"ज्ञान, विज्ञान आणि सुसंस्कार यांसाठी शिक्षण प्रसार"
-शिक्षणमहर्षी डॉ. बापूजी साळुंखे

Shri Swami Vivekanand Shikshan Sanstha's

VIVEKANAND COLLEGE, KOLHAPUR (EMPOWERED AUTONOMOUS)

2130, 'E' Tarabai Park, Kolhapur, Tal. Karveer, Dist. Kolhapur -416003
Affiliated to Shivaji University, Kolhapur (M.S.)
NAAC Reaccredited : "A" (CGPA3.24)
College with Potential for Excellence by U.G.C., New Delhi
"Star College" by D.B.T Govt. of India
ISO 9001 : 2015

(अधिकारप्रदत्त स्वायत्त)
कोल्हापूर

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Ref. No. VCK/ 2022-23 / By hand

Date : 10.05.2023

RSEARCH AND DEVELOPMENT CELL

Project Completion Certificate

This is to certify that **Dr. UBALE GOVARDHAN SUBHASH** of Geography Department has successfully completed research scheme entitled **"Application of Remote Sensing & GIS in Coastline Changes: A Study of Sindhudurg District, Maharashtra"** sanctioned by Vivekanand College, Kolhapur (Empowered Autonomous) under **Seed Money for Research** during 2018 to 2023. He worked as Principal Investigator for the project.

Date: 10 May 2023

Dr. R. R. Kumbhar
PRINCIPAL
VIVEKANAND COLLEGE, KOLHAPUR
(EMPOWERED AUTONOMOUS)

CamScanner

VIVEKANAND COLLEGE, KOLHAPUR
(AUTONOMOUS)
RESEARCH INITIATION SCHEME

Utilization certificate

It is certified that the grant of ₹ **25000** (Rupees Twenty five Thousand only) received from the Vivekanand College, Kolhapur (Autonomous) Research Initiation Scheme of support for Research Project entitled "**Application of Remote Sensing & GIS in Coastline Changes: A Study of Sindhudurg District, Maharashtra**" vide Vivekanand College, Kolhapur (Autonomous) letter No VCK/1844/2018-19 dated 27/11/2018 has been fully utilized for the purpose for which it was sanctioned and in accordance with the terms and conditions laid down by the College.

Signature of the
Principal Investigator / Co-Investigator

Signature of the
Coordinator
Research Initiation Scheme

UDIN-23122778BGZMMB5501

For P V Phatak & Associates
Chartered Accountants

PRINCIPAL
Vivekanand College
Kolhapur

136411W

Signature of the College statutory Auditor

CA Vikram Phatak
Partner
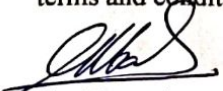**Membership No. 122778**

VIVEKANAND COLLEG, KOLHAPUR
(AUTONOMOUS)
RESEARCH INITIATION SCHEME
Statement of Expenditure in respect of Research Project

1) Name of Principal Investigator: **Dr. Govardhan Subhash Ubale**
2) Name of Department **Geography**
3) Title of the Research Project : **Application of Remote Sensing & GIS in Coastline Changes: A Study of Sindhudurg District, Maharashtra.**
4) Date of starting the project : 27/11/2018
5) (a) Period of Expenditure: From 27/11/2018 to 20/02/2023
   (b) Details of Expenditure 25,322/-

Item	Expenses incurred (₹.)
A) **Non-recurring component:**	3650/-
i) Books/Journals	3650/-
B) **Recurring component:**	20,172/-
(i) Xerox	505/-
(ii) Field Work and Travel	9100/-
(iii) Typing and Printing	4297/-
(iv) Stationary	1770/-
(v) Map Making	5000/-
(vi) Plagiarism	500/-
(vii) Auditor	500/-
Total (₹.)	25,322/-

(c) (1) As a result of check or audit objective, some irregularity is noticed, at a later Date, action will be taken to refund, adjust or regularize the objected amounts.

(2) It is certified that the grant of ₹.**25,000/-** (Rupees Twenty Five Thousands only) received from the College under the scheme of support for Research Project entitled **Application of Remote Sensing & GIS in Coastline Changes: A Study of Sindhudurg District, Maharashtra** vide College letter No VCK/1844/2018-19 dated 27/11/2018 has been fully utilized for the purpose for which it was sanctioned and in accordance with the terms and conditions laid down by the College.

Principal Investigator /
Co-Investigator

Signature of the Head / Director / Coordinator of
the Research Committee

UDIN-23122778BGZMMB5501

136411W

CA Vikram Phatak
Partner
Membership No. 122778

PRINCIPAL
Vivekanand College
Kolhapur

VIVEKANAND COLLEGE, KOLHAPUR
(AUTONOMOUS)
RESEARCH INITIATION SCHEME
Annual/Final Report of the work done on the Research Project

(Report to be submitted within 2 months after completion of each year).

1) Project report **Final Report**

2) College Reference No. **VCK/1844/2018-19 dated 27/11/2018**

3) Period of report: from **December 2018** to **April 2023**

4) Title of research project **Application of Remote Sensing & GIS in Coastline Changes: A Study of Sindhudurg District, Maharashtra**

5) (a) Name of the Principal Investigator **Dr. G. S. Ubale**

   (b) Name of the Co-Investigator **Nil**

   (c) Dept. where work has progressed **Geography**

6) Effective date of starting of the project **28/11/2018**

7) Grant approved and expenditure incurred during the period of the report:

   a. Total amount approved ₹. **25000/-**

   b. Total expenditure ₹. **25,322/-**

   c. Report of the work done: (Please attach a separate sheet)

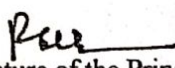|		
1)	Brief objective of the project	1)To highlight the geographical aspect of the study region. 2)To prepare change detection of land-use and land-cover of the study region. 3)To analyze topographical and morphological changes by using remote sensing and GIS. 4)To identify vulnerable coastal sites of the study region. 5)To formulate some remedies for dynamic coast for the study region.
2)	Work done so far and results achieved and publications, if any, resulting from the work (Give details of the papers and names of the journals in which it has been published or accepted for publication	1. Title: Analysis of Land-use Pattern in Sindhudurg District: A Geographical Analysis Journal: International Journal of Mechanical Engineering (Scopus) ISSN-0974-5823, Vol. 6 Nov-Dec. 2021 2. Title: Study of Rainfall Variability in Sindhudurg District, Maharashtra Journal: The Konkan Geographer, ISSN- 2277-4858, Vol.36 Jan. 2022
3)	Has the progress been according to original plan of work and towards achieving the objective. if not, state reasons	Yes
4)	Please indicate the difficulties, if any, experienced in implementing the project.	No any difficulties
5)	If project has not been completed, please indicate the approximate time by which it is likely to be completed. A summary of the work done for the period (Annual basis) may please be sent to the College on a separate sheet.	Completed
6)	If the project has been completed, please enclose a summary of the findings of the study. Two bound copies of the final report of work done may also be sent to the College.	Summery enclosed separately

7)	Any other information which would help in evaluation of work done on the project. At the completion of the project, the first report should indicate the output, such as (a) Manpower trained (b) Ph. D. awarded (c) Publication of results (d) other impact, if any.	Nil

Signature of the Principal Investigator and Co- Investigator

Signature of the Head / Director / Coordinator of the Research Committee

Signature of the Principal
PRINCIPAL
Vivekanand College
Kolhapur

A

MINOR RESEARCH PROJECT

ON

APPICATION OF REMOTE SENSING AND GIS IN COASTLINE CHANGES STUDY OF SINDHUDURG DISTRICT, MAHARASHTRA.

SUBMITTED

TO

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

RESEARCH DEVELOPMENT AND PROMOTION CELL

BY

DR. UBALE GOVARDHAN SUBHASH

(M.A., NET, SET, PGD GEOINFORMATICS, PH.D.)

ASSOCIATE PROFESSOR

DEPARTMENT OF GEOGRAPHY

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

KOLHAPUR - 416003

FEBRUARY 2023

A

Minor Research Project

ON

APPICATION OF REMOTE SENSING AND GIS IN COASTLINE

CHANGES STUDY OF SINDHUDURG DISTRICT, MAHARASHTRA.

Submitted

To

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

Research Development and Promotion Cell

BY

DR. UBALE GOVARDHAN SUBHASH

(M.A., NET, SET, PGD GEOINFORMATICS, PH.D.)

Associate Professor

Department of Geography

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

Kolhapur - 416003

February 2023

DECLARATION

I hereby declare that tha project entitled "**APPICATION OF REMOTE SENSING AND GIS IN COASTLINE CHANGES STUDY OF SINDHUDURG DISTRICT, MAHARASHTRA.**" Is a original work done by me. The findings in this report based on the data collected by researcher. This work has not been submitted for any other degree of this or any other University. Whenever reference have been made to previous works of others, it has been clearly indicated as such and included in the Bibliography.

Signature of candidate

Dr. Ubale Govardhan Subhash

Place : Kolhapur

Date:

ACKNOWLEDGEMENT

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CHAPTER – I
INTRODUCTION

1.1 INTRODUCTION

Coastal area is very precious for human being since the beginning of human life. Most of the cities around the World are situated at the coastal areas. About the one third population is living in the coastal zone, there are abundant natural resources. The expansion of urbanization and rapid growth of population are creating problem and having pressure on it. Coastal zone having lot of coastal landforms such as sand dune, beach, shore line, coral reef, Rocky shore, delta, estuaries, tidal inlets, flood plains coastal plains and salt marshes at these landforms also developed by various forces of erosion and depositional as caused by waves tide, winds and river discharge. The interaction between this process and coastal environments produce a variety of landforms.

Accurate detection and proper monitoring of the coastal is a very essential to understand the coastal process and dynamics of various coastal features which will be helpful is in assessing the dynamic nature of cost. Sindhudurg district has near about 125 KM coastline and it is highly vulnerable and experiencing the adverse consequences of hazards related to climatic silver and human activities there are various coastal landforms are very dynamic in character due to the erosion and acceleration patterns also vary in time. There are highly developed economical activities such as fishing, tourism which is also impact on coastal line and creates many problems later to the coastal ecosystem.

The dynamic coastline and the change detection of coastal zone it is a study in complex nature that is highly challenge for research by using remote sensing and GIS techniques. This is special technique will be helpful in accessing the dynamic nature of coast. Coastlines are one of the most dynamic parts of the Earth's crust. They contain some of the world's most sensitive

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ecosystems, such as mangroves, wetlands, coral reefs, dunes and beaches. In addition, they house large human populations. About 23% of the world's population lives within 100 km of a coast (Small and Nicholls 2003). Coastal systems have many important functions, such as regulating the exchange of water between land and sea, regulating the chemical composition of sediments and water, storing and recycling nutrients and human waste, maintaining biological and genetic diversity, and facilitating agriculture, transportation and navigation. performed by the regions. , providing recreational and touristic means as well as various information regarding aesthetic, historical, cultural and scientific aspects. These functions can be classified into three categories: regulatory functions, user-product functions and information functions (de Groot, 1992; Vellinga et al., 1994).

Remote sensing provide information over a large area has proved to be a very useful in identifying and monitoring various costal features toward a sustainable action plan to achieve the development in any question area. Geographical information system is a computer-based system which is carried out collecting checking integration and analyzing the spatial and non-spatial data of the Earth surface the advantages of GIS techniques for the data acquisition from satellite data and collect all data are significant in arriving at integrated coastal zone management.

In the Sindhudurg district utilization of land increasing with increase in population, increasing in agriculture, increasing in industrialization and mining also. It shows varies from tahsil to tahsil. The utilization of land is needs to have general frame work of strategic and effective management and analysis of their characteristics and also used for developmental planning in the study area

The importance of coastal zone and its specific environment there is a need of sustainable development preservation and conservation effective

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management of highly dynamic costal features located in the areas under development pressure requires in-depth understanding of their evolution.

1.2. SIGNIFICANCE

Coastal landforms are very important on the earth surface which is represented with various features and its morphology. Landforms also developed by process of erosion and deposition due to the waves tide veins river charges this area also represented with highly populated and leads to a rapid economic and social logical environment coastal landforms and coastline are very dynamic in character and then proposed research will focus on quantitative analysis of coastal changes analysis of coastal area of Sindhudurg district Maharashtra and its impact on morphological structure. The impact of natural environment and human induced changes in the coastal zone will be analyzed by using remote sensing and GIS technologies and need to protect this coastal environment.

1.3 STUDY AREA

Sindhudurg district is the southern part of coastal area that is known as the Konkan. Sindhudurg district situated between 15º 37' North latitude to 16 º 40' North latitudes and 73 º 19' east longitude to 74º 13' East longitudes. It is bordered by Ratnagiri district on the north, Arabian sea on the west, Goa state on the south by Belgaum district of Karnataka state and Sindhudurg district on the east also. Total area of the district is 5087 km$^{2.}$ Sindhudurg district has a coastline about 121 km. The topography of the Sindhudurg as a part of Konkan region. Physiographical Sindhudurg district has also divided into three sections that is Khilati, walati and Sahyadri hills region and respectively. The coastal trip of the coastal area called khalati and walati having a width of 20 to 25 km. respectively and also shows with beaches, shores, creeks and mud flats in the seashore. The eastern portion of Sindhudurg district covered by Sahyadri mountain ranges with small plateaus and flat area. All three sections are north to south direction. Sindhudurg district has 8,48,868 (Male-4,16,695,

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Female-4,32,173) population as per 2011 census. Mean monthly minimum temperature near about 16^0 C. and mean monthly maximum temperature is about 33^0 C in the study area. Annual rainfall range is 2500 mm to 3500 mm. There are number of important cities in the study region, those are also famous tourist point such as Malvan, Vengurla, Mhapasa, Nevra, Varekwadi etc.

1.4 IMPORTANT TERMINOLOGY

1.4.1 Geo-informatics:

It is the group of geographical data management tools such as remote sensing geographical information system and global positioning system. There is remote sensing and global positioning system argues special as well as temporal data and geographical information system have carried out then analysis, arrangement and management for the sustainable development of the region. This data also used for better understanding of the complex interrelationship between physical biological cultural economical and demographical arrangement around the specific resources.

1.4.2 Remote-Sensing (RS):

Remote sensing is defined as the science of deriving information about an object without touching itself. Remote sensing is the measurement tool of information of property of an object or natural phenomena by recording device that is not in physical contact with an object or natural phenomena. It is well known that number of earth observing satellite and meaning air born instruments are available for remote sensing research in the world. The science of remote sensing which is playing a crucial role in observing, monitoring and study the natural resources and environmental situation and condition an area. The information also collected from spectral data of reflected electromagnetic radiations (EMR) that's range extends across the full spectrum from gamma rays two radio waves. Modern techniques used to detect radiation now days

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are better capable, more stable and produce more channels and division of spectrum data. It is also capable for imaging spectroscopy, multiple view of angle, multi polarization bands that capture various important specific and desired data about the surface. Using this information in complex environment models, one can credit environmental process such as ecosystem exchange their condition and situation from global warming. It is very important for understanding the fundamental and basic characteristics of electromagnetic radiation and how to interact with the various constituents of earth surface including natural vegetation cover soil cover, rocks structure, water bodies' urban area and agricultural pattern also. Remote sensing is also useful for to access ecosystem goods and services and to evaluate sustainability of the land use activities.

1.4.3. Electromagnetic Radiation (EMR):

Remote sensing is work out basically using an instrument often termed as sensor. The categorized by different type such as thermal sensor pressure sensor optical sensor and biosensor etc. The majority of remote sensing instruments records electromagnetic radiation that travel at a velocity of $3x10^8$ meters/second from the source, directly through the vacuum of interstellar space or indirectly by reflected or re-radiation to the sensor. The EMR represents especially highly efficient communication connectivity between the remotely located object and the sensor.

