sharan (1992) has prepared a landslide hazard zonation map for Chenab river valley with the help of rock mechanics analysis. The input from the geology, structural features and slope were used as basic input data by him.

Pachauri and Pant (1992) have suggested new method for the landslide susceptibility zoning using geological and geomorphological factors by applying weighted rating system. The data collected from aerial photographs, topographic sheets and image suggests that there is a correlation between the distribution of landslide and some of the geological and geomorphological factors.

Gupta et al. (1993) have again prepared landslide hazard zonation map for the Upper Sutlej Valley with the help of various geological parameters.

Zonation of areas susceptible to landslides in Garhwal Himalayas along Pindar river was done by Nagarjun and Roy (1994).
Mehrotra et al. (1994) have applied morphometric analysis to bring out landslide zonation maps for Chilla landslides of Sikkim Himalayas.

Landslide hazard zonation was discussed as an important input for the geo-environmental assessment for parts of Garhwal Himalayas by Sharma and Kandpal (1995).

Sarkar et al. (1995) have brought out landslide hazard zonation maps for parts of Garhwal Himalayas. They attributed the risk factor involved in the Rudraprayag region to mass movements and also to slope stability characteristics.

Venkatachalam (1996) have developed a technique for analysing the mass movements and slope failure using DTM.

Sidharthan et al. (1997) have showed the importance of socio-economic evaluation of landslide prone regions because over exploitation of resources and the development activities and traditional land use practices depends upon the socio-economic situation of the region which aggravates the vulnerability. The natural disasters are usually affected by weaker section or people below poverty line of society since they are economically ill-equipped to cope up with the disruption of life. Hence the role of socio-economic evaluation in the case of disaster management is much emphasized.

Studies conducted by Nagarajan et al. (1998) on parts of Western Ghats demonstrated the importance in selection of temporal remotely sensed data and its integration with terrain attributes using GIS in the demarcation of areas prone to slide.

Sati et al. (1998) have correlated the trends of the rocks, slopes, the structural features and the rock lithologies with landslides and finally illustrated how the slopes on the ridges parallel to the Himalayan trend (i.e. WNW-ESE) are most susceptible for the mass failure.

Suresh Francis (1999) has developed threshold for over 18 terrain parameters on the basis of landslide incidence and generated buffered GIS
outputs, integrated all in GIS and based on the number of parameters loaded, prepared LVZ map for Nilgiri Mountain.

Landslide hazard susceptibility mapping of tropical monsoon region of Western Ghats of Maharashtra was developed by Nagarajan et al. (2000) using terrain factors and climatic factors.

Ramakrishnan et al. (2002) have prepared landslide hazard zonation map with the help of remote sensing and GIS. The authors considered slope, soil, land use/land cover and geology. In Nilgiri district high intensity rainfall triggers landslide and studies reveal that it occur mainly due to exhaustive deforestation for the development of urbanization and plantation.

Sarkar and Kanungo (2002) have described the influence of various parameters in landslide occurrence with the help of remote sensing and GIS. Their study has shown that the terrain parameters such as lineaments, drainage density and road cutting influences landslide frequency. Except drainage density, other two factors show a direct relationship. They considered road construction as one of the important anthropogenic factors that often cause slope instability.

Kishore Kumar and Sati (2003) have mainly focused on the relationship between seismicity and landslides in Himalayan region with special attention to Uttaranchal Himalayan region, which lies in zone IV, and V of seismic venerability atlas of India.

Emmanuel et al. (2004) have analyzed 3 years of daily sediment load and daily rainfall data and inferred that the relationship between these two acted as triggering parameters for landslides in the Annapurna region of Nepal. These further suggested that, for a given hill slope, regolith thickness determines the seasonal rainfall necessary for failure, whereas slope angle controls the daily rainfall required for failure.

Sarkar and Gupta (2005) have showed that density of landslide occurrence is high in low drainage density (<2 km/km²) followed by
moderate (2-3 km/km²) and high drainage density (>3 km/km²). This result may be explained in terms of the fact that in the areas of low drainage density, the surface runoff is less resulting in high water seepage and pore pressure for landslide occurrence.

