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Landslide Susceptibility Mapping in Mahabaleshwar Tehsil, Satara, Maharashtra using Geospatial Technology.

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Abstract : *Western Ghats on the western part of the Indian peninsula is recognized as the most frequent landslides potential zone. South west monsoon rainfall is major triggered factors of the landslide. The present work is carried out to evaluate the landslide susceptibility of Mahabaleshwar tehsil of Satara district, Maharashtra, India using geospatial technique. Landslides are influenced by several natural and manmade factors, such as slope, rainfall, relief, lithology, soil depth, soil erosion, soil texture, land use / land cover, road distance, drainage distance, drainage density, lineament distance, lineament density, aspect, temperature, seismology. The weighted overlay methods and multi-criteria model in ArcGIS 10.5 software were used for the mapping landslide susceptible zones. The landslide susceptible zones are classified into six classes: very high (0.3 %), high (2.2 %), moderate (6.4 %), low (14.2 %) very low (20.7 %) and no risk zone (56.2 %). Out of the total 113 villages of the tehsil, the study identified 06 villages are situated in very high, 18 in high, 13 in moderate, 19 in low and 17 in very low risk zones. The study has significant for the prevention and mitigation of the high landslide potential villages in the study area*

Key Word*:* Remote Sensing and GIS, Landslide Susceptibility, Weighted Overlay Analysis, Multi-criteria

I. Introduction

Landslide is a very ruinous and fatal natural hazard. Landslide phenomena happen when the ground slope is unstable due to the influence of natural movements or anthropogenic activities. The report of Geological Survey of India (GSI) visualizes 12.6 % area of India comes under landslide prone. Western ghat, Eastern ghat, Darjeeling (West Bengal), Sikkim, Himachal Pradesh, Uttarakhand, Jammu and Kashmir in the Himalaya are affected by landslide every year and suffer heavy losses in terms of life and property. Landslide had been recorded in most frequent as incidence every year during south west monsoon (June to September) period and during the snowfall in Himalayan region. Maharashtra, Karnataka, Goa, Kerala and Tamil Nadu states have occupied by Western ghat mountain range. The intensive and heavy rainfall in the steep slope of Western ghat had causes of landslide movement. Hence the study of the landslide in this region has important to save the life and property.

The demarcation of landslide susceptibility map will be helpful for the prevention and mitigation of the region. Various qualitative and quantitative methods are used for the demarcation of landslide susceptible zones but geospatial technology is widely used in demarcation of the landslide susceptible zones and mapping of probability of occurrence of landslide. The use of remote sensing data and thematic map in landslide zonation is time and cost saving techniques. In the mountain, forest and remote area the geospatial technology is ideal for mapping.

Different researcher have been using the geospatial techniques for the generation of landslide susceptibility map. Ajin et al. [1] uses weighted overlay analysis using multi-criteria model. Mukherjee et al. [10] have been studied debris slides of Verandah Ghat of Pune district. Karthic Kumar et al.[8] examined landslide study of Kothagiri region of Western Ghats, Tamil Nadu using weighted overlay techniques in GIS platform. E. Nithya et al.[11] analyzed the landslide in Nilgiris mountain of Tamil Nadu by using the weighted overlay techniques. Jishnu E. S et al.[7] analysed hazard mapping of landslide vulnerable zones in a Rainfed Region of Southern Peninsular India using weighted overlay analysis methods. Tripathi M. K. et al.[14] studied landslide hazard zonation mapping of Chamoli landslides of Himalaya using information value method under GIS environment. Hariharan S. et al.[6] studied landslide susceptibility map of Thenmala Sub-Watershed, Southern Western Ghats, India using the weights of evidence method. Gawali P. B. et al. [5] identified landslide susceptible villages around Kalsubai Region, Western Ghats of Maharashtra using the heuristic

technique based on weighted score method. Mondal S. [9], examined landslide potentiality assessment of the Shivkhola Watershed of Darjiling, Himalaya, Erdas Imagine (9.0), Arc Map, PCI Geomatica and MATLAB Software. Sriramkumar. C. et al. [13] analysed the landslide zonation map of Konkan railway, Ratnagiri region by using Multi-criteria analysis in ArcGIS software by preparing various thematic maps. In this study, the landslide susceptibility map of Mahabaleshwar tehsil, Maharashtra prepared by using weighed overlay methods and multi-criteria analysis of various thematic maps in ArcGIS software.