1.4.4 Geographical Information System (GIS):

Geographical information system is a powerful tool for the natural resource management; it is the computer-based system, which has carried out store, retrieval, analysis, interpreted, integration and representation on special form of the data.

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1.4.5 GPS:

The Global Positioning System (GPS) is a space based global navigation satellite system (GNSS) which provides reliable positioning, navigation and timing services to worldwide users on a continuous basis in all weather, day night and anyway where anyway anywhere on or near the Earth.

1.5 REVIEW OF LITERATURE

The study about question landforms and its impact on human being is also studied by various researchers into different aspect. C.Y.Ju ,Y.G.Ju ,H. X. Shan (2012) worked on coastal area with assessment of environmental factors in Loshan district, Qingdao in China. They has also used GIS techniques for special analysis and sustainability of environmental system for the coastal city of Qingdao China. They have used analytical hierarchy process and prospects of GIS based land use sustainability analysis in the study area. They have prepared the local plan for the lotion district in China.

Study around wetlands bay and delta margins was carried out by Thomas and Williams (2006). They have created you environmental map series based on primary define the mapping criteria and wetland units are coded according to a wetland classification in Texas gulf coast. Yahan Mansoor Al (2009) have studied and stated the urban development fishing activities tourism industrial development and agricultural activities effect indicates and valuable coastal ecosystem. He have studied that in the relation of human impact and landscape evolution and to determine to the extent cultural change is where environmental influences and focused on North Western coast of Egypt.

John shockley shooting (2006) they have analyzed and study the downstream hydraulic geography of Allah wale channels and examine through a nonlinear regression analysis, there has also tested the regression equation where tested for a channel with ranging from 0.2 to 1,100m, flow depth from

0.01 to 16m , flow velocity from 0.02 to 7m/s , channel slope from 0.0001 to 0.08 and shields parameter from 0.001 to 35m.

Dahdauh-Guebas, Nico Koedam (2008) they have worked on the understand ecosystem changes and stated that the retrospective research generates a basic for prediction that can be used to protect an ecosystem this research highlighted the trans-disciplinary way. Pawar (1993) geomorphic evaluation of the coastal belt along with the upland.

V.P. Upadhyay, P.k. Mishra (2008) they have worked on mangrove ecosystem with relation to economically important resources. These study highlights and shows that effect of natural and man created problems on Mangalore population status in the Orissa Coast of India with special reference to Bhitarknika, Thakardia, Kakranasi and Dangmal sites. They have also observed that the attachment of river Braham mean and b which discharge the water in the Karanatka story are being heavily concentrated with new steel and power industry and iron chromate mine which has bolted to the histories.

ABP Marine environmental research limited report 2008 and environment agency joint scale modeling theme 2.12 2.10 TP in this report shows that how you are there is a more towards more holistic khichuri mein measurement management both within existing and new logistic it has also considered with the morphological changes and the management scheme for the better improvement and reservation of ecosystem of fisheries with legislation framework. M. Thanikchalam and S. Ramachandran (2010) they have study around the remote sensing and GIS technique using in the study of coastal environment of the Tuticorin Coast, India. They has constructed oral route mapping coastal land use land cover mapping coastal landforms mapping shore line change mapping, bathometry mapping. There has a highlight that, changes in coral reefs, coastal area and land use pattern in Tuticorin coast of India.

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Gujar A.R., Angusamy N., Rajamanickam G. V. (2007) have analyzed and detailed study on Konkan coast Maharashtra India and characterized of Opaque's. They have quoted that, Wada Vetya bay shows almost equal-distribution of magnetite and hematite and Vijaya Durga bay is consisting of lime mite and amyloidal hematite they have studied mineral properties and chemical properties of coastal Maharashtra Central coast of India. Geological study about coastal track between Aligarh and riverton Colaba district Maharashtra bye sawan 1988 he has also studied quaternary sediments of the coastal tract in details.

Ahmed (1972) has studied the coastal geomorphology of India with reference to India two West coast of India geological survey of India 1980 published a special bulletin on geomorphology of coral crest Kerala coast. Moni (1980) has thrown light on the coastal erosion in Kerala and the reported the rate of erosion as 0.4 m per year with area level rise of about 1.2 mm per year. Nageshwara Rao and Srinivasan (1980) have studied the structure and sedimentation in the the Palghat region of Kerala.

Costal geological studies around Malvan Maharashtra have been carried out by Pathani Ravindra Angat (1991). Marpho-tectonic evaluation of the southern part of Western coast track of Ratnagiri Sindhudurg district of Maharashtra has been studied by Tiwari (1984) according to topography of the coastal track of Maharashtra has mainly under the tectonic influence coupled with erosional processes and lower evolution have formed due to period uplift of the tract of a hole. Powar (1978, 1979) have made detailed study by field was mapping and land sat imagery is to understand geomorphology and tectonic evaluation of the Konkan coastal track of the West coast of Maharashtra.

Geological study about coastal track between Aligarh and riverton Colaba district Maharashtra bye sawan 1988 he has also studied quaternary sediments of the coastal tract in details. Gehan Mansour El – Bayani (2009)

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He has studied and stated that urban development, fishing activity, tourism, industrial development and agricultural activities that affect delicate and valuable coastal ecosystem. He has studied that interrelation of human impact and landscape evaluation and to determine to what extent cultural changes were environmentally influenced and focused on north-western coast of Egypt.

Reddy (1976) has thrown light on wave refraction in relation to the sediments transport tendency along the west coast of India. Khan and Banarjee (1984) 4 geomorphic unites around Tapti-Vaghur confluence in the Jalgaon district of Maharashtra. These unites are -1) Present day flood plain of Tapti-Vaghur rivers. 2) Terraces of the Tapti-Vaghur rivers. 3) Ravinous tract. 4) Mound of Deccan Basalts. Coastal laterite of Maharshtra state have been studied by Sahastrbudhe (1988) with spatial to its chemistry.

Kulkarni Sanjay Anant (1993), earlier reference to the geological studies of the southern Konkan region is by Wilkinson (1871) and Foot (1876). Later studies by Forc (1923), Deshpande (1938), Iyer (1939), Kelkar (1952, 1956) mainly related to the preliminary observation pertaining geological formation exposed in the region along with their field characteristics.

Coastal geomorphology studies along the coast of Maharashtra in general have been carried out to name a few include Deshpande (1968). There are also number of publications with had appeared on the various aspect of the beach sediments along the Maharashtra coasts.

1.6 AIMS AND OBJECTIVES

The proposed study focused on the main objectives for assessing coastline and coastal landforms, these are follows.

1) To highlight the geographical aspect of the study region.
2) To prepare change detection of land-use and land-cover of the study region.

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3) To analyze topographical and morphological changes by using remote sensing and GIS.

4) To identify vulnerable coastal sites of the study region.

5) To formulate some remedies for dynamic coast for the study region.

1.7 DATA BASE

1.7.1 Sources of Data:

The study of coastal analysisis also connected with changes is carried out by using various sources. The present study is based upon both primary and secondary sources of data. The primary data is collected through field survey and questionnaire method and secondary data is collected from various sources.

1.7.2 Primary Data:

The primary data is collected from conducting the field work. Well planned questionnaires are prepared for collecting information to have the required data about various aspects i.e. household, farming, industrial, natural vegetation condition and other details. To understand the land use land cover condition of the urban and rural habitat household's questionnaire was prepared and collected required data. Random sampling technique is adopted to bring out the realities. The informal interviews are conducted with people and respective officials to collect specific information. The agricultural pattern, transport network, industrial growth and water bodies are checked through questionnaire and personal informal interviews. For the present study we have conducted ground truthing observation with questionnaire scheduled. Through this questionnaire we have collected the information about highly changed area. We have also collected the information related to land cover land use changes in agricultural area, settlement and forest area from local people. There have four blocks selected purposely for data collection such as Northwest block presented with hilly and forested area, East block presented

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with highly cultivated i.e. agricultural land, Middle block were presented with river channel and south block that is highlighted with dense forest area. For each block we have selected randomly hundred families for getting information. Through this total samples of 1000 family the detailed questionnaire were developed and pre- tested and uses to collected the information personally by the researcher related to the objectives of the present study. The questionnaire contained questions on the opinion, and the seriousness of the local people about land use land cover of surrounding area. The use of GPS is also made to collect the primary data and mapping purpose. The mapping of present limit and extension of land use land cover pattern also assessed through GPS Ground Control Points (GCP) are collected in the form of Point. GPS is also used for ground truthing verification i.e. cross-checking of features status of satellite image with real ground condition.

1.7.3 Secondary Data:

The secondary data is collected from various sources i.e. Survey of India, Census of India, Statistical abstracts of Sindhudurg district, Socio-economic reviews, Town Planning Department, Grampanchyat and Talathi offices, etc

1.7.3.1 The Survey of India Toposheet:

Survey of India toposheets of 1:25000 and 1:50000 scale, are used to prepare a base map. The contour, riverside, natural vegetation, etc. information collected from toposheet.1:25000

1.7.3.2 Satellite Dataset:

Satellite Image is a true picture of earth surface hence it is considered as authentic source of information as well as geographical data. Satellite data is available in different resolution pattern, bands with temporal basis and it is utilized as per the need of the study. Satellite images are used in many applications like environmental conservation, agriculture, forestry conservation, biodiversity conservation, regional planning, education, urban

studies, etc. The development in the field of remote sensing is producing high resolution data and temporal data for users.

1.7.3.3 Other Sources:

The District Census Handbook and CD (Compact Disk) are used to collect demographic information for the year, 1991,2001, 20111. The land-use details and other information about Sindhudurg district is collected form socio-economic reviews of Sindhudurg District.

1.8 METHODOLOGY

Techniques and methods of using satellite imagery as data sources have been developed and successfully applied for land use classification and change detection in various environments (Meyer and Turner, 1996). In such studies GIS has played a central role for analysis. Hence, Geo-informatics and its advance tools are the widely applied in land-use and land-cover studies.

Change detection in remotely sensed imagery is defined as the process of quantitatively analyzing and identifying changes occurred on the earth's surface from remotely sensed imageries acquired at different times (Zhang and Shu, 2009). This study is conducted under the discipline of Geography with the help of Geo-informatics hence; it is carried out by combining various methods.

1.8.1 Geographical aspect analysis:

Slope, aspect, elevation, soil depth, lineaments and distance to road settlements and drainage were recorded as they would be more accruable derived through data post- processing in GIS frame work. It is important to qualify forest fragmentation, because spatial structure of habitat in which an organism lives, influence their population dynamics and community structure. Anthropogenic activities can disrupt the structural integrity of landscape and expected to impede, or facilitate organism.

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1.8.2 Software used for the Study:

This study is based on application of Geoinformatics therefore, specific GIS software used for data preparation, representation and analysis. Several commercial, open source software and computer applications are used in this study.

1.8.2.1 ERDAS:

ERDAS IMAGINE® is the world's leading remote sensing solution providing tools to create, manage and analyze satellite image related applications. It is having advanced image processing, comparison and classification capabilities. The satellite image related tasks are done in this software i.e. image processing, enhancement, classification, etc.

For the achievement of above objectives following methodology have adopted for the present research work.

1.8.3 Toposheet Work:

The study was started with collection of topographical maps of the Sindhudurg District. Topographical maps (1: 50000 scale). Then study area was encompassed by four topographic maps. Toposheets were scanned separately and exported to Erdas Imagine in image format for mosaicking. Before mosaicking all scanned to topographic maps were georeferenced to geographic lat-long projection to sub- fixel accuracy. The common uniformly distributed ground control points (GCP) were marked with root mean square error of one of third of a pixel and images were resampled.

After Georeferencing all topographical maps were mosaicked. Then this data was re-projected into UTM – WGS 84 projection for further analysis. After this projected image was exported to Erdas imagine – 9.1 and vectored. The vector map was polygonised.

1.9 LIMITATIONS

This research based on old satellite imageries and mainly primary data were collected by field work. So, various problems were created in the field

work. There were problems related to previous data collection for the comparative study.

1.10 CHAPTER OUTLINE

Chapter 1 provides a general overview of the research. This includes title of research significance of research, research objectives, study area, used data base, adopted methodology, used for the study, brief literature review, etc.

Chapter 2 deals with the geographical setting of the study area. The geographical setup is included of both physical setup and human aspects. The physiographic aspect contained of location of study region, topography, geology, natural vegetation, drainage system and climate etc. In human aspects the study of demographic characteristics such as population density are studied and population growth are studied.

Chapter 3 deals with systematic observation and evaluates the coastal analysis and its changes occurred in the study region. This chapter aims to check the changes taken place in coastal analysis in the period 1990 to 2020 in the study region with tehsil to tehsil level. The change in dynamic land categories like, built-up, agricultural land and natural vegetation area are examined using satellite image classification In last analysis of statistical data is made to check the changes in general coastal analysis pattern.

Chapter 4 deals with examines published coastal vulnerability indices that were created to evaluate and classify responses to the dynamic change in coastal zones throughout the Sindhudurg district.

Chapter 5 included vulnerability analysis with eight variables were considered for developing the CVI: rate of relative sea level change, historical rate of shoreline change (erosion or accretion), coastal regional elevation, coastal slope, mean tidal range, significant wave height, and socioeconomic data.

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Chapter 6 deals with evaluates the summery and findings of the study with reference to the research objectives and offers discussion along with suggestions and direction for further research.

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CHAPTER - II

PHYSIOGRAPHIC CONDITION

2.1 INTRODUCTION

The sustainable development and the regional planning is depend upon geographical environment, setup and resource in any region. The information of the physical (land, water etc.) and social status (population, settlements, economy etc.) becomes essential for the planning and whole development of any region. A study of interrelationship between these two characteristics is the subject matter of environmental sciences and researches also in social environment the organism's works to derive matter from the physical environment for their livelihood and their development. This process gives birth to economic environment the educational, health and economic status of human being have been either directly or indirectly affected by this physical, social and economic environment. In the discipline of Geography physiographic and cultural aspect has been recognized as a vital tool and basis for regional studies (Sharma and Kumar 2009).

2.2 PHYSIOGRAPHIC DIVISION

The Sahyadri region (height above 300 m s the middle belt of the only reason for quality height hundred meter to 300-meter three coastal belt region or Kahlati height between 100 meters.

Physiography is one of the dominant parameters of physical environment and its impact on patterns and density of agriculture is immense (Chouhan T. S., 1987). Agriculture in mountains, plateaus and plains is different from scarps, pediments valleys, flanks, flood plains ridges, alluvial flanks, drumlins, monadnocks, levees and dunes.

The relief features are essentially the product of geological past, the nature of geological composition mantle (Deshpande C. D., 1971). A number of small bands of crushed conglomerate are noticed especially between Niwati

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village and Malvan town (Sahsrabuddhe Y. S.). Relief of the land influences land use, particularly through the elevation, ruggedness and slope. Relief also influences farming by modifying climate and by affecting the ease of cultivation (Sing, 1974). The relief varies remarkably from place to place and the broad and relief changes   are seen in the west-east direction with local variations. These variations in land are due to the geographical evolution (Deshpande C. D., 1971).

Konkan zone of Maharashtra state especially the important physiographic unit. Sindhudurg district is broadly divided into three small sub-divisions based on the elevation and local topography.

