A Study in Correlation of Landslides and Increase in Areal Extent of Quarries in Malappuram District

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Abstract—Malappuram is one of the 14 districts in the Indian state of Kerala, with a coastline of 70 km. It spans an area of about 3,554 km^2, making it the third-largest district of Kerala by area. The highlands of Kerala experience several types of landslides, of which debris flows are the most common. The processes leading to landslides were accelerated by anthropogenic disturbances such as deforestation since the early 18th century, terracing and obstruction of ephemeral streams and cultivation of crops lacking capability to add root cohesion in steep slopes. For regions like Kerala in the Western Ghats, multiple factors add up to the impact we saw during the monsoons of 2018 and 2019.. Since the 19th century, over 50% of land with tropical forests and grasslands has been converted to monoculture plantations and agricultural fields. This has made the terrain much more vulnerable to landslides. Behind every landslide, there is an unscientific change of crops, cutting off the slope of the hill, construction, and quarrying. The 2018 floods debate revolved around the huge rains and dam operations. But a third primary reason, ecological destruction of western ghats largely remains undebated.In this project, we are trying to find out is there any correlation between increment in area of quarries and landslides in Malappuram.

Key words: Quarries, Landslides

I. INTRODUCTION

Landslides of shallow nature but disastrous are very common in the hill ranges of Kerala, the southernmost state of India. Kerala is a state highly vulnerable to natural disasters and the changing climatic dynamics given its location along the sea coast and with a steep gradient along the slopes of the Western Ghats. Kerala is also one of the most densely populated Indian states (860 persons per square kilometers) which makes it even more vulnerable to damages and losses on account of disasters. A landslide is defined as the movement of a mass of rock, debris, or earth down a slope. Different factors trigger occurrence of landslides such as relative relief, slope, aspect, curvature, drainage intensity, drainage frequency, land usage, road buffer, drainage buffer etc. The structurally disturbed weakened bedrock, the increased frequency of slope failures etc. have been associated with unscientific land use practices and developmental activities in naturally existing landslide hazard areas. An evaluation of landslide risks is a requirement for the region's sustainable growth.

Quarrying is the process of removing rock, sand, gravel or other minerals from the ground in order to use them to produce materials for construction or other uses Scientists and environmentalists claim that not only heavy rainfalls, increasing number of quarries and unscientific excavations there makes certain regions of Kerala vulnerable to landslides. The abundance of quarries in the ecologically sensitive areas and soil piping phenomena can be cited as two major reasons for the landslide disaster. There were 21 quarries within the 10km range in Kavalappara where a massive landslide occurred. Quarrying disturbs the rock structure in mountains and may cause it to become unstable. Operation of quarries in an area results in changing the landscape of the area.

We chose Malappuram district as our site of selection because of the exceeding number of quarries and the landslide disasters. A temporal study is conducted on landslides in Malappuram district and increment area in quarries is found out to check a correlation between both. Landslide data are collected from Disaster Management Authority to get details about the location of landslides and their intensity. Quarry data are collected from Google Earth and Open Street Maps. The different data collected are incorporated into a GIS platform and the correlation between increase in quarry area and landslide is checked.

Objectives

- To carry out a temporal study on landslides occurred in Malappuram
- To identify the increment in area of quarries in Malappuram district.
- To find the correlation between landslides and quarries in Malappuram.
- To prepare a detailed map on quarries and landslides that have occurred in Malappuram

Scope

- Not considering any impact other than landslides due to quarrying.
- Detailed data about landslides are not available.

- Lack of year wise data of quarries.

General Plan of Implementation

Site Selection

Malappuram is one of the fastest growing districts of Kerala. We chose Malappuram district as our site because of the exceeding number of quarries and the land sliding disasters. We noticed that there has been an increase in quarries in the past 8 years.

Collection of Data from Concerned Authorities

In this step we collected the data in detail from the disaster management and from the collected data, we got an idea about the location of landslides and time of landslides etc. We also collected the data of various other factors which trigger the landslides and can correlate with quarries.
The factor which may trigger the quarries are: Rainfall intensity, Type of Soil, Effects of quarries in soil etc. The data on rainfall intensity can be collected from the meteorological department of Kerala and soil quality from the geology department of Kerala.