**Saha et al. (2002 & 2005)** have developed GIS based landslide hazard zonation for a part of the Himalayas and also developed GIS based route planning in landslide prone areas.

**Champati Ray et al. (2008)** have demonstrated the utility of remote sensing (ASTER) in providing valuable information that is critical for hazard mitigation in case of landslide dam breach.

**Ghoshal et al. (2008)** have prepared LVZ maps using Lithology, structure, slope morphometry, relative relief etc using BIS method.

**Ramasamy et al. (2008)** have developed a newer methodology using the geospatial technology by preparing various GIS databases on landslides controlling geosystems, development of thresholds on the geosystems on the basis of landslide incidences and integrating them using GIS for bringing out landslide vulnerability maps.

**Sharma and Kumar (2008)** have carried out statistical cum GIS- based landslide hazard Zonation for Parwanoo area, lesser and outer Himalayas.

**Shipra Chaudhary et al. (2008)** have used the Ground Penetrating Radar (GPR) to investigate the subsurface features. On the basis of detailed geological study of the sinking zone observed zones prone for landslides.

**Vijith (2008)** has used weights of evidence method to derive landslide hazard zonation in GIS environment.

**Saraf et al. (2010)** have studied earthquake induced landslides especially in different terrains like Himalaya, based on temporal high spatial resolution remote sensing data and provided important inputs towards existing landslide hazard zonation methods.
1.3 STUDY AREA

Owing to its geographic and geologic position in Tamil Nadu, Salem region gains much importance. Moreover, the less understood concept based study warrants a place where the evidences are pooling and the complexities are more. Two study windows are selected in order to emphasize the regional tectonic setting and much focus was given to an area selected out of the first window, based on anomalous signatures picked out from terrain parameters (Fig.1.1).

1.3.1 Lithology

Geologically, the study area is covered predominantly by hard crystalline rocks belonging to Precambrian in the central and western parts with the Cretaceous, Tertiary, Pleistocene (Laterite) and recent alluvium are exposed in the eastern parts (Fig.1.2; GSI, 1995).

While the Charnockites of the Precambrian’s form high order hill ranges, the Granites and Gneisses belonging to Precambrian’s form the vast Pediplain called as Peninsular Gneissic Complex (PGC). In the eastern fringe, while the Cretaceous rocks form pediment surfaces, the Mio-Pliocene formation (Cuddalore Sandstone) forms marginally raised uplands. Further, Laterite of Pleistocene age forms a marginally hard and compact rock either forming rocky pediments or gravelly horizons and the recent alluvium are mostly sands, silts and clays related to fluvial activities.

A wide variety of lithologies including charnockite, pyroxenite, amphibolites, banded magnetite-quartzite, garnetiferous metagabbro, anorthosite, ultramafite and vast areas of quartzofeldspathic gneiss, hornblende-biotite gneiss, granite gneiss, quartzite, metapelites, sillimanite schist represent different stratigraphic units of diverse ages in various tectonic blocks surrounding the study area. Most of the hills viz., Yelagiri hills, Biligirirangan, Shevaroyan-Kalrayan hills, Kollimalai-Pachaimalai hills, Bodamalai hills, and other minor hills expose high grade rocks comprising
massive, structure less or poorly banded charnockite, mafic granulite and amphibolites.

Fig 1.1 Study Region and Study window
The gneiss and supracrustal rocks are bounded by Moyar-Bhavani Salem-Attur Shear Zone (MBSASZ) in the middle of Attur valley, which is marked by intense development of mylonite, mylonitised pyroxene granulite, quartzofeldspathic gneiss and garnet amphibolite. The amphibolites are retrograded to actinolite schist, chlorite schist, phyllonite and mylonite.
The most extensive domain of hornblende-biotite gneiss and quartzofeldspathic gneiss are mixed together on all scales. Dark coloured mafic enclaves, now occurring as amphibolite, are either intensely folded or sheared along with the country rocks. Regionally, most of the gneisses trend E-W in contrast to the N-S trending supracrustal belts within the Peninsular Gneiss.

Numerous small bodies of garnet amphibolite, two-pyroxene granulite, ultramafite (hornblendite) meta-dolerite and alkaline rocks intrude the country rocks in the low-lying region of the MBSASZ of interest. There are patchy and incipient developments of charnockite on to the quartzofeldspathic gneiss; the later gradually loses its gneissose character to become massive and structure less (Ravindra Kumar et al., 1992).