1. The main Sahyadri with its their plateau scarps and hilly buttresses (Hilly Sahyadri Region),

2. The low-level lateritic plateau (the Central zone or Valati), and

3. The riverine and estuarine leveled surfaces. (Coastal zone or Khalati).

The framework of the physical setting of the study region is simple. The division of physiographic sub-regions of the study region is presented in table no. 2.1

Table no. 2.1

Physiographic sub-divisions of Sindhudurg District

Sub Region	Local Name	Area in Hectare	% to the total Geographical area of the district
Coastal	Khalati	1,11,978	22.23
Plateau	Valati	1,83,623	36.43
Hilly	Sahyadri	2,08,349	41.34
Total		5,03,950	100.00

Source :- Agriculture Technology Management Agency (ATMA)
Sindhudurg District 2005

2.2.1 Sahayadrian Mountain Range

The eastern part of Sindhudurg district is covered by Sahyadri Mountain range. Its coverage height is above 450m. The eastern part of the study region which is is covered by the Sahyadri hill ranges consists of height above 300 meters from sea level. The Shivgad, Kankavli tahsil Manohargad and Rangnagad, Kudal taluka and Paragad Sawantwadi taluka are important food in the region this region is extended into north south direction having steep slope occupying by Spurs and saddle.

The hilly region covered 208349 hectares (table 2.1) it means that 41.34 percent of geographical area of the district. Many spurs and saddles occur in the area. The Shivgad, Manohargad, Ranganagad, Pargad are the important forts loacated on sahyadri range. This region is extended into north – south direction having steep slopes, occupied by spurs and saddles. Manohargad, Mansantoshgad and Mahadevgad are the important peaks near Amboli pass east of Sawantwadi town. Prassiddhgad or Rangana Fort north of Sawantwadi. Kupicha dongar near village Valaval and in the west are the isolated hills near Vagheri. There are seven chief passes crossing Sahyadri range and Dodamarg in Sawantwadi (now Dodamarg) limits, two of them the Amboli ghat and the Ramghat suitable for cart Five others namely Ghotge, Ranagana, Hanmant, Talkat and Mangeli are suitable only for foot passengers and pack cattle. Amboli pass about 22 kms. East of Sawantwadi town has a motarale road. It is close to and nearly on the same old parpoli pass. The Ram pass is located about 46 kms. east of Banda.

2.2.2 Central Zone or Valati

The central zone or the transitional belt covers the middle part of the region. This plateau region covers 183623 hectares area of the study region which is 36.43% of total geographical area of the district. The central zone which is covered by small hills and ridges having height above 150 meters to 450 meters from the sea level. It includes western parts of the Kankavali, Kudal and Sawantwadi tahsils and eastern parts of the Devgad and Malvan tahsils. This

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part of the study region is locally known as "Valati". The general slope of the zone is from east to west and it is formed by denudation of the rocks. The sub region is well traversed by the north – south road and rail links.

2.2.3 Coastal Zone or Khalati

The coastal strip of the study region characterized by lowlands, shoreline, terraces, sand dunes, cliffs, numerous sandy pockets, beaches, tidal inlets, creeks and estuaries shows a great amount of variability from the study region has occupied 1,11,978 hectares and 22.23 % of the total geographical area of the district (Table 2.1 and Map 2.2)

Narrow, flat and low shoreline terraces covered with a thin apron   of coastal alluvium borders the tidal inlets. This zone, which lies on the west of the central transitional belt is associated with lowlands an Arabean sea coast. Small hills and lowlands cover the western part of Devgad, Malvan and Vengurla tahsils. The elevation of the area is below 150 meters and is formed by alluvial soil, which is fertile, locally called, "Khalati Soil". Cliff formed by wave action and there is a great variety of shore marks between 2 mts. to 10 meters above sea level (Karlelar, 2000). The tidal basins are a series of small flat plains.

2.2.4 The Middle Belt:

The Central or middle part of the study region which is covered by many small hills and regions having height above hundred meter to 300 m from sea level this part of the study region is locally known as Valati this part of the study region is formed by demolition of the rocks.

2.2.5 Coastal zone:

The western part of the study region is associated with cost of Arabian Sea. This part is formed by alluvial soil which is more fertile so it is locally called as Khalati. The western part of the Devgad and Malvan tahsils are formed by laterite soil and rocks which is not much fertile and useful for cultivation of the rice, but it is more useful for plantation of the mangoes and national cashew nut.

Map No. 2.1 Physiographic sub-divisions of Sindhudurg District
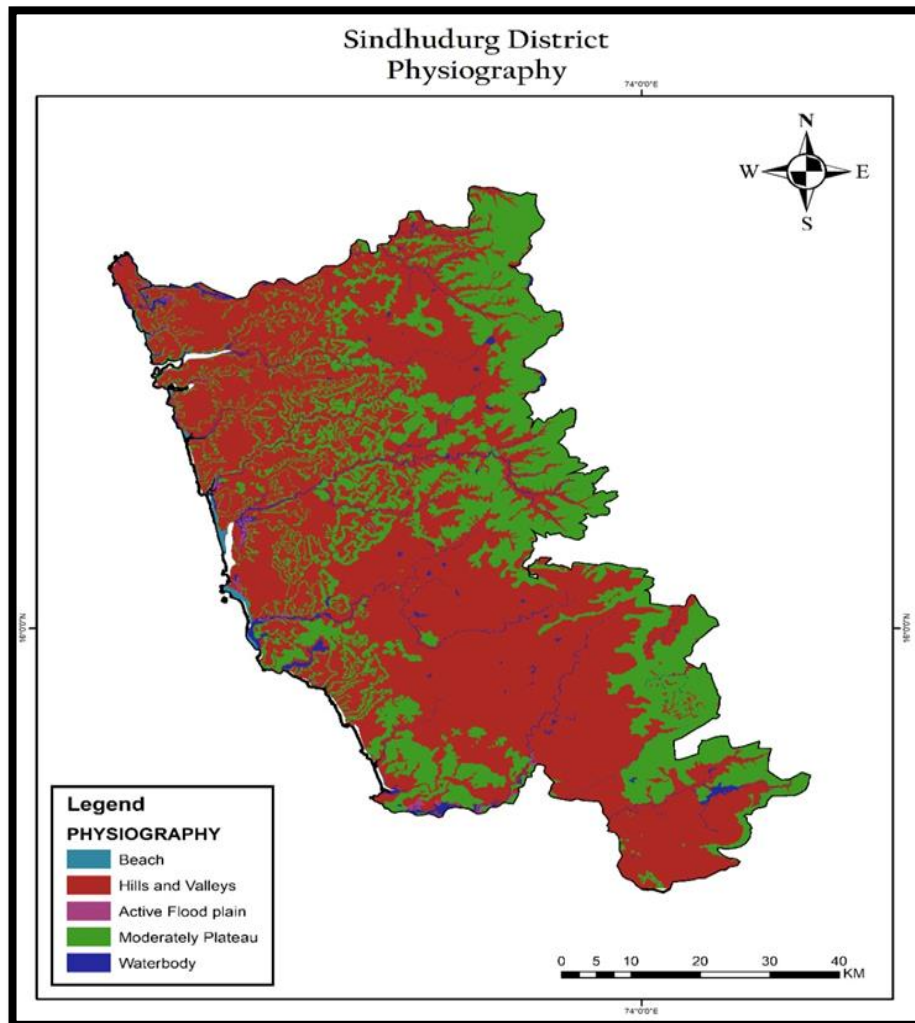
Source- SRTM Data

2.3 DRAINAGE SYSTEM

There are eight important rivers nearly Shak river, Devgad River, Kadvi river Terekhol river and Tilari river all of the rivers originate from the Sahyadri ranges all the rivers are flow with east west direction and drains in the Arabian sea. level is the most important river of district from the point of view of basin river. carnival river basin area near about 1000 square km. lowest area covered by river that is 304 square kilometer, but it is drainage Population is very high that is 1.3 per square kilometer. Shak Waghotan river is the northern most

important river in the district and formed natural boundaries between Ratnagiri and Sindhudurg district. This river also used for navigation. The river Devgad and other rivers are flowing from the east to west. Devgad river as a natural boundary between Devgad tahsil and Malvan tahsil. There is the most important river which flows from the middle part of the district, called and Tilari river are in the southern part of the district. Nearest to the sea coast from part of the carnival Akshara and macha and Devgad river are tidal this river are useful for navigation and fishing. These river are famous for water transport in Goa state.

2.4 CLIMATE

2.4.1 Rainfall:

Along the Western Ghats on the eastern boundaries of the district rainfall is very heavy. In this district generally rainfall is very high as compared to other district of Maharashtra. The highest annual normal rainfall is in Kankavli tehsil that is 4000 mm and the lowest normal annual rainfall is in Devgadh tehsil that is 1000 mm. The average rainfall of Sindhudurg district is 3000 mm.

Map No. 2.2 Sindhudurg District- Rainfall
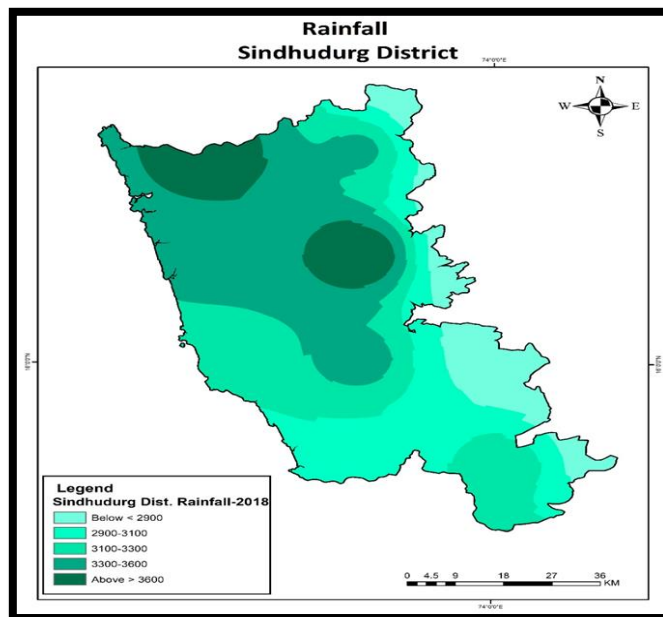
Source- Census of India (2011)

The rainy season is due to the south-western monsoon, that is June to September. The rainfall is very high in Vaibhavwadi followed by high rainfall recording at Kankavali, Kudal, Swantwadi above rainfall was found. Below average rainfall of study region is found in Devgad, Malvan and Vengurle tahsils.

2.4.2 Rainfall Variability

Standard deviation is an absolute measure of dispersion but it fails to give us a precise idea about the Variability without reference to the central tendency of the series. The co-efficient of Rainfall Variability is calculated by using the following formula.

S. D. Coefficient of Rainfall Variability =

$$\text{S.D.} \quad \frac{100}{X}$$

Where,

S.D.   =   Standard Deviation

X = Mean of rainfall during last 25 years.

In general, the Variability is high where the rainfall is less (Das, 1969). But this statement is not perfect match to this study region because the co-efficient of rainfall Variability is high in Vaibhavwadi tahsil and also the rainfall is high. Average annual rainfall and co-efficient of Rainfall Variability in Sindhudurg district is given in table no. 2.4.

To compare between two or more distributions which are expressed in different units or even when expressed in the same units having widely diffused means. In this case, we take help of some relative measures of dispersion. The most commonly used measures of relative dispersion are the co-efficient of variation.

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Table no. 2.2 Average Annual Rainfall and Co-efficient of Rainfall Variability in Sindhudurg District (1981-2020)

Sr. No.	Tahsils	Average Annual Rainfall in (m.m.)	Co-efficient of Rainfall Variability (%)
1	Devgad	2334.48	19.55
2	Vaibhawadi	4336.16	23.80
3	Kankavali	3441.56	20.25
4	Malvan	2285.76	19.18
5	Vengurla	2798.92	16.37
6	Kudal	3226.88	21.62
7	Sawantwadi	3729.81	19.33
	District	3164.79	20.01

Source :- Socio Economic Absrtact of Sindhudurg District (1981 to 2020).

Table 2.4 indicates the coefficient of Rainfall Variability in Sindhudurg District. It is clear from the table and the map that the variability of rainfall in the study region ranges from 16.37 per cent to 23.80 per cent in Vengurla and Vibhavwadi tahsils respectively. Rainfall Variability is below 20 per cent is in Vengurle (16.37 %), Devgad (19.55 %), Malvan (19.18 %), and Sawantwadi (19.33 %) and it is 20 per cent to 25 per cent in Kankavali (20.25 %), Kudal (21.62 %) and Vaibhavwadi (23.80 %) tahsil.

Fig. No. 2.1 Sindhudurg District- Rainfall

Source- Census of India (2020)

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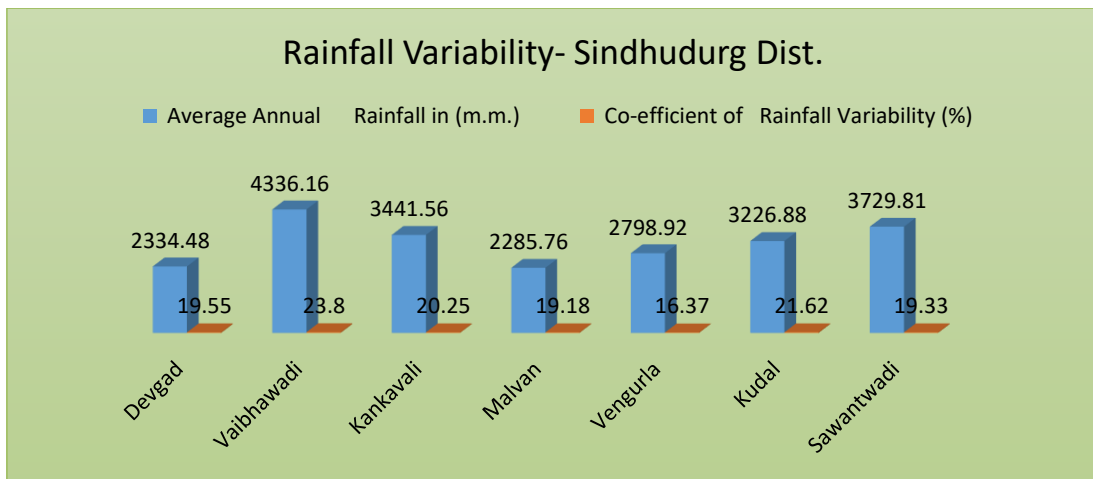
2.4.3 Temperature:

Temperature above the minimum is therefore, effective in furthering the growth of plant towards maturity and ripening. The crucial air temperature is 6oC and above which degree plant grows (Schimper, 1903). Without suitable temperature conditions, germinations of seed and growth of plant are retarded. Temperature regulates all the chemical and physical processes of plant metabolism. The metabolic processes begin at a certain minimum temperature and increase with rise of temperature until they reach a maximum at a temperature called the optimum temperature.

Table No. 2.3 Temperature of Sindhudurg Dist. From 1981 to 2020

Sr. no.	Months	Maximum Temperature	Minimum Temperature
1	January	33.5	16.6
2	February	34.4	17.1
3	March	35.0	20.0
4	April	35.7	23.0
5	May	34.9	24.9
6	June	31.6	24.6
7	July	29.1	24.1
8	August	29.1	24.0
9	September	30.2	23.6
10	October	32.9	22.9
11	November	33.9	20.6
12	December	33.5	17.4
Average		32.8	21.6

Source :- Agricultural Research Station, Sindhudurg (1981-2020)

The above table reveals the January is the coldest month with the mean daily minimum temperature at 16.6 degree C and mean daily maximum at 33.5 C. The temperature is slightly low in December and February. In the month of January mean daily minimum lowest temperature is recorded 16.6 C.