Quarries Data from Open Source

In this step we used KOMPAS software, Google Earth and OpenStreetMap as an open source for the collection of quarries data. From KOMPAS software we got the location of different quarries in Malappuram district. We incorporated the location data obtained from KOMPAS software to Google Earth. From Google Earth we found out the areal extent of quarries from 2007 to 2018. We used the Polygon tool in Google Earth to find the area and perimeter of quarries. The historical imagery of satellite images were obtained from the historical image option of Google earth. The extracted data from each quarry was saved using the save image option in Google earth.
Using the Open Street Map, we plotted each quarry in Malappuram. The layers were maintained in Maxar Premium Imagery (Beta) to get the updated satellite image. We can give all the details including the area in the description. We can overpass turbo to write queries to extract the quarries in Malappuram. Thus we can conclude all the quarries of Malappuram district in a single Map.

Incorporating the Data to GIS Platform

In this step we analyzed each factor caused by the exceeding number of quarries in Malappuram which may trigger landslides. The impact of each factor was analyzed. The factors are prioritized based on the intensity of impact in landslides. We used various methods for analyzing the factors and different degrees of intensity were given to each one. The values should be given to the software the shape files of landslide locations of 2007 and 2018 which we got from the disaster management Authority of Kerala were added as vector layers to the GIS platform using the Add Layer tool. The quarry data we mapped with the help of KOMPAS and Google Earth was incorporated to the GIS platform. For that the quarry location which was saved in CSV format was used. Thus we incorporated them into GIS platform.

Checking Correlation of Landslide with Quarries

In this step, we checked the correlation between landslides and areal extent in quarries. In the previous step we incorporated the data into GIS platform. Now we created a buffer zone around the location where landslides occurred. The buffer zones were created at a radius of 2km, 4km, 6km and 8km. For this we used the Multi Ring Buffer tool in QGIS software. The landslides occurring within the buffer zones created with respect to quarry locations are noticed. The variation of intensity in rainfall, the change in quality of soil, the chances of flood, changes in groundwater etc. also triggers landslides.

Map Generation

Maps were created for each buffer zone created around the quarries. For this we used the add map tool in the QGIS layout. We created maps individually for each factor. And we use overlay analysis to consolidate into a single map. Then we find the correlation of the areal extent of quarries with landslides.

Steps Involved

Geographic Information System

A geographic information system (GIS) is a conceptualized framework that provides the ability to capture and analyse spatial and geographic data. GIS applications are computer-based tools that allow the user to create interactive queries, store and edit spatial and non-spatial data, analyse spatial information output, and visually share the results of these operations by presenting them as maps. Geographic information systems are utilized in multiple technologies, processes, techniques and methods. They are attached to various operations and numerous applications that relate to: engineering, planning, management, transport/logistics, insurance, telecommunications, and business.
Quantum geographic information system (QGIS) functions as geographic information system software, allowing users to analyses and edit spatial information, in addition to composing and exporting graphical maps. QGIS supports both raster and vector layers; vector data is stored as point, line, or polygon features. QGIS 3.14 “Pi” version is used in this project work. Multiple formats of raster images are supported and the software can geo-reference images. QGIS supports shape files, coverage, personal geo-databases, dxf, MapInfo, PostGIS, and other formats. Web services, including Web Map Service and Web Feature Service, are also supported to allow use of data from external sources. QGIS integrates with other open-source GIS packages, including PostGIS, GRASS GIS, and MapServer. QGIS can display multiple layers containing different sources or depictions of sources. Various features provided by QGIS 3.14 “Pi” like buffer zone creation, Overlay analysis, map generation etc. are utilized for our study.