In the eastern part of the region cretaceous and tertiary rocks are having a sharp contact with the older crystalline rocks.

1.3.2 Physiography and Geomorphology

The study region is having varied physiography with alternating highlands and plains. A relatively long broad depression lies in between Shevaroys, Chitteri and Kalrayan hills in the north and Kolli and Pachchai hills in the south, forming wide valley (graben?). Maximum elevation of the study region is around 1649m which is in Shevaroian hills. There are many linear depressions in the northern hills and linear ridges in the central valley region.

By interpreting the IRS-1B FCC satellite imagery, the geomorphology map was prepared for the study region (Fig.1.3) and the same shows that the Precambrian rocks (Predominantly Charnockite) form the higher order structural hills in the western part of the study area and these only form the outer most eastern limb of the Cochin-CapeComorin-Madurai-Salem fold belt, (Ramsamy et al., 1999).
On the contrary, the Precambrian gneisses form the vast pediplain / pediment-inselberg complexes. While the Mio–Pliocene Sandstone and the Laterite form the rolling upland along the east coast, the Pleistocene sediments are of colluvial fills, alluvial plains and deltaic plains of Ponnaiyar, Vellar and Kolli dam river system. The river systems responsible for the fluvial landforms (colluvial fills, flood plains, alluvial plains and deltaic
plains) are Ponnaiyar River in the north and Vellar in the middle and Kollidam in the south.

In general, the Charnockitic hills are forming higher order mountains in the west central part whereas rest of the eastern plain of the study area has a smooth easterly gradient facilitating the birth and well evolved growth of the above river systems.

1.4 AIMS AND OBJECTIVES

The present study was taken up as the preliminary observations made in the area indicated the possible linkage between recent tectonic movements and the environmental systems. So, an attempt was made in this study to understand the geodynamic processes in relation to geoenvironment.

The aims and objectives of the present study are,

- Regional study on central part of Tamil Nadu and demarcating potential area for selecting a study window for detailed tectonic analysis.
- Remote Sensing has greater potentials in revealing various geological and geomorphological anomalies; while the other tools like aeromagnetic survey and ground based resistivity survey have their own values. The GIS technology has enormous virtues to amalgamate and visualize various Earth system dynamics related phenomena.
- Peninsular India has become more prone for earthquakes and identifying the causative lineaments will give an idea on futuristic safety and geothermal sources studies.
- Detail study on shear zones on selected windows with extensive field work.
- Implications of tectonism and neotectonism on the georesources are enormous- in terms of mineral and water potential. The control of lineaments over the mineral resources and their metasomatic and hydrothermal alteration.
➢ The control of lineaments over the migration of ground water and their implications.

➢ Demarcating tectonically active region and studying the geological and other input to the geohazards such as landslide and water quality oriented hazards of this part and thereby emphasizing the role of geosciences for the safe negotiation of human with nature.

Hence the main aims of the study are

(1) **Finding suitable study window from regional study**
   - Based on topographical, lithological, geomorphological, structural and lineament anomalies

(2) **To map the Neotectonic and Seismotectonic lineaments**
   - Using all possible anomalies viz: tectonic, fluvial, geomorphological, lithological, geophysical, drainage and trend line anomalies, etc. with the help of Remote Sensing and GIS

(3) **To validate the Neotectonic and Seismotectonic map**
   - With multi-depth isoresistivity data, alignment of springs, field study and with historical seismic records.

(4) **To bring out the tectonic association of mineral deposits, their alteration with respect to Neotectonic lineaments.**
   - Alignment of mineral deposits along lineaments and their alterations

(5) **To find out any possible new mineral resources based on alignment of major lineaments.**
   - Basic image processing operation like band ratio and density slicing on the segments of probable lineaments influencing zone.

(6) **To demarcate the water potential zones**
   - Preparing thematic maps and identification of water potential zones by rank and weight method.
(7) To establish the conduit lineaments and leaky/ discharge lineaments

- Analyzing preferential direction of water level fluctuation and identifying conduit lineaments.
- Looking for springs along the conduit lineaments and marking the leaky lineaments.