Fig No. 2.2 Sindhudurg District- Temperature
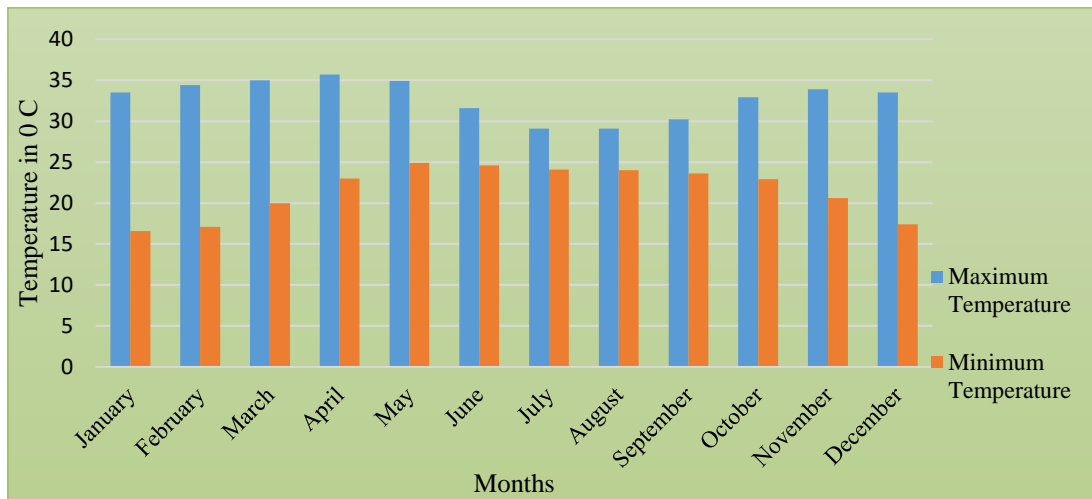
Source :- Agricultural Research Station Sindhudurg (1981-2020)

2.5. SOIL PROFILE

In Sindhudurg district, there is laterite soil commonly found in this area. It is varying in color from bride to yellow and brownish red. The color of soil comes from the hydrated iron oxides; it is rich with nitrogen and organic matter. Its texture is loamy they are r for rose and nest retentive of moisture soils are found in various types which are follows:

2.5.1 Rice soil and Warkas soil:

This type of soil is available on the slope of the hills. It is yellowish red in color and poor in fertility. Ragi, Nagli is the main food crop in this area the cash and that is also an important cash crop in this area the world renewed Alpha 9 mangoes are grown on the soil only.

2.5.2 Garden soil

This soil are located in the bottom of the hill ranges and are really fertile coconut and are not gardens through well in this soil.

2.5.1 Rice soil and Warkas soil:

This type of soil is available on the slope of the hills. It is yellowish red in color and poor in fertility. Ragi, Nagli is the main food crop in this area the cash and that is also an important cash crop in this area the world renewed Alpha 9 mangoes are grown on the soil only.

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Map No. 2.3 Sindhudurg District- Soil
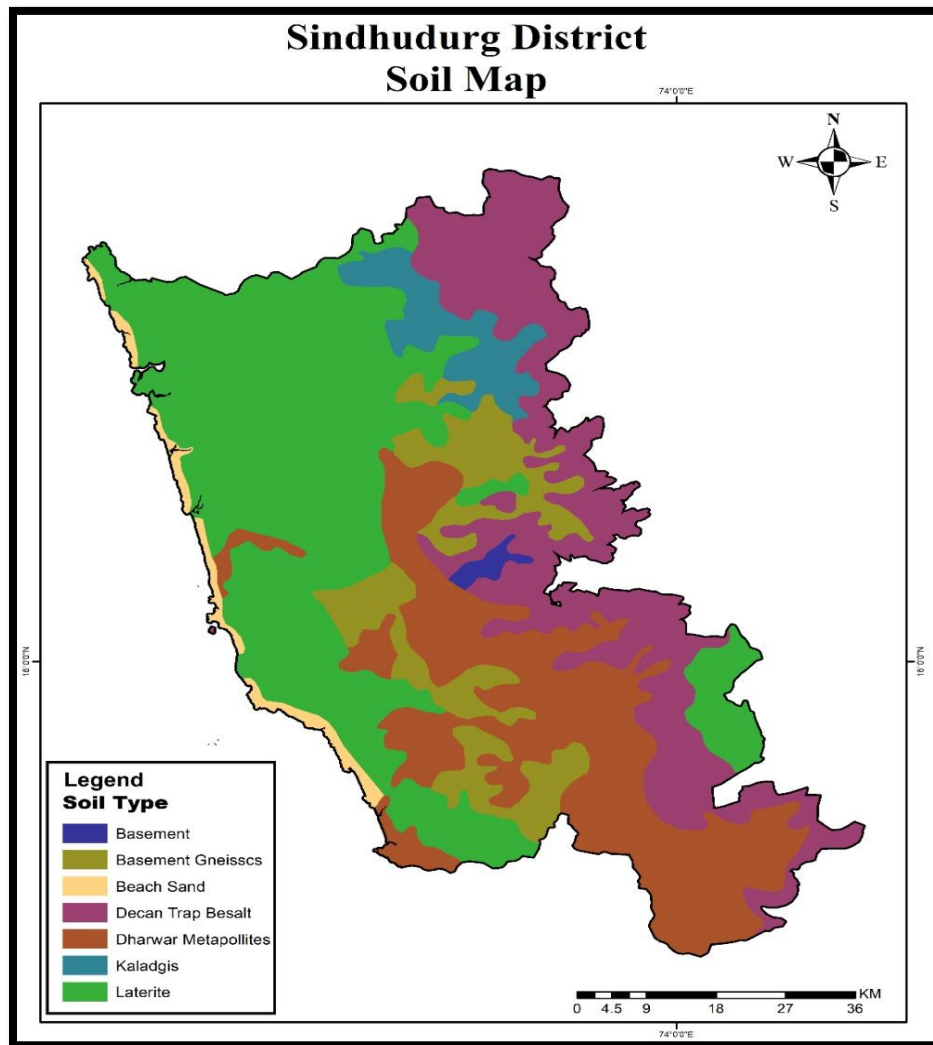
Source- Census of India (2011)

2.5.2 Garden soil

This soil are located in the bottom of the hill ranges and are really fertile coconut and are not gardens through well in this soil.

2.5.3 coastal Olivia

The coastal strips in devgadh malvan and vengurla tahsil are deep Sandy looms the coconut and arecanut garden are also fairly found in these areas.

2.5.4 Salty land

Due to the in condition of the sea a part of coastal soil has become salty they are locally known as ka land or cousin in Devgad, Malvan, Vengurla tahsil the entire Western states are salty.

2.6 POPULATION

Table No. 2.4: Sindhudurg- Tehsil wise Population (2011)

Sr. No	Tehsil Name	Population
1	Devgad	1,20,909
2	Vaibhavwadi	43,845
3	Kankavali	1,35,295
4	Malvan	1,11,807
5	Vengurla	85,801
6	Kudal	1,55,624
7	Sawantwadi	1,47,466
District	Sindhudurg	8,48,868

Source- Census of India (2011)

Map No. 2.4 Sindhudurg District- Population
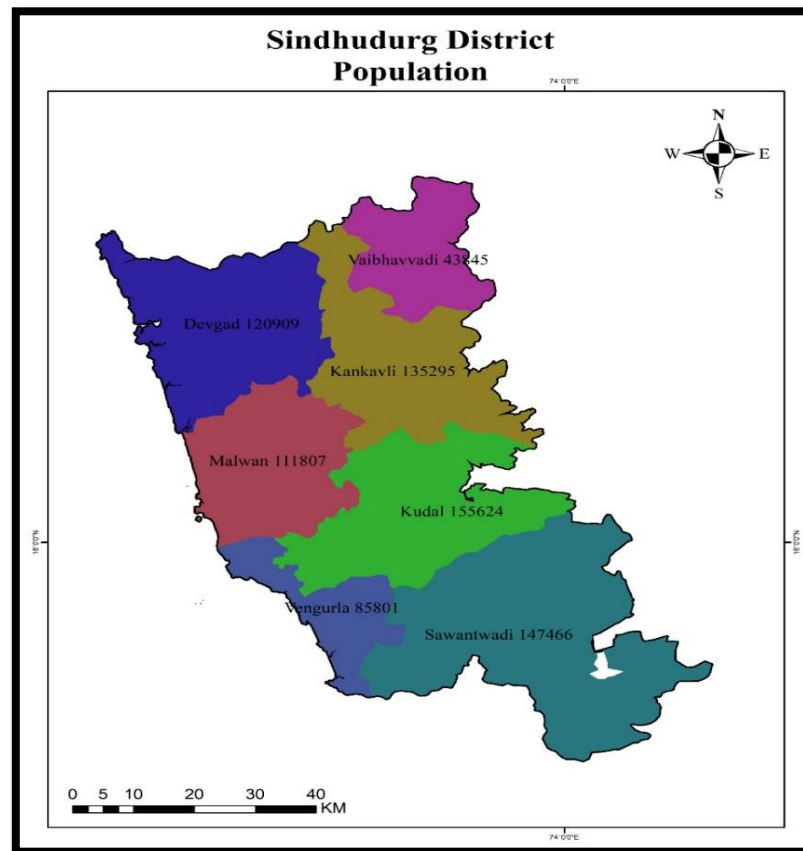
Source- Census of India (2011)

Sindhudurg district has 8,48,868 (Male-4,16,695, Female-4,32,173) population as per 2011 census. Within the district highest population was recorded in Kudal tehsil (155624) fallowed by Sawantwadi tehsil (147466). Whereas a lowest is in Vaibhavwadi tehsil (43845). It is shown in the table of 2.5 there is most of the well-developed agricultural setup and agro-industrial belt and tourism development. There is almost heavy rainfall and dense forested area so there is no option for economic development in Vaibhawwadi tehsil. Second one lowest population presented in the Vengurla tehsil (85801). Kankawali is middle part of Sindhudurg district and it is also connected with Karnataka and Goa state with the hilly topography showing with high population (135295). Devgad tehsil presented with 120909 population due to the agricultural (Alphonso Mango) as well as tourism and fishing.

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CHAPTER-III
LAND USE AND LAND COVER OF SINDHUDURG DISTRICT

3.1 INTRODUCTION

India being one of the important countries for utilization of natural resources like land, soil, water and climatic conditions etc. India has experienced the utilization pattern of natural resources and land use pattern varies from place to place as well as state to state. General land use pattern also affected by physical setting, proportion of population of the area, economic status of the area and climate also. General land use pattern changes from time to time due to the increasing urbanization, agricultural activities, unplanned human activities, forest cutting etc. Hence, an attempt has been made to study the detailed study of the land use pattern and its relation to human and environment in the study area.

Land use pattern is also important for the development of Agricultural sectors, industrialization as well as environmental condition. It is showed the surface utilization of all developed, undeveloped, vacant land for specific purpose. In the Sindhudurg district utilization of land increasing with increase in population, increasing in agriculture, increasing in industrialization and mining also. It shows varies from tahsil to tahsil. The utilization of land is needs to have general frame work of strategic and effective management and analysis of their characteristics and also used for developmental planning in the study area.

Sindhudurg district is the southern part of coastal area that is known as the Konkan. Sindhudurg District situated between 15 37' North latitude to 16 40' North latitudes and 73 19' east longitude to 74 13' East longitudes. It is bordered by Ratnagiri district on the north, Arabian sea on the west, Goa state on the south, Belgaum district of Karnataka state and Kolhapur district on the east also. The total area of the district is 5087 sq. km. the topography of the Sindhudrg district as a part of Konkan.

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physiographical Sindhudurg district has also divided in to three section that is, Khalati, Valati and Sahyadry hilly region respectively. The coastal strips of the district are called, Khalati and Valati having width of 20 to 25 km respectively.

3.2 DATABASE AND METHODOLOGY

The present study based on secondary data which is obtained from Socio-Economic Abstract of Sindhudurg district (2020) and gazetteer of the Sindhudurg district. For the calculation, used the simple statistical techniques and calculated the proportion of every and each types of land. The final results and important finding have been presented through the divided circle for the quality of the work.

3.3 THE ANALYSIS

General land use pattern in Sindhudurg district is shown in chart form with tahsil wise utilization of land.

Table 3.1. Tahsil-wise General land use pattern in Sindhudurg District (2020) (Area under hectares)

Sr. No.	Tehsil	Tot. Geog. Area	Area Under Forest	Area not avail. For Cultivation	Uncultivable Land	Fallow land	Net Sown Area
1	Devgad	78,127	3,604	35,077	211	20,810	16,193
2	Vaibhavwadi	41,662	2,744	8,838	730	14,635	10,847
3	Kankavali	77,339	8,997	12,837	10,203	541	28,351
4	Malwan	61,829	298	22,347	8,896	5,388	21,329
5	Vengurla & Sawantwadi	1,13,573	11,358	25,236	933	6,540	40,457
6	Kudal	81,897	9,843	20,562	13,786	4,611	31,145
7	Dodamarg	49,573	2,399	18,371	408	5,465	14,315
	Total	5,03,950	38,643	1,43,268	35,167	57,990	1,62,637

Source – Socio-Economic Abstract of Sindhudurg District (2020)

Fig. no. 3.1 Sindhudurg Dist. - Land Use
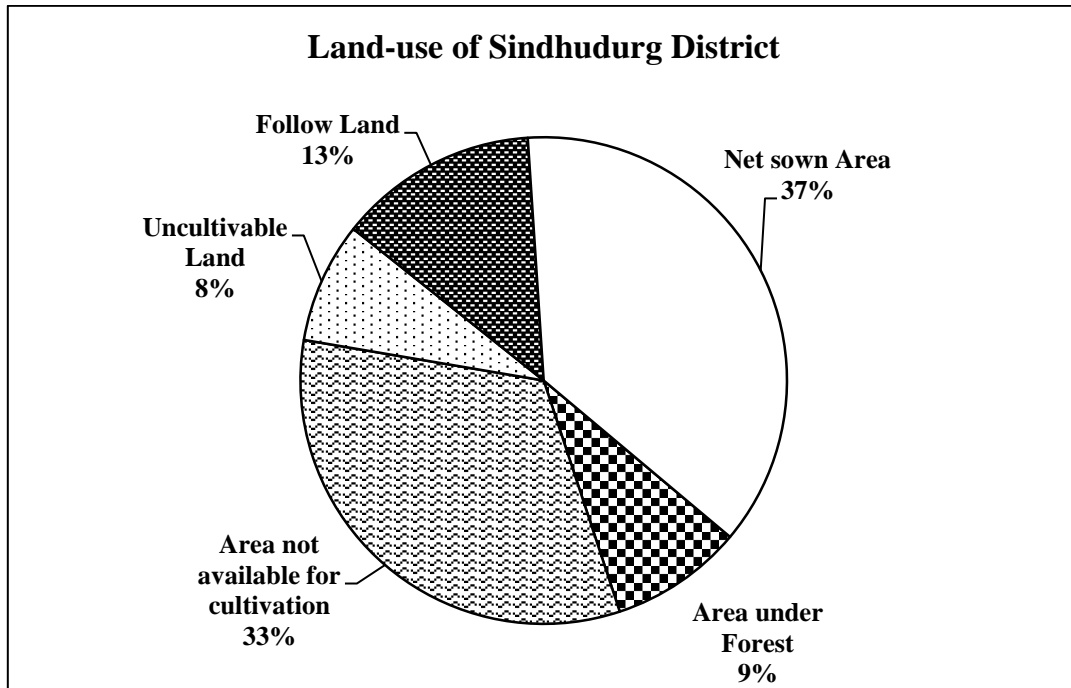
Source – Compiled by Researcher

I) Area under Forest:

The total geographical area of the Sindhudurg district is near about 503950 hectares. About 38643 hectares (7.6 %) of the total geographical area of the Sindhudurg district is under the forest during the year of 2002-2003. It is the lowest proportion out of the total geographical area of study region. The area under the forest presents with varies from tahsil to tahsil. The highest area under forest is found in Kudal tahsil (25.4 %) whereas the lowest forest area is found in Malvan tahsil (0.7 %) due to the physical setting and existence of the Arebean Sea.