II. Study Area

The study area is located in the Mahabaleshwar tehsil of Satara district, Maharashtra. It lies between latitude $17^0$42'2" N to $17^0$58'55" N and longitude of 73^o32'14" E to $73^0$51'34" E with a geographical extent of 518 Sq. Km. The maximum elevation is 1440 m at Mahabaleshwar and the average elevation is 1050 m, above mean sea level. The important tourist places are Mahabaleshwar, Tapola, Panchagani, Pratapgad in the tehsil. The average annual rainfall of the study area is 5805 mm, whereas it is 5627 mm during southwest monsoon. The maximum and minimum temperature is 26 ^{0}C and 16.2 ^{0}C respectively [12, 16]. Mahabaleshwar tehsil has experienced several major and minor landslides in the past. On 1st July, 2005 at Bhilar and Kaswand, on 20th July, 2005 at Mahabaleshwar (Hotel Gautam), Panchgani, Metgulad, Gadalwadi, on 26th July, 2005 at Tapola to Mahabaleshwar road, in 2015 at Panchgani and Bhekawli, on 12th August 2017 at Umbari village, in July 2021 around the Birwadi, Kasrud, Chaturbet, Goroshi villages and Mahabaleshwar to Tapola road [4]. All landslides and debris fall was triggered due to heavy rainfall.

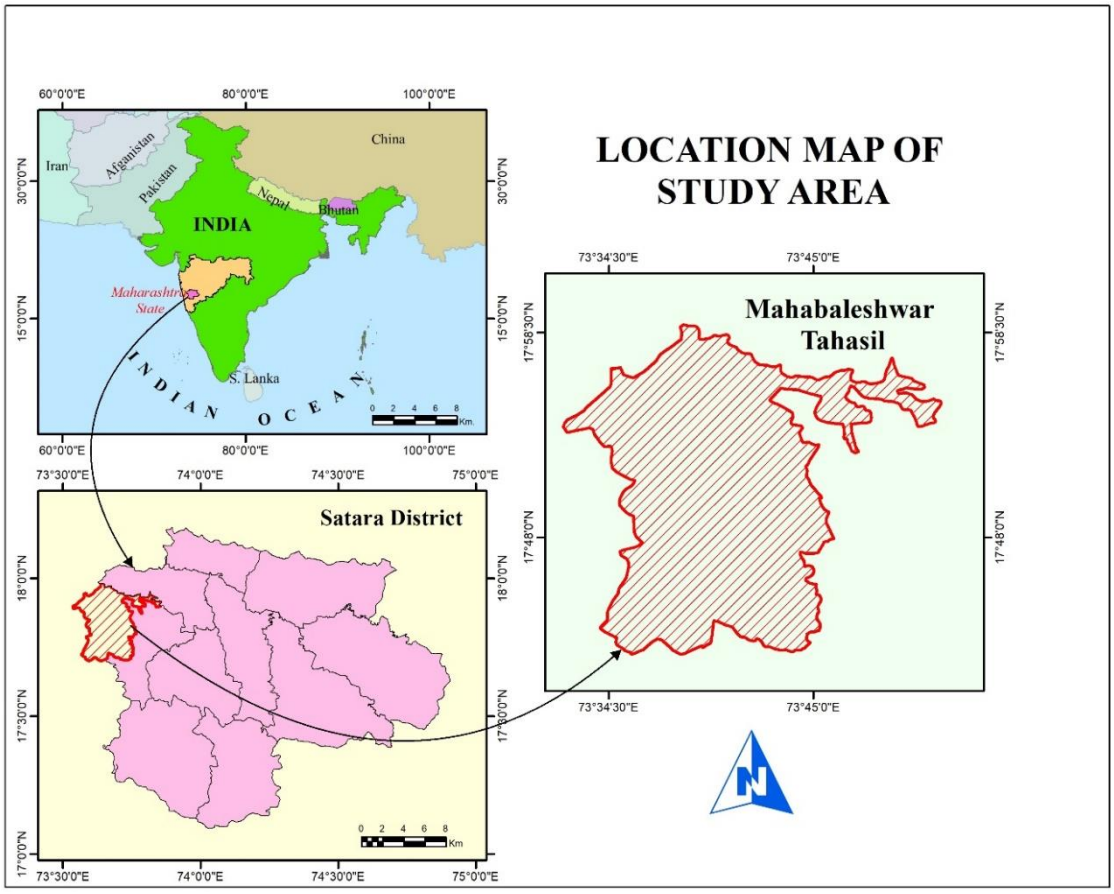

Fig. 01 : Location map of study area

III. Data and Methodology

For the present study the methodology is divided into two part, data collection and construction of a geo database and data validation through field visit. The slope, rainfall, relief, lithology, soil depth, soil erosion, soil texture, land use / land cover, road distance, drainage distance, drainage density, lineament distance, lineament density, aspect, temperature, seismology landslide parameter are collected from various