(8) To study the water quality spatial distribution pattern and mapping Hydro-chemical hazardous zones

- By analyzing the concentration pattern of the hazardous ions above the standard limits prescribed by IS10500-1991 (Tambekar et al., 2008)

(9) To analyze the role of conduit lineaments in the spatial distribution of cations and anions.

- Analyzing preferential direction of ions distribution with respect to Neotectonic lineaments.

(10) To demarcate the landslide vulnerable zones and analyze the role of Neotectonic lineaments.

- By Index overlay method.
- Analyzing the spatial relationship between loci of landslide occurrences and Neotectonic lineaments.

1.5 METHODOLOGY IN BRIEF

The methodology adopted in the present research is shown in the form of flow chart in Fig.1.4. In the study IRS IC LISS III data acquired on 19th February 2004 (P100/R67) four band raw and digitally processed IRS-1A data of 1992 (P24-R60) were used extensively for detecting and mapping the tectonic and geomorphic anomalies. Shuttle Radar Topographic Mission (SRTM) data was used to build topographic profiles and topographic anomalies were detected.
Topographic, lithologic, tectonic, fluvio-geomorphic, and aeromagnetic anomalies were catalogued and taken into account in mapping Neotectonic zones. The anomalies observed by the earlier workers in parts of South India were also taken into account. In addition, lot of anomalies and a number of GIS based visualization techniques were used in the present study to identify newer and characteristic anomalies which can signal such Neotectonic zones.

By duly interpreting raw and digitally enhanced IRS-1C satellite images, the lineament map was prepared for the study area and from the same, various anomalies such as curvilinear lineaments, branch-off lineaments and parallel lineaments were interpreted and probable zones of Neotectonics were deduced.

In the same way, various drainage / fluvial anomalies were interpreted such as radial drainages, palaeochannels, deflected drainages, compressed meanders, eyed drainages, etc.

SRTM based shaded relief map poured enormous information on the anomalous relief variations and such anomalies were picked for Neotectonic mapping. Similarly, the rocks which symbolize the tectonic break or weak zones and evidences of shearing were taken as possible places of reactivation and such area were underlined with caution so as to validate the zone later with field study.

Aeromagnetic total intensity anomaly map was drawn and analyzed for magnetic lineaments and breaks.

All such anomalies were amalgamated together using GIS and areas of tectonic weak zones were identified.

All these anomalies picked up from lineaments, fluvial and tectonic geomorphology, geophysical resistivity and ground water were integrated using ARCGIS and zones of coincidence were identified as probable zones of Neotectonics in the study area.
In addition to building up the concept for Neotectonic mapping, the Neotectonic model brought out for the study area was also validated with the help of historical seismicities data.

![General Methodology Flow Chart](image)

**Fig. 1.4 General Methodology Flow Chart**

The geophysical resistivity data were collected for 1300 locations for the study area and 3D GIS images were generated for multiple depths viz. 30, 50, 80, 100 and 150m and anomalous zones were analyzed for their alignment with Neotectonic lineaments.

At the next stage, impacts/contributions of Neotectonics over the resources and certain hazards were analyzed such as mineral and water resources and hazards like landslides.
1.6 SYNTHESIS

The Indian Peninsula (Present study area) which has all along been thought as tectonically inert and seismically safe, a large number of seismicities numbering about 250 (more than 2.5 in magnitude) have occurred during the last 200 years or so. In addition, many disastrous earthquakes have also started occurring in many parts of Peninsular India. Hence, it has become very much important to understand the seismic vulnerability of the region, so that possible mitigation strategies can be evolved.

At the same time, globally lot of studies have been conducted and these studies seem to have used either tectonic, geomorphic, geophysical or instruments based mapping and much detail analysis was not done on their implications on mineral and water resources and hazards like landslides and hydrochemical related. Further, the newer technologies like Remote Sensing and GIS and the advanced credentials of GIS visualizations and integration have not been done in the past.

Hence, the present study has been undertaken by taking all the possible anomalies to evolve precise concepts / methodology for Neotectonic mapping and proper validation with seismic record, isoresistivity method and alignment of springs. Moreover, number of test sites were selected for detailed field study.