Out of the total geographical area of Sindhudurg district, bellow 10 % area is found in Devgarah (07.7%), Vaibhavwadi (7.1 %) and Dodamarg (6.2%) tahsil. General we have to experience the area under forest is very less in Sindhudurg district.

Table 3.2. Tahsil-wise General land use pattern in percentage

Sr. No.	Tehsil	Tot. Geog. Area	Area Under Forest	Area not avail. For Cultivation	Uncultivable Land	Fallow land	Net Sown Area
1	Devgad	15.5	7.7	24.4	0.5	35.8	9.9
2	Vaibhavwadi	8.2	7.1	6.1	2.0	25.2	6.6
3	Kankavali	15.3	23.2	8.9	29.03	0.9	17.4
4	Malwan	12.2	0.7	15.5	25.2	9.2	13.1
5	Vengurla & Sawantwadi	22.5	29.3	17.6	2.6	11.2	24.8
6	Kudal	16.5	25.4	14.3	39.2	7.9	19.1
7	Dodamarg	9.8	6.2	12.8	1.1	9.4	8.8
	Total	100	100	100	100	100	100

Source – *Compiled by Researcher*

II) Area Not Available For Cultivation:

About 143268 hectares (28.4 %) of area is under not available for cultivation in Sindhudurg district. The area under these categories varies from tahsil to tahsil. The highest area under this categories presented in Devgarah district is 35077 (24.4 %) and the lowest area of not available for cultivation is found in Vaibhavwadi tahsil (6.1%) and Kankavali tahsil (8.9%).above 10 % area under the area not available for cultivation are found in Malwan (15.5 %), Vengurla and Sawantwadi (17.6%), Kudal (14.3%) and Dodamarg (12.8%).

III) Other Uncultivable Land (Excluding Fallow Land):

Out of the total geographical area of study region, about 35167 hectares (6.9%) area under the other uncultivable land .the highest area under this category is found in Kudal tahsil (39.2%) whereas the lowest area found in Devgarah tahsil (0.5%). Out of the total geographical area bellow 5% is found in Dodamarg (1.1%), Vaibhavwadi (2%) and Vengurla + Sawantwadi tahsil (2.6%).

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Map No. 3.1. Tahsil-wise General land use pattern in Sindhudurg District (2020) (Area under hectares)
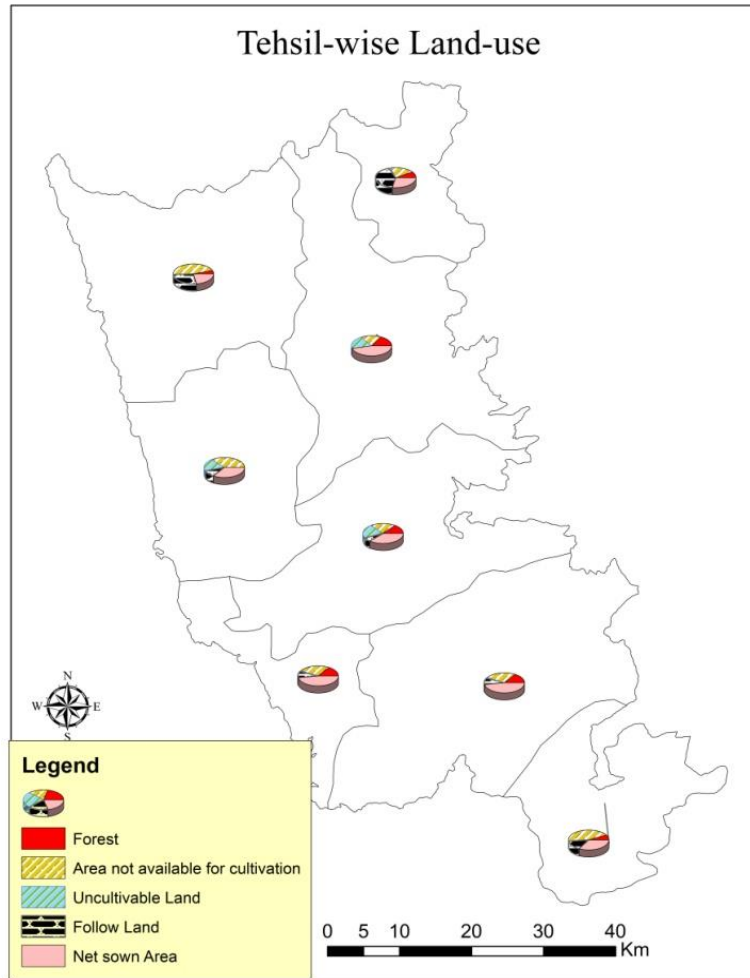
Source – Socio-Economic Abstract of Sindhudurg District (2020)

IV) Fallow Land:

Out of the total geographical area of Sindhudurg district about 57990 hectares (11.5 %) land is under fallow land. The proportion of fallow land is varies from tahsil to tahsil instudy region. Bellow 10 % area under the fallow land is found in Kudal (7.9%), Malvan (9.2%). Dodamarg (9.4%). The highest area under this category is found in Devgarah tahsil (35.8%) and the lowest area under this category is found in Kankavli (0.9%). Above 10% area under the fallow land is noticed in Vaibhavwadi (25.2%) and Vengurla+ Sawantwadi tahsil (11.2%).

V) Net Sown Area:

About 62637 hectares (33.2%) land is under the net sown area. The highest area under the net sown area found in Vengurla + Sawantwadi tahsil (24.8%) and the lowest area under this category noticed in Vaibhavwadi tahsil (6.6%). Bellow 10% area under this category is noticed in Dodamarg (8.8%), Devagarah tahsil (9.9%). Above 10% area under net sown area noticed in Malvan (13.1%), Kudal (19.1%) and Kankavali tahsil (17.4%).

3.4 GENERAL LAND-USE PATTERN IN DEVBAG

The Devbag, Sindhudurg district is a part of Western Ghats Maharashtra and extremely southern part of Maharashtra state is Devbag, Sindhudurg district lies between 16º 1' north latitude to 73º 31'east longitude. The Devbag, comprises 13.553sq. km area. The general height of the district is 10 mtrs. In general the physiographic arrangement of the district has Sahyadri hills in a north-south direction, plateau area situated to the east of the Sahyadri hills and eastern plain area and Belgum district of Karnataka state in the south. General land use pattern in Devbag, Sindhudurg district is shown in chart utilization of land. In this chart shows, every land utilization in percentage to the total area.

Table No. 3.3 Land use pattern in Devbag, Sindhudurg District

	Geographical area in sq. mts	Percentage
Total Area in Sq. mts	13553.53	100 %
Area under Forest	4488.56	33.00%
River Bed	2401.46	17.77%
Other Water Bodies	126.56	00.93%
Open Land	398.68	02.94%
Open Laterite Rock	1370.63	10.11%
Beach	214.46	01.58%
Agricultural land	4553.53	33.39%

Source – Socio-Economic Abstract and Satellite Image of Devbag, Sindhudurg District (2020)

Fig. No. 3.2 Land use pattern in Devbag, Sindhudurg District
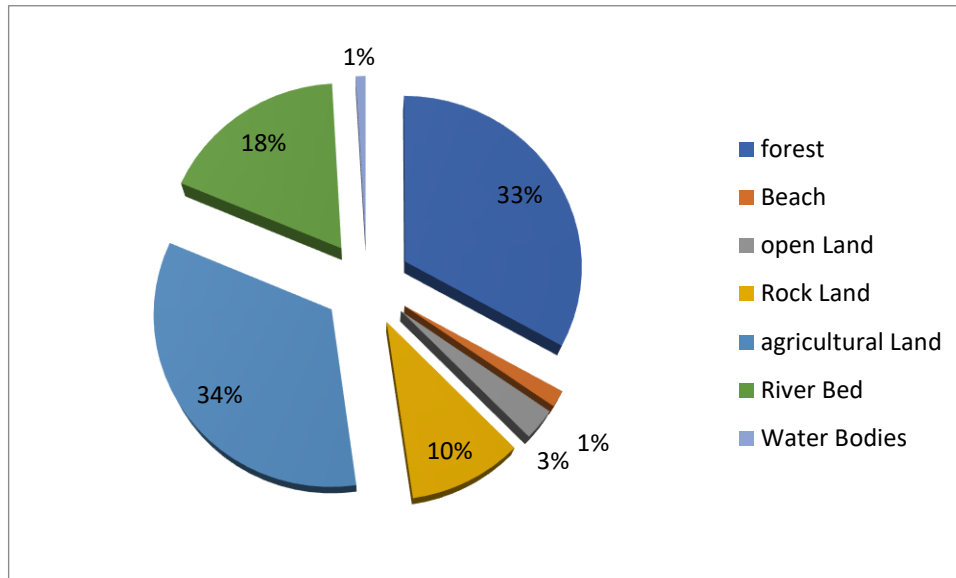
(2020)

Source – Socio-Economic Abstract and Satellite Image of Devbag, Sindhudurg District (2020)

1) **Area under Forest :-**

The total geographical area of the Devbag, is near about 13553.53 sq. mts. About 4488.56 mts (33%) of the total geographical area of the Devbag, Sindhudurg district is under the forest during the year of 2020. It is the highest proportion out of the total geographical area of study region. The area under the forest presents with varies from place to place. The highest area under forest is found due to the rainfall and this tahsil having in high altitude i.e. 1000 to 1200 meter, so the highest area under the forest is found in that tahsil.

2) **Area under Agricultural land :-**

About 4553.50 mts (33.50 %) of area is under agricultural land in Devbag, Sindhudurg district. The area under this category varies from tahsil to tahsil. This is highest area to total geographical area in Devbag region. The highest proportion of land also found in agricultural land due

to the rainy season is long and this is the sub-plan area so there are most of the area accurse under the cultivation also.

3) Area under River Bed :-

Outof the total geographical area of study region, about 2401.11 mts (17.77%) area are under the River bed. There is most of the area also covered by estuary of Devbag.

4) Area under Open Laterite Rock :-

After studying satellite images we have observe that, out of the total geographical area of Devbag near about 1370.63 mts (10.11 %) land is under open laterite rock. We have observed that there are most area represent with laterite rock structure. There are also found mining activities.

5) Area under Open land :-

The chart is presented the total area under the Open land that is 398.68 mts (2.94%). There is complexes in the utilization of land and its characteristics. There are beaches and laterite rocks bed are concentrated so nothing any more area remaining for the open land.

6) Area under Beach :-

After studying satellite images we have observe that, out of the total geographical area of Devbag near about 214.46 mts (1.58 %) land is under the beach. We have observed that there are most area occupied by agricultural land, forest area and river bed also. There is a small thin belt lying between ocean and Konkan plain.

7) Area under Other Water Bodies :-

After obsorving satellite images we have found that, out of the total geographical area of Devbag near about 126.56 mts (0.93 %) land is under other Water bodies as like small pond, water of flood. It is the smallest portion in the utilization of land in the Devbag area.

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3.5 CONCLUSION

In the study region the general land use pattern is varies from tahsil to tahsil due to physiographic structure, climatic condition and other economic activities. The highest proportion of area under the net sown area (33.1%) and the lowest area found in under the uncultivable land (6.9%). The highest area under the forest is found in Kudal Tahsil (25.4%) and the lowest area under the forest found in Malvan tahsil (0.7%).

In the Devbag, the general land use pattern is varies from places to places due to physiographic structure, other economic activities and change settlement growth and pattern also. The highest proportion of area also represent under the agricultural land (33.59%) due to there were proportion of high-quality soil, optimum precipitation and water availability. The lowest area also represented with other Water bodies (0.93%). After the agricultural land the second one area is found under forest (33 %) due to hills, steep slope, high rainfall and critical condition for development of settlement protect forest in this area. Where is the open laterite rock is represented with 10.11 percent due to the very high mining activities is in that area. There are most of the settlement built up with laterite blocks. It is also need and important for better management of natural resources and development of study region.

It is also need and important for better management of natural resources and development of study region. There are most potentiality for the precious utilization of land and natural resources.

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CHAPTER -IV
AFFECTING FACTORS FOR VULNERABLE SITUATION-PHYSICAL, SOCIAL AND ECONOMICAL FACTORS

4.1 INTRODUCTION

Maintaining coastal processes is crucial because they provide ecosystem services regarded crucial for human well-being and are defined by significant ecological and natural value (MEA, 2005; Ramieri et al., 2011). The relationship between the coastal ecology and humans has already been heightened by a large variety of frequently competing human activities. Sea level rise and climate change are also putting a greater strain on coastal regions, which have been negatively impacted by significant human activity throughout time. A negligible rise in sea level might have an impact on natural coastal systems (Din et al., 2019). Particularly, the rise in 2100 may be up to 1 m, which will have an impact on the coastal property zone, where the majority of people would be residing by the year 2040. (Hamid et al., 2018).

One of the most dynamic regions of the earth's surface is the seashore. They are home to some of the most delicate ecosystems in the world, including mangroves, wetlands, coral reefs, dunes, and beaches. In addition, a sizable human population resides there. In the world, 23% of people reside within 100 kilometres of the shore (Small and Nicholls 2003). The regulation of water exchange between land and sea, the control of sediment and water chemistry, the storage and recycling of nutrients and human waste, the preservation of biological and genetic diversity, the provision of land for agriculture, the provision of means for transportation and navigation, the provision of means for recreation and tourism, and the provision of a variety of information regarding aesthetic, historical, cultural, and scientific

The basis for determining coastal vulnerability is human perception and assessment of danger to various components of the natural system from a range of sources (McFadden, 2007; McLaughlin and Cooper, 2010). The variety of physical, biological, and human features that result in coastal

vulnerability has led to efforts to categorise coastlines using interdisciplinary data (LOICZ, 1995; Cooper and McLauglin, 1998). Earth scientists have created a variety of methods to make it simple for non-specialists to grasp complicated, multidimensional environmental data. This study examines published coastal vulnerability indices that were created to evaluate and classify responses to the dynamic change in coastal zones throughout the world.