source (**Table-1**) and in this approach 16 thematic layers are prepared in GIS platform using ArcGIS 10.5 and ERDAS IMAGINE software.

The landslide susceptibility map of the study area is prepared by using the weighted overlay method. Weighted overlay is a simple statistical method whereas weights are assigned to the various landslide parameters according to their importance and triggering intensity in the landslide frequency. In this paper the heuristic technique [5] based on the local information and prior knowledge of past landslide are used for assigning the scale and weight for individual parameter (**Table 2**). The highest weight assigned to slope (20), rainfall (15), relief (12) and lithology (12) based on their highest influence on bringing about a landslide. Hence the scale for each class within individual parameter has been assigned based on their degree of hazard probability.

The landslide susceptibility map is prepared by using the integration of sixteen thematic layers through multi-criteria and overlay analysis using ArcGIS10.5 software. The work flow diagram of methodology is shown in **Fig. 2.** The entire area is delineated based on the score and local information is divided in six classes like Very high, High, Medium, Low, Very low and No risk. The location of villages in the tehsil has been demarcated using satellite imagery and village wise tehsil map of MRSAC, Nagpur. The village location map has been superimposed over the landslide susceptibility map and identify the landslide potential map of villages. Finally, the landslide susceptibility map has been validated through field visit and interaction with local peoples.

Table no 1: Data sources and specific use

Sr. No.	Data Types	Source	Data/Layer Extracted
1	Multispectral satellite image: Sentinel-2 Spatial resolution - 10 M	Sentinel Data Open Access Hub (*https://scihub.copernicus.eu/*)	Land use / Land cover
2	DEM Satellite data: Cartosat-I Spatial resolution- 2.5 M	Bhuvan (*https://bhuvan-app3.nrsc.gov.in/data/download/index.php*)	Slope and Aspect Map
3	Soil Data Scale -1: 500000	European Soil Data Center (*https://esdac.jrc.ec.europa.eu/*)	Soil depth and texture map
4	Lithology and Lineaments Scale - 1:50000	Bhukosh website (*http://bhukosh.gsi.gov.in/Bhukosh/MapViewer.aspx*)	Lithology map, Lineament Density and distance
5	Rainfall data	IMD and Maharashtra agriculture websites (*http://mahaagri.gov.in/*)	Rainfall data
6	Temperature data	India Meteorological Department of Pune (*https://imd.gov.in/*)	Temperature data
7	GPS Data	Field work	Ground truthing points
8	Socio-Economic Data	Field work & Census of 2011	Population Data
9	Road Network	Google Earth Image	Road network and road distance map
10	Seismology	Bhukosh website (*http://bhukosh.gsi.gov.in/Bhukosh/MapViewer.aspx*)	Seismology Map

Table 2: Allotted weightage to parameter

Parameter	Weightage (%)	Parameter	Weightage (%)
1. Slope	20	9. Drainage density	4
2. Rainfall	15	10. Soil texture	4
3. Relief	12	11. Lineament distance	3
4. Lithology	12	12. Lineament density	3
5. Soil depth	5	13. Soil erosion	3
6. Land use / Land cover	5	14. Aspect	2
7. Road Distance	4	15. Temperature	2
8. Drainage distance	4	16. Seismology	2
Total		**100**	

