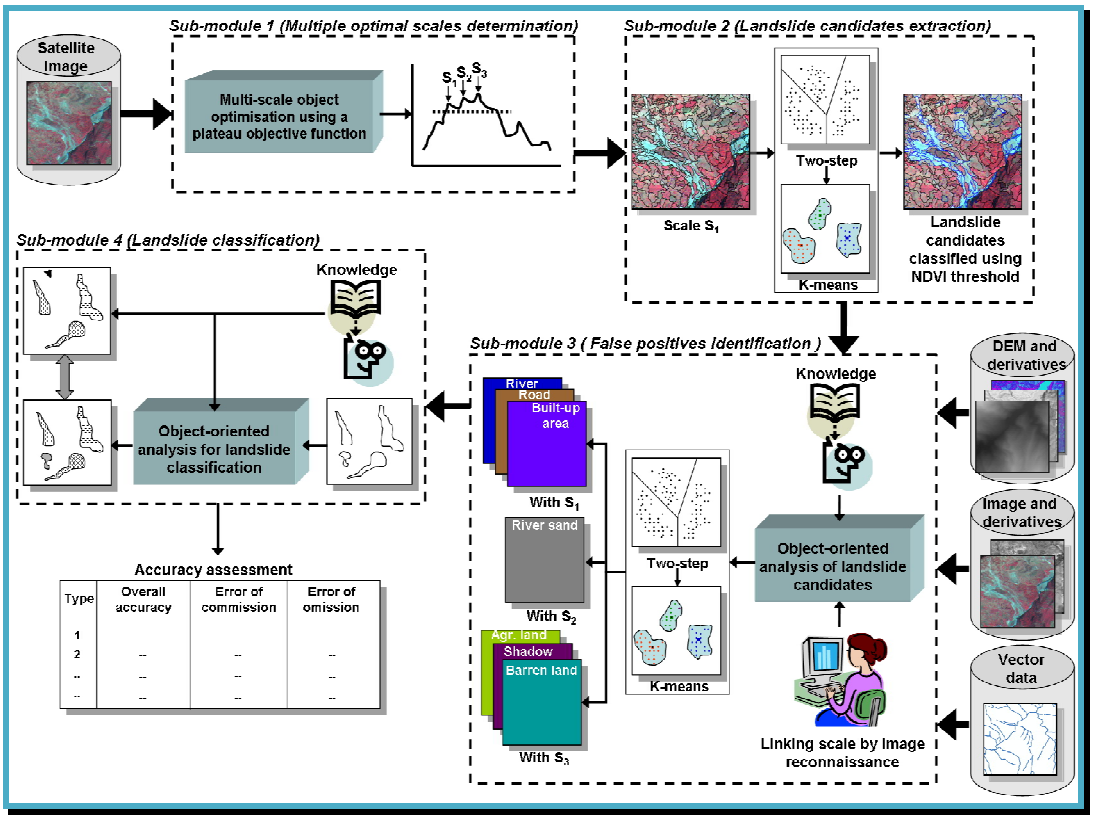
DETECTION OF LANDSLIDES FROM HIGH RESOLUTION OPTICAL SATELLITE DATA

Landslide is a major natural disaster in India or countries elsewhere where significant portion of landmass is in mountainous areas. For such areas, identification of landslide forms a fundamental input to develop landslide hazard management and mitigation measures. Previously, landslides used to be identified either by manual image interpretation process or by field investigations that demanded considerable amount of time and labour. Recently, a new technique using advanced object-based image classification method is developed to automatically detect landslides from satellite data. This technique imitates the human interpretation process in identification of landslides. This technique has the potential to be integrated in the DMS programme of ISRO for landslide incidence and hazard mapping.