4.2 BACKGROUND INFORMATION OF RESPONDENT-SEX COMPOSITION

Table No.4.1-Sex Composition

Sr. No.	Respondent sex	Frequency	Percentage
1	Male	640	64.00
2	female	360	36.00
	Total	1000	100

Source- Compiled by researcher

Figure No.4.1--Sex Composition
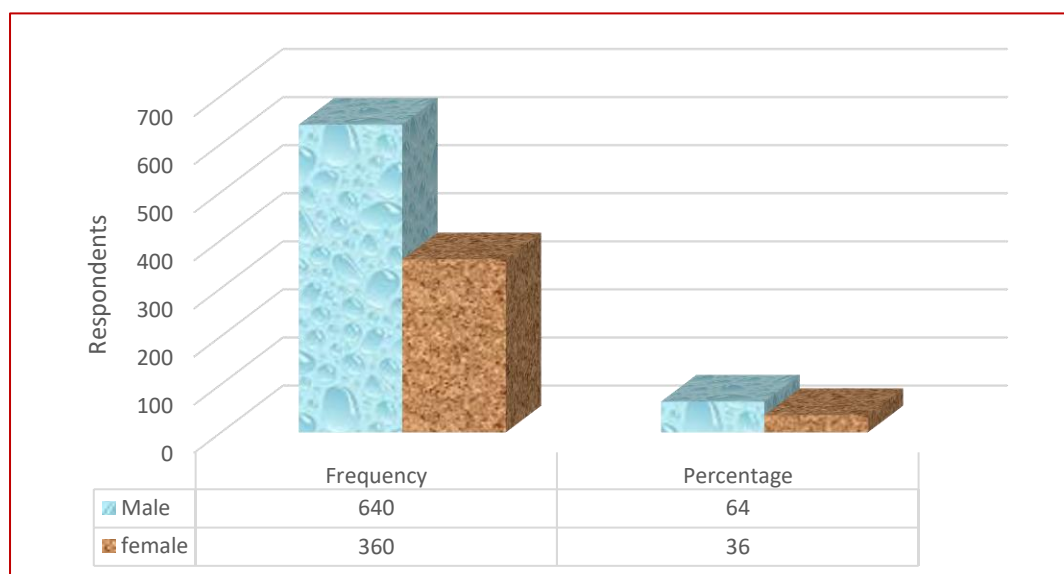
Source- Compiled by researcher

Table no. 4.1 is showing the sex composition of respondents. It is indicate that the respondent 64 % was male respondent 36 % respondent was

female respondent out of the 1000 observation. We have found the 90% are male headed household and 10% household headed by female.

4.3. - AGE CATEGORY OF THE RESPONDENT

Table No.4.2-–Age Category

Sr. No.	Age Category	Frequency	Percentage
1	20-30	150	15.00
2	30-40	200	20.00
3	40-50	520	52.00
4	50-60	130	13.00
		1000	100

Source- Compiled by researcher

Figure No.4.2-–Age Category
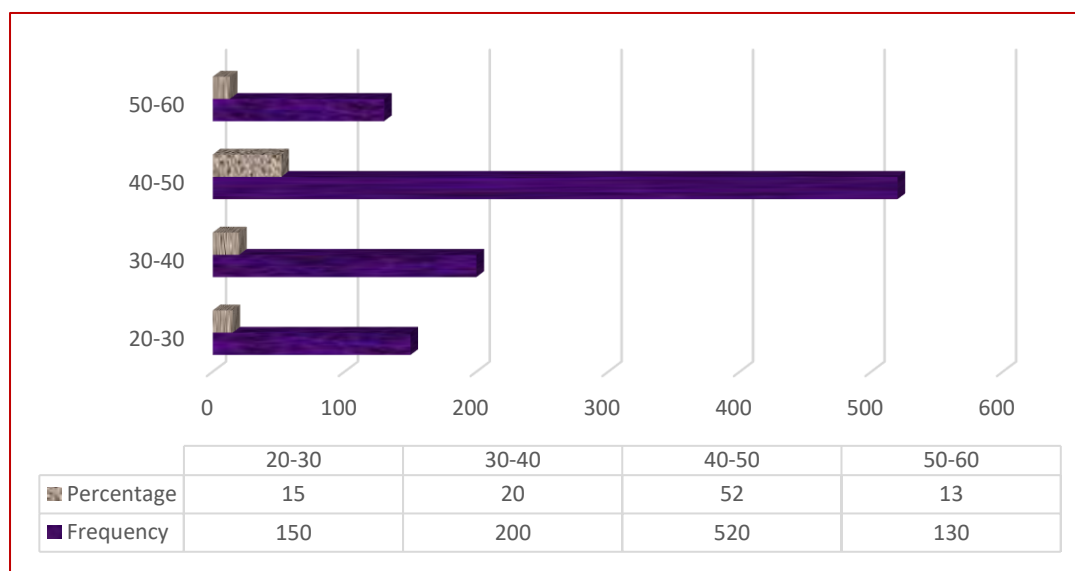
Source- Compiled by researcher

Table no. 2 shows that, 150 respondents (15%) was from the age group of 20-30. 100respondents of age group of 30-40 (20%). 520 respondents from the age group of 40-50 (52%). Remaining 130 (13%) respondent from 50-60 age group. Most of the respondent selected from age group of 50-60 due to their experience, knowledge and right and true information about region.

4.4 EDUCATION STATUS

As is indicated in the table no. 4.3 represented that, the educational level of the respondents. Out of 1000 respondents there are 5.5% respondent are unable to read and write they are illiterate people. Out of the total respondent 21% respondents are educated up to 10th standard. 54.3% respondent has study of graduation level. 19.4% respondent are complete Post Graduation level education. 7 respondents represented of technical education like It, engineering and medical.

Table No.4.3 -Education status

Sr. No.	Education	Frequency	Percentage
1	Illiterate	55	5.5
2	Up to 10th Standard	210	21.00
3	Graduation	543	54.3
4	Post-graduation	195	19.5
5	Technical education	07	0.70
		1000	100

Source- Compiled by researcher

Figure No.4.3 -Education status

	Illiterate	Up to 10th Standard	Graduation	Post-graduation	Technical education
Frequency	55	210	543	195	7
Percentage	5.5	21	54.3	19.5	0.7
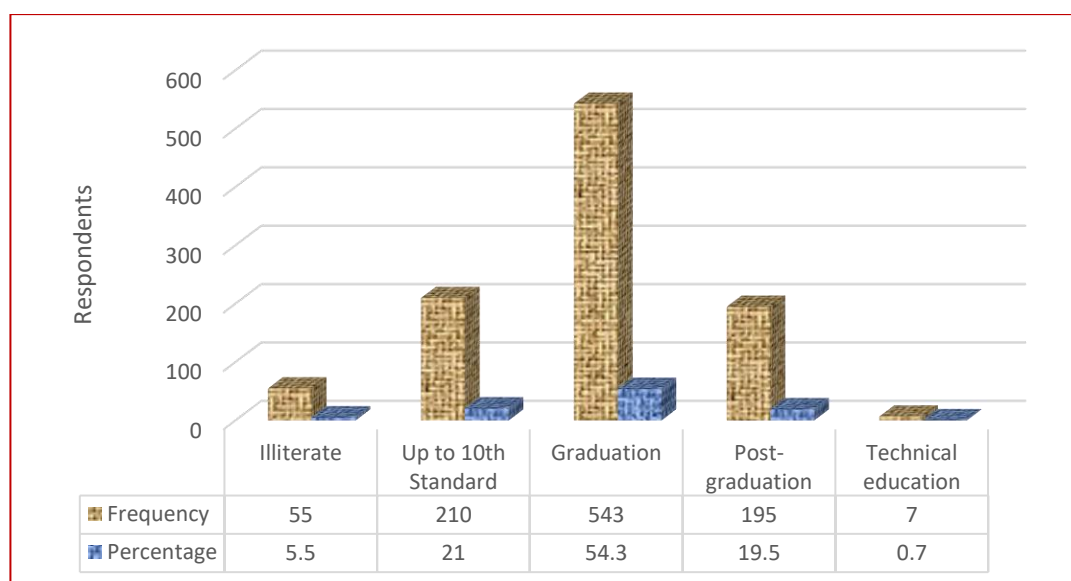
Source- Compiled by researcher

4.5 SOURCE OF OCCUPATION INCOME

Table No.4.4-– Occupation Composition

Sr. No.	Occupation	Frequency	Percentage
1	Farmer	225	22.5
2	Civil Servant	175	17.5
3	Merchant	345	34.5
4	Unemployed/housewives	255	24.5
		1000	100

Source- *Compiled by researcher*

Figure No.4.4 -– Occupation Composition

Source- *Compiled by researcher*

Above table no. 4.4 shows the source of income of the respondent means the occupation composition. Out of 1000 respondents 225 respondents are farmer it is near about 22 percent. About 17 percent people represented with civil servant category. 345 respondents are merchant or businessman it is near about 35 percent. 24 % respondent are unemployed people or housewives.

4.6 LAND USE CHANGE STATUS (YES - NO)

Table No.4.5-– Land Use change status

Sr. No.	Land-use Status	Frequency	Percentage
1	Yes	864	86.4
2	No	120	12.00
3	Not Answered	16	1.60
		1000	100

Source- Compiled by researcher

Figure No.4.5-– Land Use change status
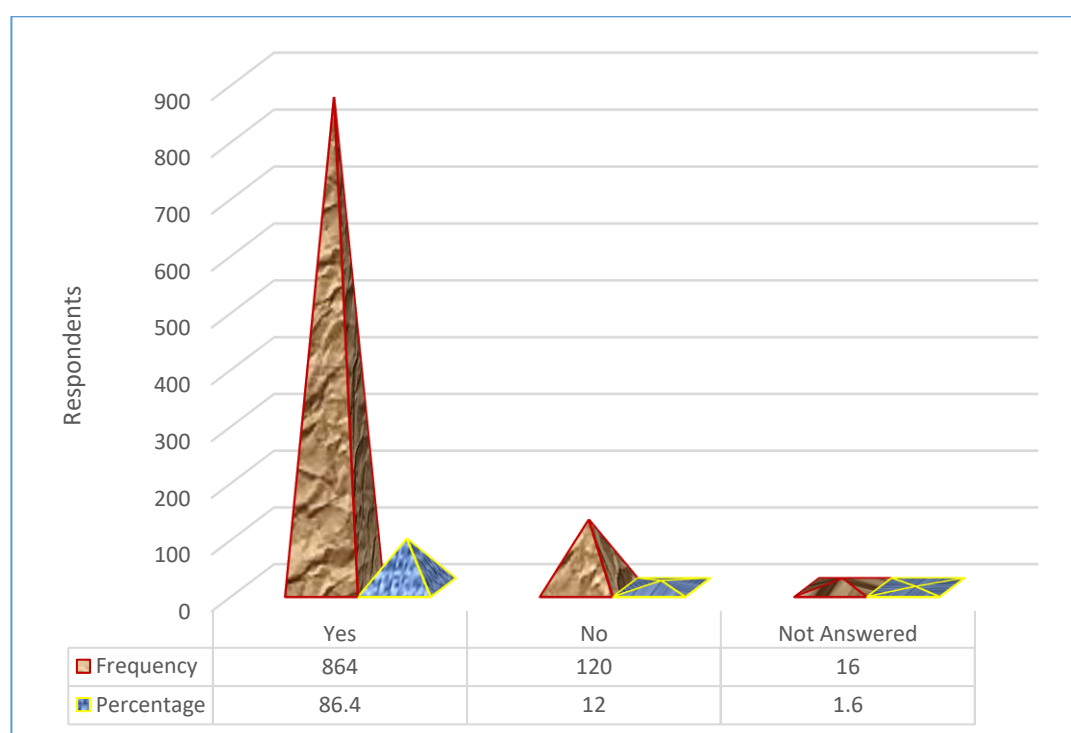
Source- Compiled by researcher

The table no. 4.5 represented that, the perception about land use change from respondents in the -in study area. Out of 1000 respondent's 86 percent respondents indicated that the land use change is accurse in this region. 120 person indicates the negative perception about land use change. They said haven't look any land use changes in that area. Remaining 16 respondent not answered.

4.7 AFFECTING FACTOR OF VULNERABLE SITUATION

Table No.4.6 -Affecting factors

Sr. No.	Affecting Factors	Frequency	Percentage
1	Physical Setting & Wind	400	40.00
2	Climate	542	54.20
3	Population Growth	670	67.00
4	Urbanization Growth	800	80.00
5	Tourism	961	96.10
6	Road Network	798	79.80
		1000	100

Source- Compiled by researcher

Figure No.4.6 - Affecting factors
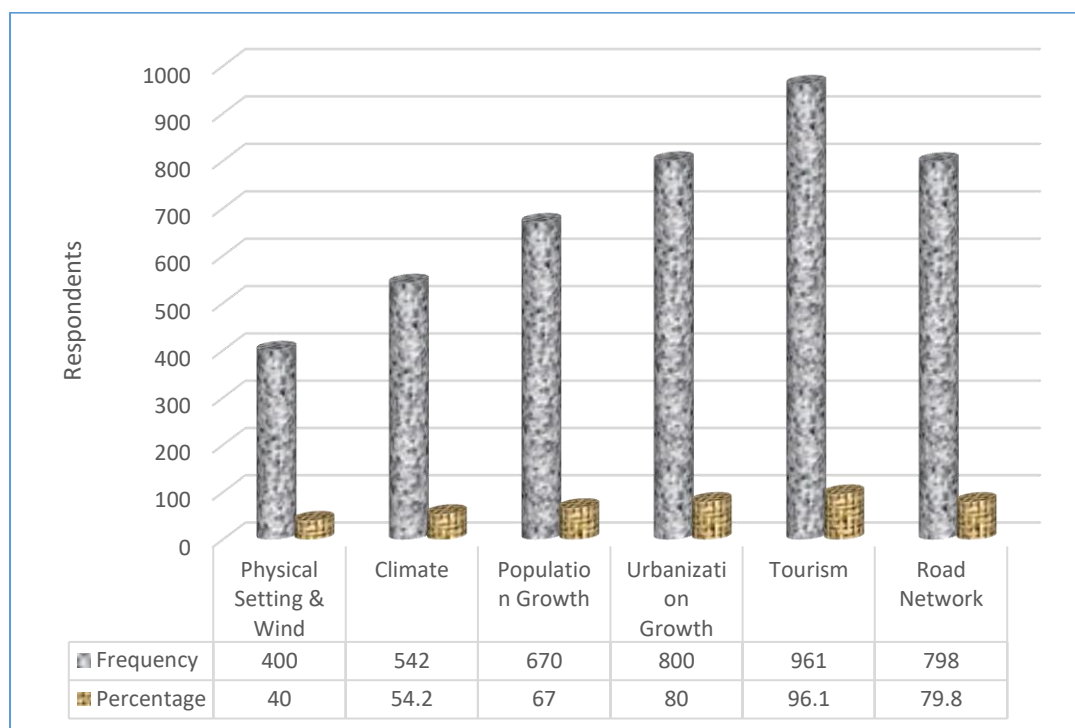
Source- Compiled by researcher

Above Table no.4.6 shows that which factors affecting for vulnerable situation in the region. 40 % respondents said the physiographic setting and wind condition of the region is also affecting to vulnerability. In this region the mountain range lies and affects the structure of the coast and land use and land cover. Total 542 respondents also said the climate is the most

impact factor for this area. 670 respondents said the growth of population and urbanization affects the land use in the coastal area affects the vulnerability in this region. 961 respondents said another affecting factor is tourism growth. affected to vulnerability because most of the 798 (79%) respondent also says the road network expansion affects to the forested area and agricultural area. 56 percent people said the coastal area also converted in urban area.