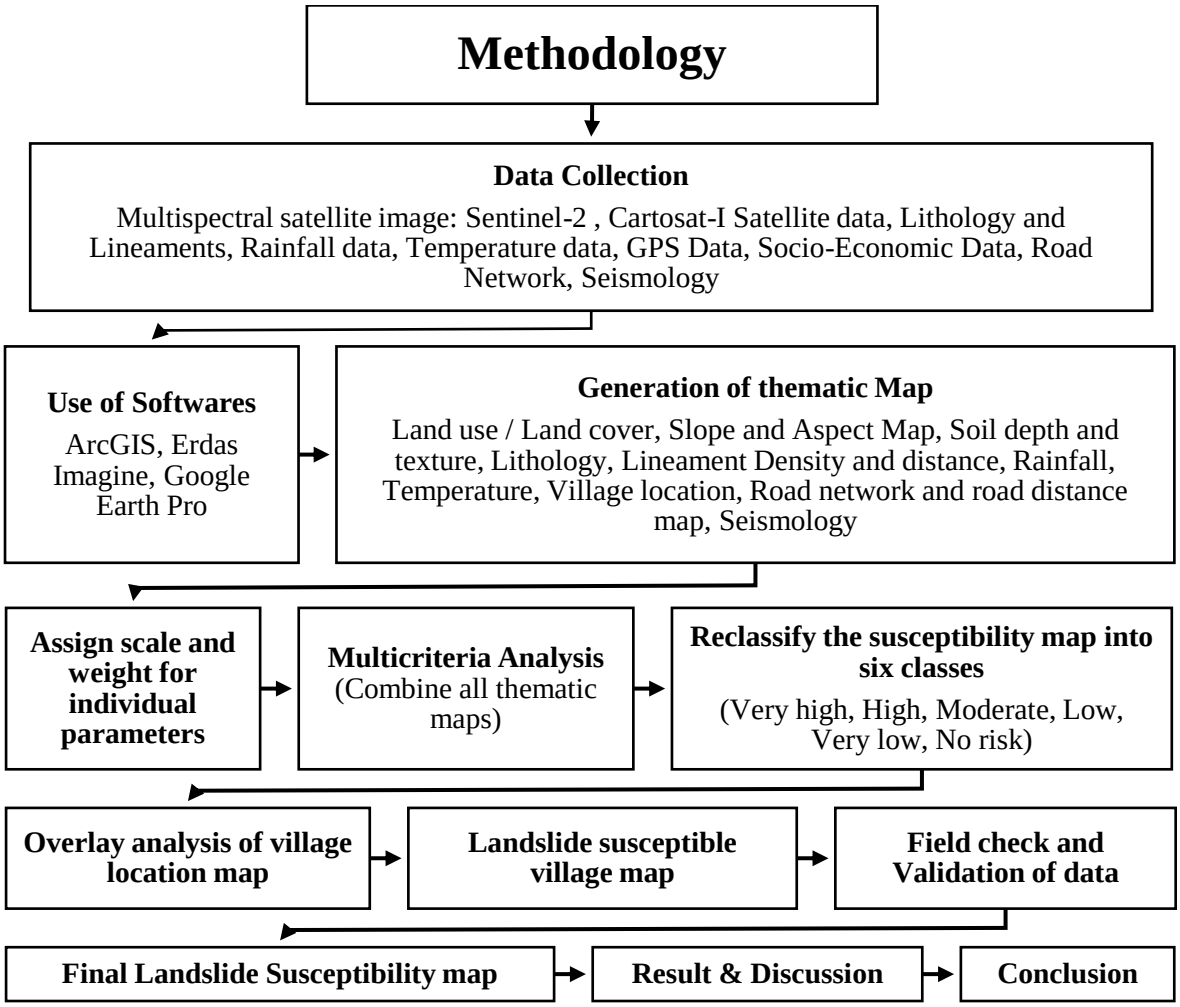

Fig. 02 : Methodology

IV. Result and Discussion

Landslides are natural uncertain phenomena, it is difficult to predict the landslide incidence in any area in the world. The triggering factor of landslide has been changed according to the region. Geological survey of India [15] suggested some affected factor for meso and micro level study of the landslide hazard zonation. In this study, all spatial geo-database were reclassified in ArcGIS 10.5 software by assigned weightage **(Table 2)** and prepare the landslide susceptibility map of the Mahabaleshwar tehsil. The landslide susceptible map has been categorized into six zones: Very high, High, Medium, Low, Very low and No risk, Final landslide susceptibility map is shown in **Fig. 3**. In the study area, the steep slope and ghat section of the road network are highly prone for landslide hazard and the lowland area is more stable in occurrences and initiation of landslides. The landslide susceptible map shows, very high risk zone is about 0.3 percent (1.51 Sq. Km.) of the total area followed by high risk zone with 2.2 percent (11.47 Sq. Km.), moderate risk zone 6.4 percent (33.2 Sq. Km.), low risk zone 14.2 percent (73.7 Sq. Km.), very low risk zone 20.7 percent (107.4 Sq. Km.) and no risk zone is 56.2 percent (291.3 Sq. Km.) (**Fig. 3**). The result shows that the slope more than 35^0 and elevation more than 1100 m shows very high susceptible zones and the slope between 25^0 to 35^0 and elevation 1000 m above sea level indicate high susceptible zones. Very high and high susceptibility zone located around the Mahabaleshwar and Panchagani city.