THE PROCESS OF LANDSLIDE DETECTION

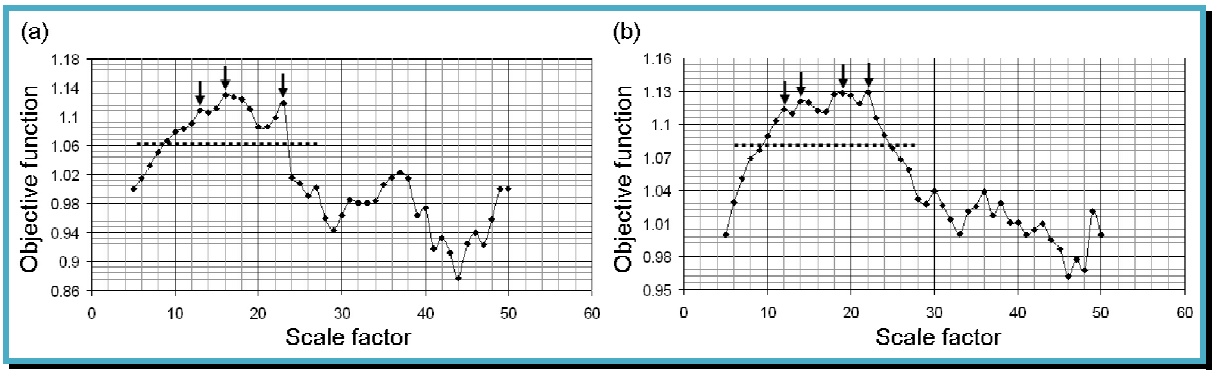
Landslide is a geomorphic phenomenon, therefore its identification is difficult to address in spectral domain alone using satellite/aerial data sets. The common noticeable feature after occurrence of landslides is the loss of vegetation and exposure fresh rock and soil. This unique property of a landslide in combination with its relationship with slope related parameters is used to create a generic routine in a COTS s/w, and is implemented through four sub-modules.



[An illustration showing the four sub-modules in the work flow of the landslide detection method]

Objective determination of segments

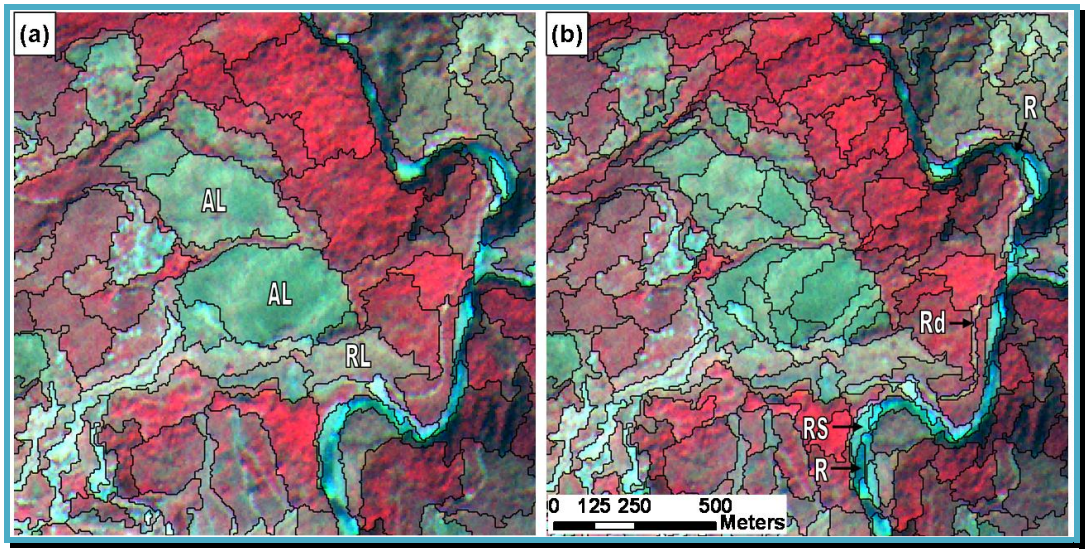
These four sub-modules are developed using knowledge-based hierarchical classification technique that works in an object-based environment, where effective integration of spectral, contextual and morphometric properties of landslides is possible to accurately and meaningfully identify landslides. Size of the segments/objects obtained from segmentation technique (a pre-requisite for object-based classification) is determined objectively through a newly created plateau objective function (POF). POF is a statistical function, created using intrasegment variance and spatial autocorrelation (Moran's I).



[Multiple scale factors (shown by arrows) obtained through POF are used in the landslide detection method. Scale factor is used to control the size of segments e.g. small scale factor will produce small size segments]