4.8 EFFECT OF VULNERABILITY SITUATION

Table No.4.7 - Effect

Sr. No.	Management Option	Frequency	Percentage
1	Affects to Ecosystem	780	78.00
2	Affects to Beach structure	531	53.10
3	Affects to People	365	36.5

Source- Compiled by researcher

Figure No.4.7 - Negative Effect

	Affects to Ecosystem	Affects to Beach structure	Affects to People
Frequency	780	531	365
Percentage	78	53.1	36.5
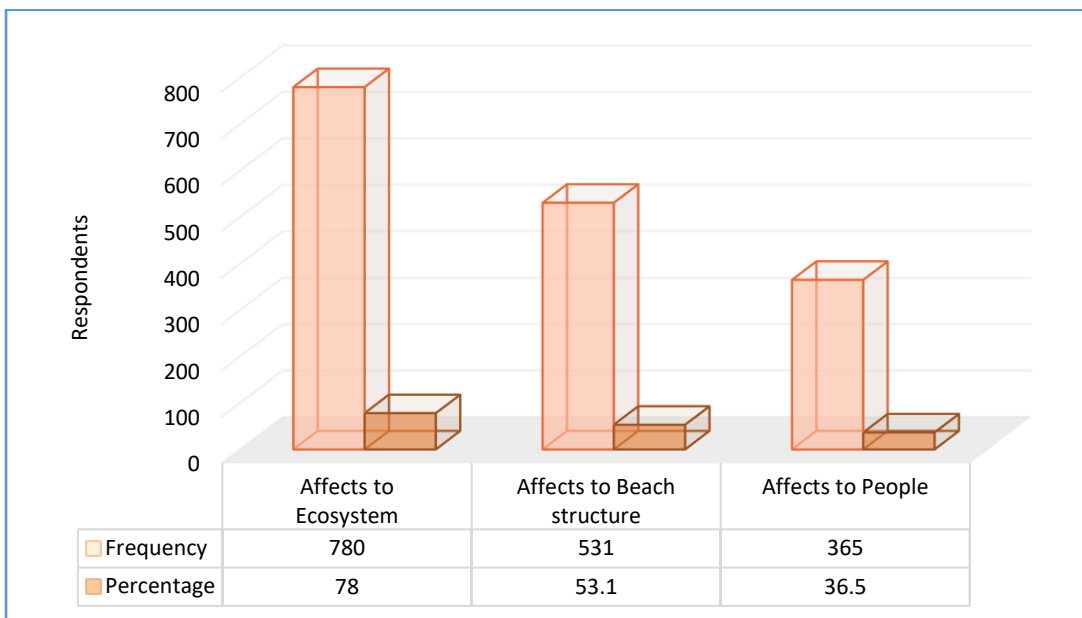
Source- Compiled by researcher

Above table reveals that, the negative effect of land use is land cover pattern in the region. It is affected the various aspects of the natural condition and ecosystem. Out of 1000 respondents total 780 people claimed

that, vulnerability affects the all-natural phenomenon such as agriculture, natural vegetation and environment. 51% respondents say the beach structure reduced due to vulnerability. 35 percent respondents said that, affects to demographic situation and environmental degradation take place by high consumption of land for tourism, transport and settlement.

4.9 MANAGEMENT OPTION FOR LAND USE, LANDCOVERS CHANGE

Table No.4.8 -Management Options

Sr. No.	Management Option	Frequency	Percentage
1	Sustainable Land use policy	862	86.20
2	Land registration	541	54.10
3	Social Awareness	649	64.90
4	Cooperation of Local People	577	57.70

Source- Compiled by researcher

Above table no. 4.8 also shows that the, land use land cover management strategy propounded by respondents. 86 percent respondents said the land use management policy need, and in sustainability towards protect the high use of land consumptions. They also said that we most policy a head about biodiversity protection. 541 respondents said that there is need of proper land registration and its certification and protected human interference such as in this region there are most affected due to the buildup restaurants ,hotels and tourists centers.

649 respondents said there is need of social awareness about environment importance and its degradation. There is need of Social movement towards environment in rural area as well as in urban area. 57 percent people claimed the cooperation of local people is very necessary in management strategy.

Figure No.4.8 - Management Options

	Sustainable Land use policy	Land registration	Blocks Bareiers	Mangroves/Vegetation Plantation	Social Awareness	Cooperation of Local People
■ Frequency	862	541	649	577	800	680
■ Percentage	86.2	54.1	64.9	57.7	80	68
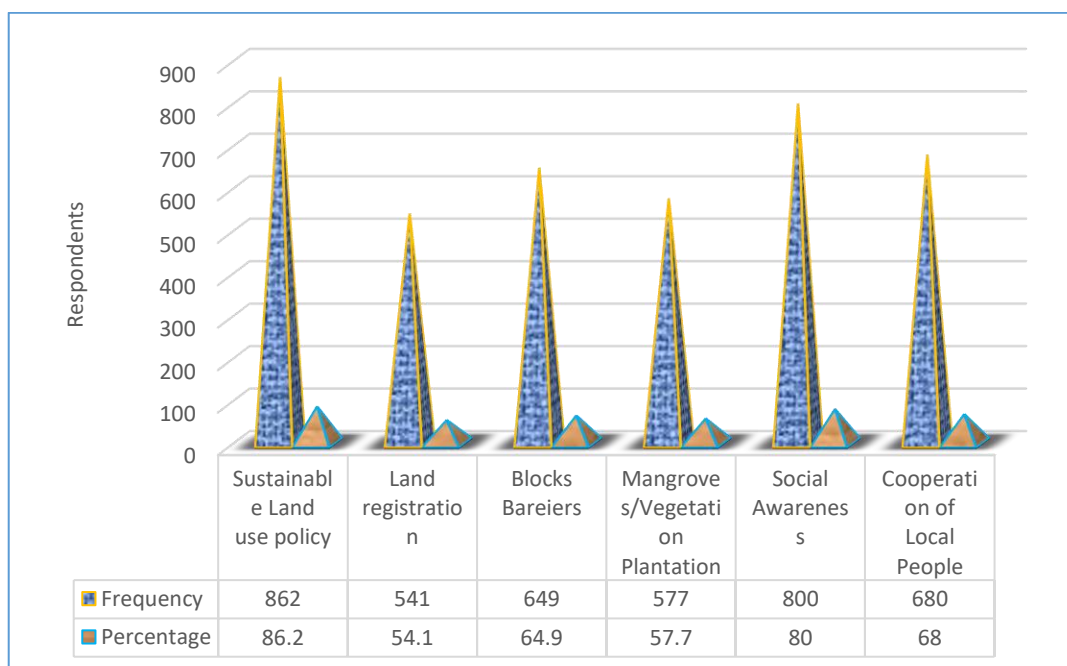
Source- Compiled by researcher

4.10 CONCLUSION

The impact factors of vulnerability n Sindhudurg district. The vulnerability are having close relationship with natural condition as well as human activities, hence those are studied briefly. The future land use and landcover conditions are predicted for the prevention of environment.

All the study there is several changes occurred in the general coastal land use land cover and its pattern with changes in the Sindhudurg district during year 1990 to 2020. Chapter fifth deals with affecting factors of vulnerability in the Sindhudurg district. For this study used primary data which carried out by questionnaire scheduled. Present study reveals that, the natural factors as well as socio-economic factors and activities affected the general vulnerability pattern of Sindhudurg district. Physiographic setting of the area, climate, agricultural practice, increasing population, industrialization and tourism are the main factors affects the land use and land cover and formed the vulnerability situation. Out of 400 respondent 40 percent respondents claimed physiographic condition reflected in vulnerability in the area of beaches and coasts included Malvan, Tarkarli,

Achara, Devbag and Chivala coastal region. In this region presented most famous tourist centers.

Out of 1000 respondents total 780 people claimed that, vulnerability affects the all-natural phenomenon such as agriculture, natural vegetation and environment. 670 respondents said the growth of population and urbanization affects the land use in the coastal area affects the vulnerability in this region. 961 respondents said another affecting factor is tourism growth. 86 percent respondents said the land use management policy need, and in sustainability towards protect the high use of land consumptions. They also said that we most policy a head about biodiversity protection.

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CHAPTER -V

VULNERABILITY ASSESSMENT

5.1 INTRODUCTION

Indian main land has a coastline of about 5,400 km and around 250 million people live within 50 km of the coastline of India. In spite of the various policies and regulatory frameworks, India's coastal and marine ecosystems are under threat due to multiple stresses. The event of December 2004 tsunami brought about importance for scientific study of the natural hazards and coastal processes of the Indian coast. Maintaining coastal processes is crucial because they provide ecosystem services regarded crucial for human well-being and are defined by significant ecological and natural value (MEA, 2005; Ramieri et al., 2011). The relationship between the coastal ecology and humans has already been heightened by a large variety of frequently competing human activities. Sea level rise and climate change are also putting a greater strain on coastal regions, which have been negatively impacted by significant human activity throughout time. A negligible rise in sea level might have an impact on natural coastal systems (Din et al., 2019). Particularly, the rise in 2100 may be up to 1 m, which will have an impact on the coastal property zone, where the majority of people would be residing by the year 2040. (Hamid et al., 2018).

One of the most dynamic regions of the earth's surface is the seashore. They are home to some of the most delicate ecosystems in the world, including mangroves, wetlands, coral reefs, dunes, and beaches. In addition, a sizable human population resides there. In the world, 23% of people reside within 100 kilometres of the shore (Small and Nicholls 2003). The regulation of water exchange between land and sea, the control of sediment and water chemistry, the storage and recycling of nutrients and human waste, the preservation of biological and genetic diversity, the provision of land for agriculture, the provision of means for transportation and navigation, the provision of means for recreation and tourism, and the provision of a variety of information regarding aesthetic, historical, cultural.

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The majority of the studies using CVI have categorized the vulnerable of different coastal environments relatively, using basic information on coastal geomorphology, rate of sea level rise, past shoreline evolution, coastal slope, mean tidal range, and mean wave height and acknowledged that inclusion of demographic and economic variables may result in a useful and more comprehensive index.

Geographic Information System (GIS) handles spatial information by linking location with its attribute information. GIS has functions and tools required to efficiently capture, store, analyze, and display the information about places and things. The preparation of data and mapping the spatial relationships between natural hazard phenomena and the elements under threat require the use of GIS. The techniques of remote sensing, GIS, and GPS have been proven to provide extremely valuable data for analysis of the scenario and develop management action plans. Studies showed that satellite remote sensing offered high temporal resolution for monitoring of land-use change at lower costs than those associated with the use of traditional methods. The advantages of repetitive coverage and synoptic view of the region of interest from various earth observation satellites have assisted in generation of databases on various aspects of the coastal and marine environment.

Vulnerabilities associated with the various coastal states of India are being studied in recent times. The concept of Coastal Hazard Wheel (CHW) framework for the complete coast of the Sindhudurg, their framework had lacuna of the socioeconomic variables for the assessment. The present study attempts to assess vulnerability of the coastal Sindhudurg for various hazards by combining physical, geological, and socioeconomical variables using techniques of remote sensing and GIS.

5.2 METHODOLOGY

The present study adopts the CVI methodology formulated by Thieler and Hammer-Klose. The process results in a classification of coast using simple criteria and yields numerical data that cannot be equated directly with particular

physical effects but shows the area's most affected by the hazard. Initially a database of the variables under consideration for the study area was built by compiling data from various sources. The variables and their data sources used in the present study. The data values of variables under consideration were assigned a vulnerability ranking based on value ranges contributing to coastal vulnerability, while the nonnumerical geomorphology variable was ranked qualitatively according to the relative resistance of a given landform to erosion. Later, the key variables were integrated to a single index and categorized based on the relative intensity of risk it imparts to the coast, namely, very low, low, medium, high, and very high. The entire coastline was divided into 8 zones based on administrative boundary of coastal region. A grid template of 1.5 km by 1.5 km was used to store and analyze data and display the CVI. Each cell of the grid template was assigned with an identification number as shown in Figure 2. The software package ArcGIS 9.3 offers the suitable environment to carry out the process. The variation of each variable within the area was analyzed and suitable risk ratings were awarded for each specific data variable and the coastal vulnerability index was calculated.

In the present study, eight variables were considered for developing the CVI: rate of relative sea level change, historical rate of shoreline change (erosion or accretion), coastal regional elevation, coastal slope, mean tidal range, significant wave height, and socioeconomic data. The importance of each of the considered parameters and the procedure to generate the same for use in assessment of CVI are given in the following section.

Relative Sea Level Change Rate. Sea level rise shifts the wave action zone to higher elevations due to recession of coast to inland. This recession of shoreline will be greater in mild slope regions. The direct effect of such recession is submergence of coastal land and aggravated events of flooding. Long-term effects can be increased erosion and salt- water intrusion into ground water as the coast adjusts to the new conditions. Changes in mean sea level as measured by coastal tide gauges are called relative sea level changes.

Shoreline Change Rate. The shoreline change rate is one of the most common measurements used to indicate the dynamics and the hazards of the coast. Coastal shorelines are always subjected to changes due to coastal processes, which are controlled by wave characteristics and the resultant near-shore circulation, sediment characteristics, beach form, and so forth. It also trims down the distance between coastal population and ocean, thereby increasing the risk of exposure of population to coastal hazards.

Coastal Slope. The coastal slope is change in altitude for a unit horizontal distance between any two points on the coast. The degree of steepness or flatness of a coastal region determines the susceptibility of the coast to inundation by flooding. Determination of regional coastal slope identifies the relative vulnerability of inundation and potential rapidity of shoreline retreat because low sloping coastal regions are thought to retreat faster than steeper regions.

Regional Elevation. It is important to study the coastal regional elevation detail in the study area to identify and estimate the extent of land area threatened by future sea level rise. From the coastal vulnerability point of view, coastal regions having high elevation will be considered as less vulnerable areas because they provide more resistance for inundation against the rising sea level, tsunami run-up, and storm surge.

Tidal Range. The tidal range is the vertical difference between the highest high tide and the lowest low tide. From the vulnerability point of view, it is an obvious tendency to designate coastal areas of high tidal range as highly vulnerable. For the current study, coastal areas with high tidal range are considered as highly vulnerable and low tidal range as less vulnerable.

5.3 CALCULATION OF CVI

Once each section of coastline is assigned a risk value for each variable, the CVI is calculated as the square root of the product of the ranked variables divided by the total number of variables. The CVI is represented by where $a =$

risk rating assigned to sea level change rate, b = risk rating assigned to shoreline change rate, c = risk rating assigned to coastal slope, d = risk rating assigned to coastal regional elevation, e = risk rating assigned to tidal range, f = risk rating assigned to significant wave height, and g = risk rating assigned to population density.

$$CVI = \sqrt{a} * b * c * d * e * f * g \div 7$$

5.4 RESULTS AND DISCUSSION

Relative Sea Level Change Rate. For the available data, it was observed that sea level was falling at a rate of 1.3 mm per year at the Tarkarli station while it was rising at a rate of 0.8 mm per year at the Malvan station as shown respectively. Douglas acknowledged that, to determine the trends in long-term sea level changes, ideal record length greater than 60 years is desirable. Since such long duration records were not available for the present study region, the tide gauge data of Coast of India was also considered to verify the trend of SLR and it was observed that sea level rise was about 1.0 mm per year.

The sea level along the Indian coast has increased at a rate varying between 1.06 and 1.75 mm per year during the period 1960 to 2020, depending on the tide gauge recording site, with an estimated regional average of 1.29 mm per year, subsequent to a global isostatic adjustment correction. The SLR observed at the study area is less in comparison with global average rate of about 1.7 mm per year and also less than regional average. Hence, the study area is considered to be less vulnerable to sea level rise and lowest ranking of 1 was awarded for the entire coast.

Coastal Slope. The regional coastal slope was calculated for a distance of 6 km (3 km each from shoreline on sea and landside) perpendicular to the shoreline at an interval of 1.5 km. The five vulnerability classes and the slope range in each class are adopted by Pendleton et al. A slope greater than 0.6% is assigned low vulnerability and less than 0.3% is assigned high vulnerability.