The landslide potential map of villages shown in **Fig. 4** and the list of the villages presented in **Table 3**. Out of the total 113 villages of the Mahabaleshwar tehsil, the study identified that 06 villages are situated in very high, 18 in high, 13 in moderate, 19 in low, 17 in very low risk zones and remaining 40 villages are under the no risk zone. Major villages of tehsil have been validated through field visit and interaction with local peoples. It is seen that past landslide inventory has been observed in the most of the villages.

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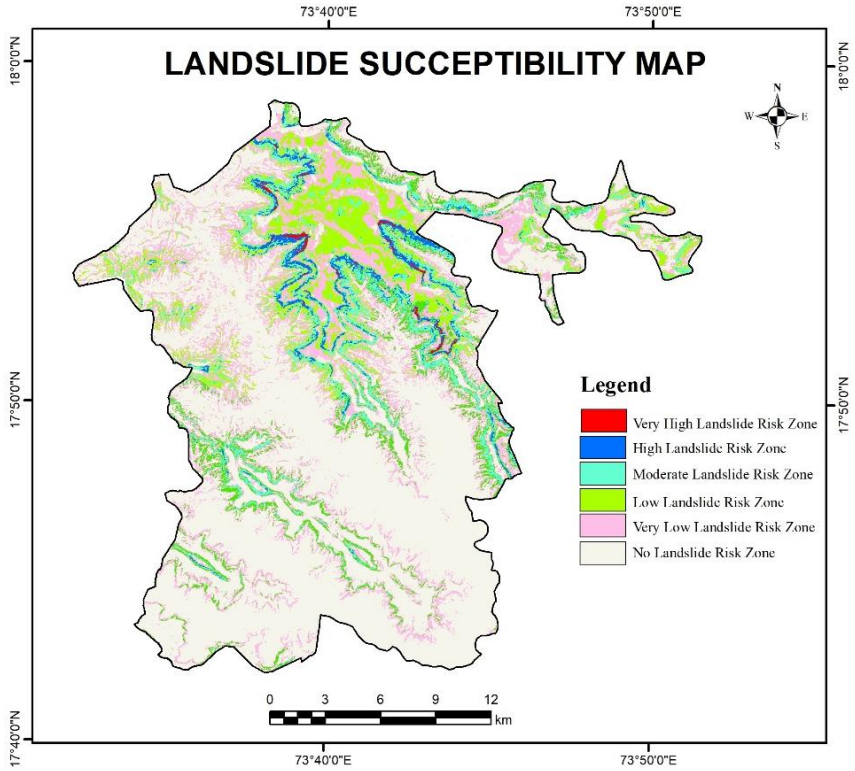