Multi-scale classification

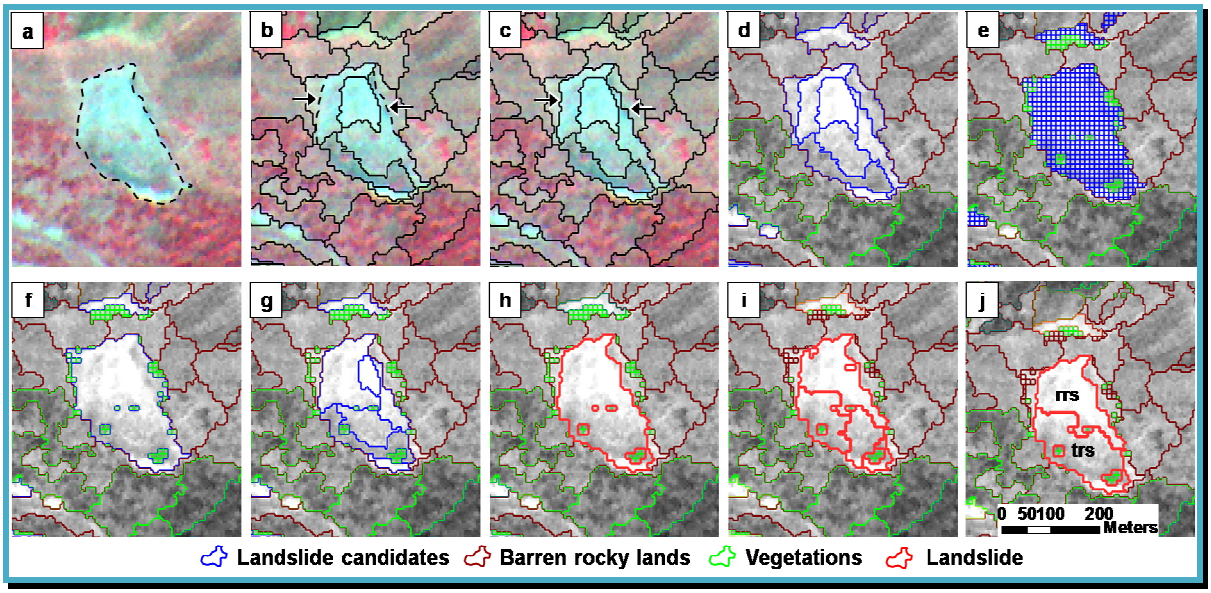
POF helps to identify inherent scales in the satellite data depending upon the sizes of the landscape features. Therefore, multiple scales are used to classify one image instead of a single scale. This helps to eliminate landslide false positives (e.g. river sand, barren land, buildings, roads, uncultivated agricultural land etc.) accurately thereby increasing the accuracy of landslide detection process.



[Agricultural lands (AL), generally of larger size in comparison to roads (Rd) were accurately identified using a larger scale factor (left image) where as roads were classified with a small scale factor (right image)]

Landslide detection

Finally, all the characteristic features of landslides derived from satellite data (e.g. NDVI, brightness) and DEM (e.g. slope, relief, curvature) were fused together in a series of steps comprising of controlled segmentation, merging, classification, thresholding etc. To increase the robustness and transferability of the landslide, a data driven thresholding approach using K-means algorithm was employed. The knowledge-based approach was further strengthened by utilising change detection technique that increased the landslide detection accuracy from 76.4 % to 96.7%. The minimum size of the landslide that can be detected using this method depends upon the resolution of the satellite data. However, using 5.8 m resolution data, a landslide of 774 sq. m was detected.



[Few steps, from segmentation to classification, of the object-based landslide detection technology developed to detect landslides]

SALIENT FEATURES

- The technique requires only high resolution optical satellite data.
- The technique combines spectral, shape, texture, morphometric and contextual information derived from high resolution Indian satellite data and DEM for the preparation of new as well as historical landslide inventories.
- The main innovative aspect lies in the selection of landslide diagnostic parameters and their use in the comprehensive characterisation of different types of landslides, a concept which is addressed for the first time for detection of landslides in an object-based environment.
- Towards the development of a robust data driven methodology, a new POF was developed that was helpful in the multi-scale analysis of a terrain.
- Together with POF, and applying a change detection method using archived satellite data, a maximum landslide detection accuracy of 96.7% in Okhimath area of the Uttarakhand state could be achieved.

- The method has been validated in other mountainous terrains of India that has a different geological and geomorphological setup.

APPLICATIONS

This technology will be used to create routine landslide inventories e.g. on monthly or annual basis for large Himalayan region in India. This technology can also be used for land cover classification or vegetation change detection after suitable adaptation, since few land cover units such as barren land, agricultural land has already been identified as false positives to landslides.

THIRD PARTY S/W

The landslide detection process is developed using the eCognition software, which is a proprietary item of M/s Trimble GeoSpatial, USA. The developed algorithm is available as a encrypted file (.dcp), which can be executed by any user having eCognition s/w.

COMMERCIAL APPLICATIONS

- Creation of a baseline data for landslide hazard and risk assessment.
- Automatic land cover classification.

TECHNOLOGY TRANSFER FROM ISRO

NRSC/ISRO is willing to transfer the knowhow of this technique to academics/industries that deal with natural resource assessment from satellite data. Interested individuals/party (s) may write to the address given below stating the end use of the technology or diversification of the existing technology, if any.

Director

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Indian Space Research Organisation

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Andhra Pradesh

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