Data collection

(i) Locating quarries in Malappuram District

In order to find the exact location of each quarry in Malappuram District, KOMPAS web portal was used. KOMPAS is the e-Governance initiative of the Department of Mining and Geology for bringing efficiency and transparency to mineral administration in the State. KOMPAS ensures citizen centric, cost effective, and quality electronic service delivery pertaining to mines and minerals in the State.
The KOMPAS ensures transparency, by providing statistics of mineral concessions in the State, particulars of mineral concessions and documents submitted for availing concessions, locations of working mines, quarries, crushers and dealers, information on mineral availability, to public. KOMPAS also provides information pertaining to genuineness of pass, permits/licenses to other regulatory agencies like Police, Land Revenue authorities of the State. A Google map based service provides location-specific information about the mining entities, quarries, and related information to public and other stakeholders. From this portal we can get the taluk wise location details of all quarries in Malappuram. Also the details of crushers, excavation, sites depot, mines and mineral processing units are available in the portal. To get the exact latitude and longitude of the quarries we searched for the names of each quarry in Google Maps as per the name given in the KOMPAS portal. A point is created almost at the centre point of each quarry. Then the latitude and longitude of that created point will be visible on the screen. It is then copied and can be saved in an excel sheet (as latitude and longitude in separate columns without a comma) as a CSV (comma-separated values) file which is a text file that has a specific format which allows data to be saved in a table structured format. If the latitude and longitude values of each quarries are not separately saved as CSV file then it cannot be opened in QGIS platform for our need. Quarries which are very closely spaced are considered as a single quarry.

ii. Area Extraction using Google Earth Pro

Google Earth is a computer program that renders a 3D representation of Earth based primarily on satellite imagery. The program maps the Earth by superimposing satellite images, aerial photography, and GIS data onto a 3D globe, allowing users to see cities and landscapes from various angles. Users can explore the globe by entering addresses and coordinates, or by using a keyboard or mouse. Google Earth covers more than 98 percent of the world, and has captured 10 million miles of Street View imagery, a distance that could circle the globe more than 400 times. In addition to Earth navigation, Google Earth provides a series of other tools through the desktop application, including a measure distance tool.
By entering the latitude and longitude of each selected quarry in the search bar of Google Pro software, we can view its latest imagery on the screen. An option called ‘View’ is available on the toolbar. By selecting the ‘Historical Imagery’ option the satellite image of the quarry over different years can be viewed. Thus the image of quarries in 2007, 2013 and 2018 can be obtained. To extract the area of quarry ‘Ruler tool’ is used. For that, the option ‘Polygon’ is selected. Then by creating polygons over the boundary of a quarry which is visible in the screen the area can be extracted. The area will be available in different units like acres, hectares, square kilometers, square meters etc. Thus the areal extent of quarries over the years 2007, 2013 and 2017 can be obtained and it is saved in an excel sheet
.

iii. Landslide Data

Location of the landslides of the years 2007, 2013 and 2018 were collected and separate vector files were created for all the landslides that have happened over a year.

Incorporating the data to GIS platform

i. Creating new Datasets

Open QGIS and open a ‘new blank project’. Click on the ‘Layer’ option in the tool bar then select ‘Add layer’ and then ‘Add vector layer’. A new pop up window appears on the screen and we can select the file that need to be opened in the screen and then click ‘Add’ and ‘Close’. District boundary shapefile of Malappuram can be opened by the same way. Add the landslide location of any of the three selected years by following the same steps explained before. To add the location of quarry click on ‘Add layer’ then ‘Add Delimited Text Layer’. Select the CSV file in which the latitude and longitude of the quarry is saved. The X-field should contain longitude value and Y-field should contain latitude value. Select EPSG: 4326-WGS 84 as the coordinate reference system (CRS) then click ‘Add’ and ‘Close’. At a time we need to be work with a single quarry, so only one quarry need to be opened in a particular project. The next step is creating buffer zones around the quarry.

ii. Buffer zone Creation

Buffering usually creates two areas: one area that is within a specified distance to selected real world features and the other area that is beyond. The area that is within the specified distance is called the buffer zone. There are several variations in the buffer distance or buffer size can vary according to numerical values provided in the vector layer attribute table for each feature. The numerical values have to be defined in map units according to the Coordinate Reference System (CRS) used with the data. In this project we are creating buffer zones at distance of 2Km, 4Km, 6Km and 8Km from the center of each quarry.