Fig. 03: Landslide suceptibility map

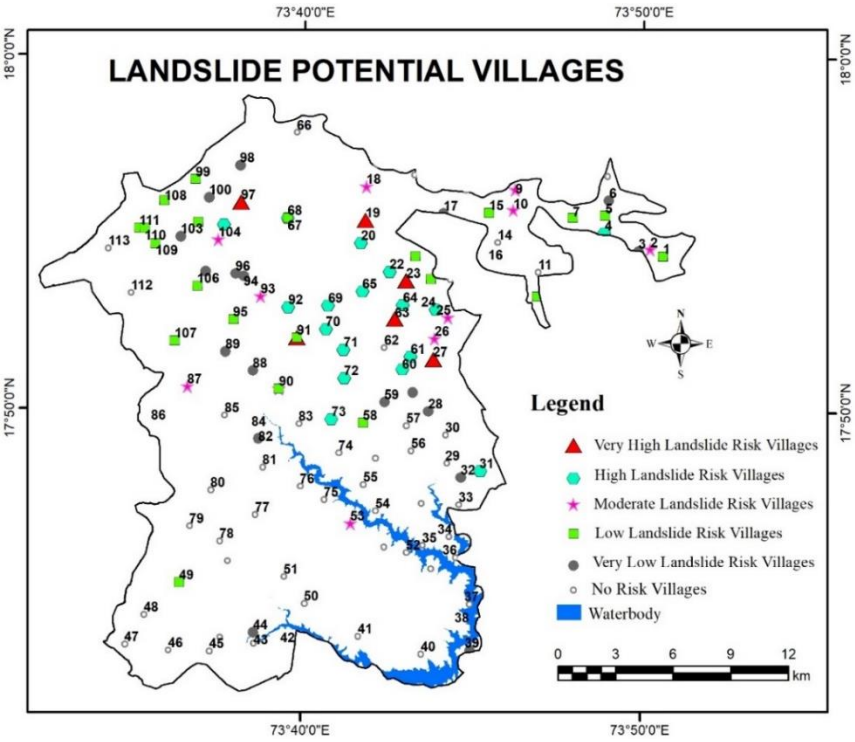

Fig. 04 :Landslide potential villages

Table 3: Landslide susceptibility villages in the Mahabaleshwar tehsil

Risk Level	Index Class	Village Id	Name of Villages	Total Number
Very high	> 525	19, 23, 27, 63, 91, 97	Metgutad, Machutar, Dhardev, Yerane Kh., Dudhgaon, Abmbnali Ghat	**6**
High	500 - 525	4, 13, 16, 20, 22, 24, 31, 60, 61, 64, 65, 67, 69, 70, 71, 72, 73, 92	Khinghar, Umbari, Danavali, Bhekavali, Navali, Moleshwar, Varsoli koli, Devasare, Adhal, Tekavali, Yerane Bk., Ran adva gaund, Malusar, Chikhali, Ghavari, Vivar, Kalamgaon kalamkar, Parut	**18**
Moderate	475 - 500	2, 8, 9, 10, 18, 25, 26, 53, 86, 87, 90, 93,104	Ambral, Taighat, Pangari, Nandanvan, Nakinda, Yerandal, Majarewadi, Gavdoshi, Dabhe Turuk, Ghonaspur, Devali, Manghar, Mettale	**13**
Low	450 - 475	1, 5, 7, 12, 15, 21, 49, 58, 68, 84, 95, 99, 101, 106, 107, 108, 109, 110, 111	Rajapuri, Godavali, Pachagani, Ranjani, Bhose, Avakali, Parwat t. wagawale, Taldeo, Mahabaleshwar, Dabhe, Goroshi, Jaoli, Dhangarwadi, Kasrud, Hatlot, Kumbhargoshi, Parpar, Petpar, Parsond	**19**
Very low	425 - 450	3, 6, 17, 28, 32, 39, 44, 59, 82, 88, 89, 94, 96, 98, 100, 103, 105	Shindola, Dandeghar, Gureghar, Kuroshi, Varsolidev, Mauje Shewandi, Morni, Sonat, Shirnar, Zanzwad, Chaturbet, Birwadi (Purv), Birwadi, Dare, Haroshi, Dudhoshi, Shiravali	**17**
No risk	< 425	11, 14, 29, 30, 33, 34, 35, 36, 37, 38, 40, 41, 42, 43, 45, 47, 48, 50, 51, 52, 54, 55, 56, 57, 62, 66, 74, 75, 76, 77, 78, 79, 80, 81, 83, 85, 102, 112, 113	Kaswand, Bhilar, Gogave, Lakhwad, Rameghar, Pali t. Ategaon, Vanavli t. solasi, Tapola, Gadhavali, Dare Tamb, Pimpari Tarf Tamb, Akalpe, Rewandi, Mahalunge, Met Shindi, Shindi, Chakdev, Valawan, Nivali, Lamaj, Walne, Harchandi, Amshi, Khambil chorge, Khambil pokale, Achali, Kshetra Mahabaleshwar, Kotroshi, Rule, Renoshi, Dodani, Saloshi, Kandat, Zadani, Kharoshi, Kalamgaon, Dabhe mohan, Araw, Birmani, Kumthe	**40**
Total				**113**

V. Conclusion

In this study, the landslide susceptibility map has been prepared using weighted score and multicriteria analysis based on the heuristic technique. It's seen that the slope of area along with the triggering factor rainfall, relief and lithology made the surface unstable. It is noticed that along with these natural factors certain anthropogenic activities like, cutting of mountain for road network, construction work on the slope side, agriculture, deforestation are also triggering factors for landslides. 24 villages along with Ambenali ghat, Pasarni ghat, Kelghar ghat and Mahableshwar-Taopla ghat are identified to be in high risk landslide susceptible zones and more than 2000 population under the threat of landslide. The partial or complete rehabilitation are required of some of villages. Mahabaleshwar, Panchagani, Pratapgad, Tapola, Bhilar etc. are major attraction of tourist in whole year. Hence, this study is very important for the hazard management of tehsil. The present study shows that geospatial technology is more significant, time saving and ideal techniques for the assessment and identification of landslide potential zone of remote, hilly and dense forest region. Weighted overlay analysis methods is the best and easy statistical for demarcation of hazardous zone as compared to the other traditional methods. Finally, the demarcation of landslide susceptibility zone would be helpful for the administrator and planners for prevention and mitigation measurements to reduce losses of lives and properties.

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References

1. Ajin R. S., Vinod P.G. and Menon A. R. (2014): Landslide hazard zonation using RS and GIS technique: A case study of Meenachil and Kanjirappally Taluk, Kottayam District, Kerala, India. *26th Kerala Science Congress*, Wayanad, Kerala, Proceedings, pp.1797-1803
2. Census of India 2011, Maharashtra, Seseries-28 Part XII-B, District Census Handbook, Satara, Village and Town Wise, Primary Census Abstract (PCA), pp. 200-218.
3. Chawla A., Chawla S., Pasupuleti S., Rao A., Sarkar K., and Dwivedi R., (2018): Landslide Susceptibility Mapping in Darjeeling Himalayas, India, *Advances in Civil Engineering*, pp. 1-17
4. District Disaster Management Plan District - Satara - 2017-18, District Disaster Management Authority Collector Office, Satara
5. Gawali P. B., Aher S. P., Lakshmi B.V., Gaikwad R. D., Deendayalan K., Hanamgond P. T., Mahesh Babu J.L.V., Arote S. A., and Bairagi S. A., (2017): Identification of Landslide Susceptible Villages around Kalsubai Region, Western Ghats of Maharashtra using Geospatial Techniques, *Journal Geological Society Of India* Vol: 90, pp.301-311
6. Hariharan S., Asok S.and Reghunath R., (2016): Landslide Susceptibility Mapping: A Case Study in Thenmala Sub-Watershed, Southern Western Ghats, India, *Emer. Life. Sci. Res*, 2(2), pp. 50-53

7. Jishnu E. S., Joseph A. K, Sreedhar S. and Basil G. (2017): Hazard Mapping of Landslide Vulnerable Zones in a Rainfed Region of Southern Peninsular India- *A Geospatial Perspective, International Research Journal of Engineering and Technology* (IRJET), Vol: 4 (07), pp 1350-1357
8. Karthic Kumar M. and Annadurai R., (2013): Mapping of Landslide Susceptibility using Geospatial Technique - A Case Study in Kothagiri Region, Western Ghats, Tamil Nadu, India, *International Journal of Engineering Research & Technology*, Vol: 2 (12), pp. 2084- 2091
9. Mondal S., (2016): Research Progress In Landslide Potentiality Assessment: A Case Study of the Shivkhola Watershed, Darjiling Himalaya., *European Journal of Geography* Volume 7 (2:21-47), pp. 21-47
10. Mukerjee A., (1998): Temporal remote sensing data and GIS application in Landslide Hazard Zonation of part of Western Ghat, India, *International Journal of Remote Sensing,* Vol:19 (4), pp. 573-585
11. Nithya S. E., and Rajesh P. P., (2010): An Integrated Approach with GIS and Remote Sensing Technique for Landslide Hazard Zonation, *International Journal of Geomatics and Geosciences*, Vol: 1(1), pp.66-75
12. Rainfall Recording & Analysis, Dept. of Agriculture, Govt. of Maharashtra 14-07-2021, National Informatics Centre, Pune.
13. Sriramkumar C., Saranathan E., Rajamanickam V., and Nadage.B. S., : Landslide Zonation Mapping - Konkan Railway, Ratnagiri Region, Maharashtra, *Commission IV, Working Group IV /022.*
14. Tripathi M. K., Govil H., Champati ray P.K. and Das I.C. (2018): Landslide Hazard Zonation Mapping of Chamoli Landslides In Remote Sensing and GIS Environment, *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Vol: XLIIn (5), Dehradun, India, pp. 475-480
15. www.gsi.gov.in
16. www.imd.gov.in