To select the buffering tool select the ‘Multi- ring Buffer (Constant Distance)’ tool by typing the same in the tool bar provided at the left bottom of QGIS window. A pop-up window will appear on the screen. Select the layer of quarry as ‘Input layer’ which we want as the center of the buffer. ‘Number of rings’ chosen is four as we need buffer zones at distance of 2Km, 4Km, 6Km and 8Km from the center of

each quarry. The next important option is 'Distance between rings'. Either we can give the input as distance or in degrees. If the input is in degrees then give the distance as 0.018 degrees where 1Km is considered as 0.008 degrees. Then click on 'Run' and 'Close'.

To change the properties of the buffer layer, right click on the layer on the layer panel and select 'Properties'. There we can change the layer properties like color, opacity, stroke width etc. The names of each layer can also be changed by right clicking the layer on the layer panel and choosing 'Rename' option.

iii. Map Generation

To create a map of the work done click on 'Project 'option on the tool bar and then 'New Print Layout' and click on 'Ok' which comes in the new pop up window. Then a new window will appear on the screen. To open the work in the new window click on 'Add Item' on the tool bar and then 'Add Map'. A cursor will appear on the screen. Drag it to form a rectangle and then release. The created work will get opened in the new window. Click on 'Add Item' and then 'Add Label' and again drag a box where we can give the title of the work. Click on 'Add Item' and then 'Add Legend' and draw a box to which shows the legend of the map prepared. To give borders, right click inside the layout and select 'Item Properties'. Click on the option 'Grid' and click the 'Plus' symbol which appear. Then selected the new grid that we have added and then click on 'Modify Grid'. There we can change the properties like Grid type, frame, interval, coordinates etc. for a better layout. After doing all the necessary changes the layout can be saved either as a project or as an image or as pdf. For that click on 'Layout' option on the tool bar and from the available option we can choose the option that we need.
Similarly do the same work by changing the landslide to another year. Thus for a single quarry three sets of image having landslides in three different year can be generated. By selecting any other quarry the same work can be continued.

RESULTS

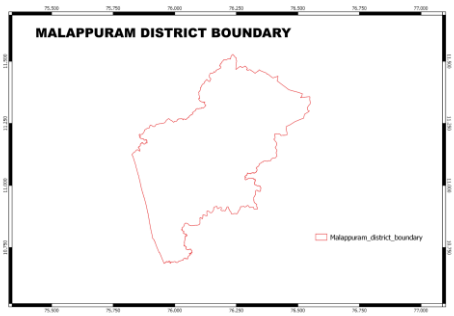

Fig 1-Malappuram District Boundary

Fig.2.Malappuram District Taluk

Quarries: Taluk Map

Fig 3.Ernadu Taluk

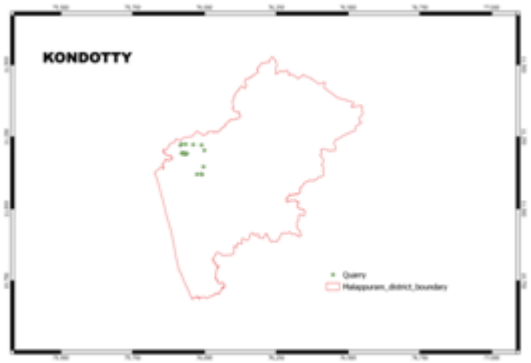

Fig 4.Kondotty Taluk

Fig 5 Nilambur Taluk

Fig 6. Perinthelmanna Taluk

Fig 7. Tirur Taluk

Fig 8.Tirurangadi Taluk

Landslide Map of 2007 and 2018

Fig 9.Landslide 2007

Fig10 .Landslide 2018

Landslides in the Buffer Zones

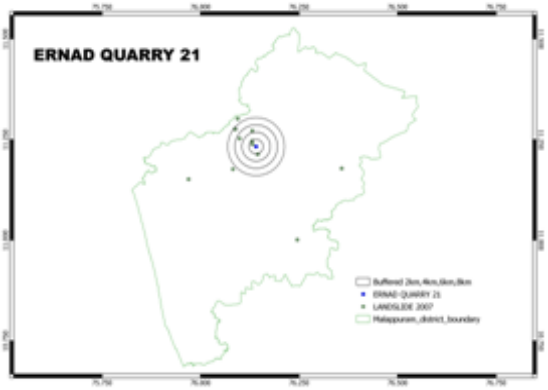

Fig 11. Figures shown landslides and buffer zone around each quarries (inside buffer)

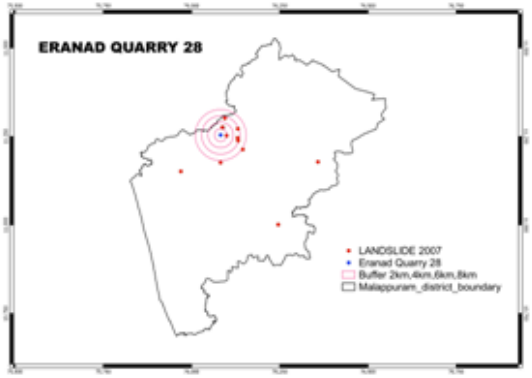

Fig 12. Figures shown landslides and buffer zone around each quarries (inside buffer)

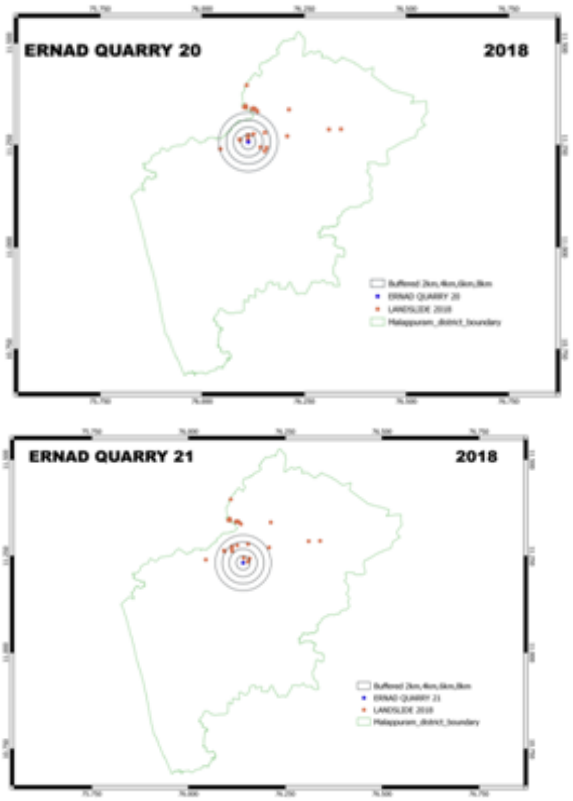

Fig 13. Figures shown landslides and buffer zone around each quarries (inside buffer)

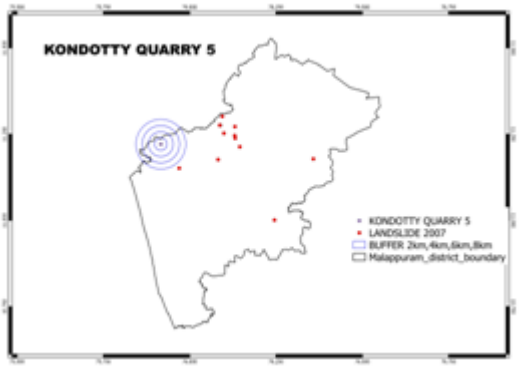

Fig 14. Figures shown landslides and buffer zone around each quarries (outside buffer)

Fig 1 shows the district boundary map created using QGIS. and Fig 2 shows the district boundary map along with Taluks. Fig 3-8 shows the numbers of quarries in each Taluks. Fig 9 and 10 shows the landslide in 2007 and 2018. Which also choose 2013 but there is no landslide in 2013. From this 2 maps we can see that there is increase in the number of landslides in Malappuram in 11 years. Fig 11-13 shows the buffer zones created using QGIS, where the landslides and quarries are near. That is the landslides occur between 2km, 4km, 6km, 8km.Fig 14 shows the landslides and buffer zones around each quarry where the landslides occur outside the buffer zones.

From this figures we can see that there is increase in both area of Quarries and number of Landslides.

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