Map No. 5.1: Tarkarli Beach Location
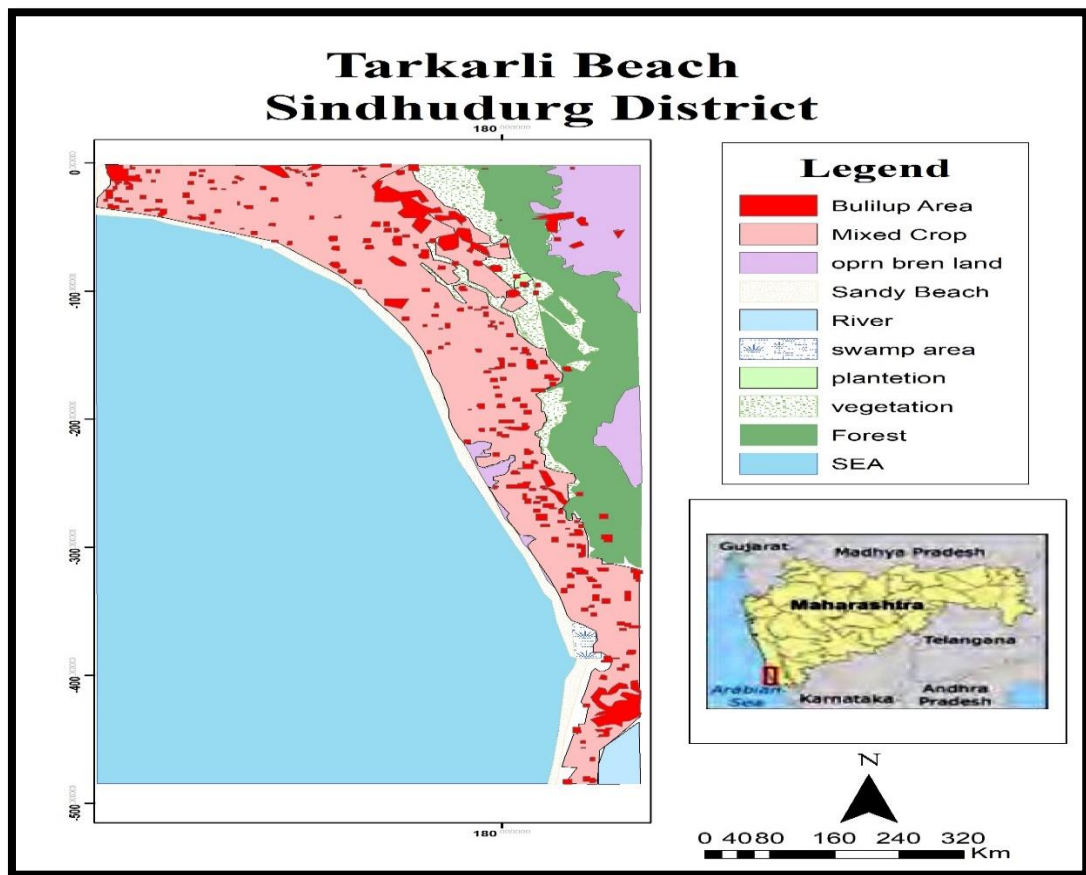
Source – Diva GIS and Erdas Imagin

Regional Elevation. The mean regional elevation within study area varied between 0.69 m in Malvan and 78.94 m in Tarkarli. An elevation value greater than 40 m is assigned low vulnerability and less than 10 m is assigned high vulnerability as shown.

Shoreline Change Rate. The shoreline change rate in the study area was calculated for a period of 50 years (1970 to 2020). The Output from DSAS revealed that about 4.09 km of coastline had a very high-risk rating along the coastal stretch of southern Malvan. About 14.25 km of coastline was of high risk rating, along the coastal stretches near southern parts of Malvan, Devbag, and Chivala and also in Achra.

Table No. 5.1: Average Wave height for different Places

Sr, No,	Location	Wave height (m)
1	Tarkarli	1.3
2	Malvan	0.7
3	Devgad	1.12
4	Chivala	1.00
5	Achra	1.9

Source – Field Survey -2019

Table No. 5.2: Tidal range for various Places

Sr, No,	Location	Tidal Range (m)
1	Tarkarli	1.4
2	Malvan	1.5
3	Devgad	1.8
4	Chivala	1.9
5	Achra	1.6

Source – Field Survey -2019

Map No. 5.2: Malvan Beach Location
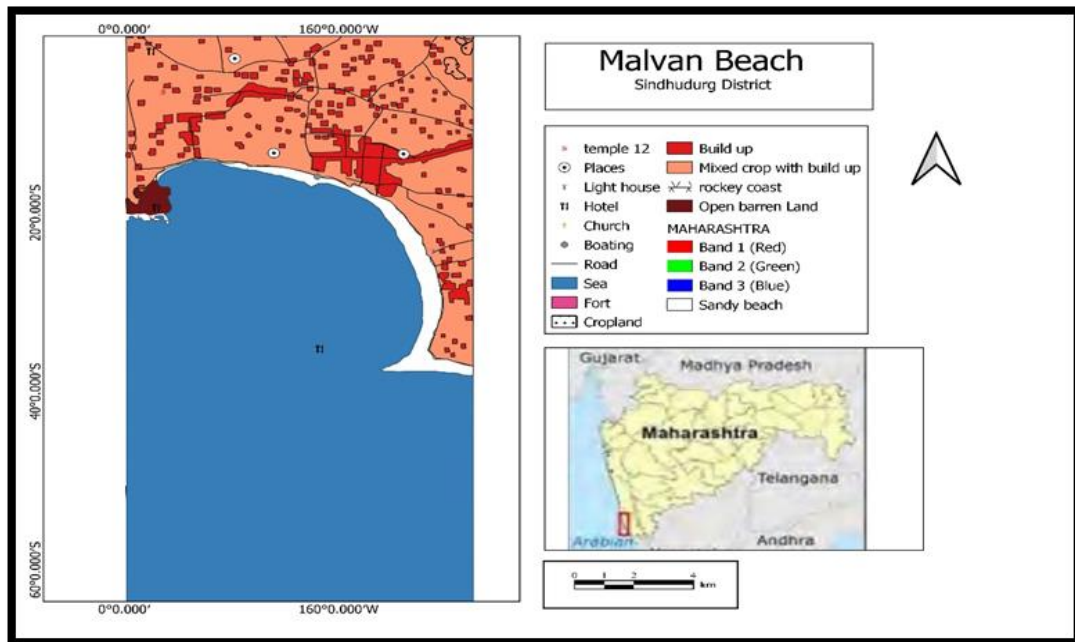
Source – Diva GIS and Erdas Imagin

Map No. 5.3: Devbag Beach Location

Source – Diva GIS and Erdas Imagin

Map No. 5.4: Chivala Beach Location

Source – Diva GIS and Erdas Imagin

Map No. 5.5: Achara Beach Location

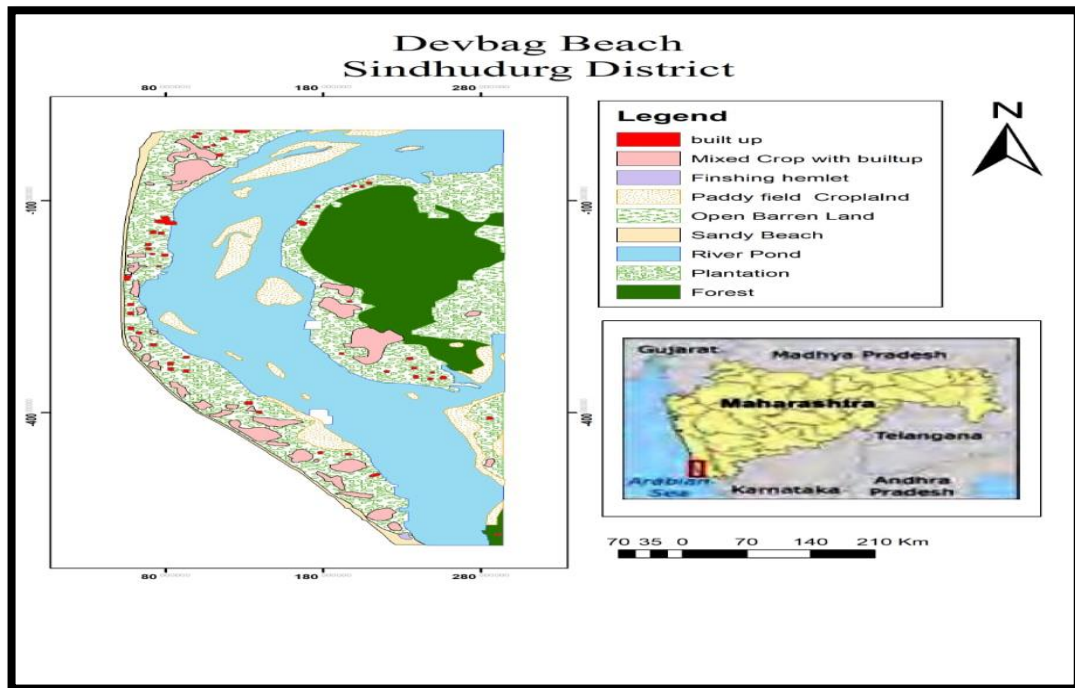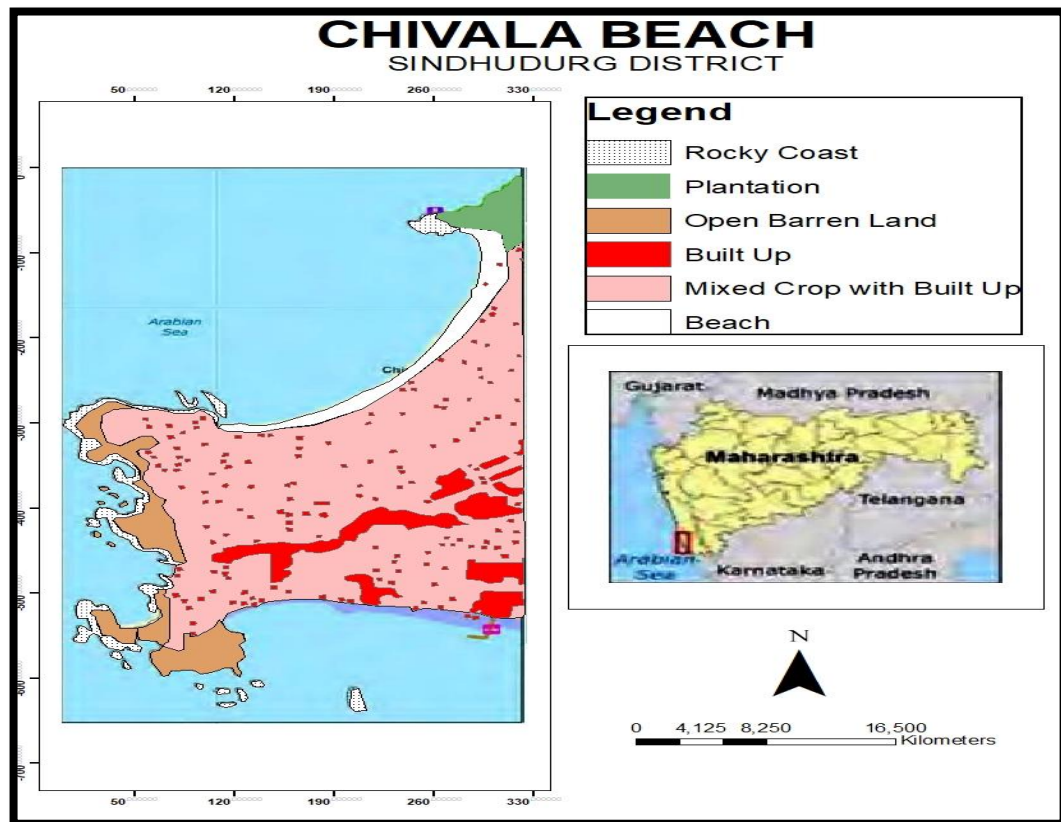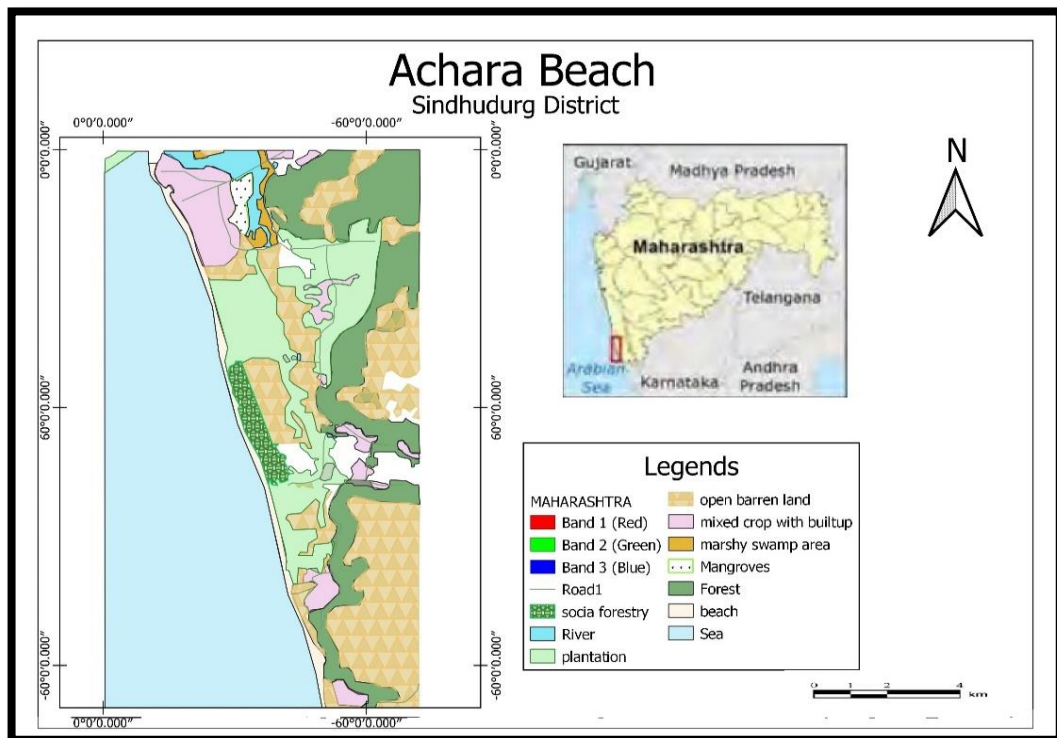*Source – Diva GIS and Erdas Imagin*

About 267.50 km of coastline was under a moderate risk while 1.5 and 10.66 km stretch were under low and very low risk category, respectively. Average accretion for the whole of the study area was found to be 1.133 m per year and average erosion was 0.533 m per year. Figure 4 shows the mean shoreline change rate in each grid along the study area. The risk ranking was awarded based on the risk category formed by Pendleton et al. and is described in Table 4.

5.5 COASTAL VULNERABILITY INDEX (CVI)

Coastal vulnerability index map for the Sindhudurg Coast is shown in Figure 5. The calculated CVI values range from 1.73 to 18.97. Table 5 details the CVI for each taluk with statistical parameters. The mean, mode, and median CVI values are 6.52, 7.34, and 6.92, respectively. The standard deviation is 2.21. The CVI scores are divided into low, moderate, high, and very high vulnerability categories based on the quartile ranges. The 25th, 50th, and 75th percentiles are 4.90, 6.92, and 7.35, respectively. The lower range of CVI values indicates low

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risk, followed by moderate risk, high risk, and finally the upper range of values indicating the coastal stretches having very high risk.

Table No. 5. 3: Ranges of variables for vulnerability ranking.

Variables	Ranking of vulnerability				
	1	2	3	4	5
Coastal slope (%)	>0.60	0.5-0.6	0.4-0.5	0.3-0.4	<0.30
Mean tide range (m)	<1.0	1.0-2.0	2.0-3.0	3.0-4.0	>4.0
Regional elevation(m)	<10	10-20	20-30	30-40	>40
Shoreline change rate(m yr-1)	>+2.0	+1.0 to +2.0	-1.0 to +1.0	-2.0 to -1.0	<-2.0
Average wave height(m)	<0.7	0.7-1.4	1.4-2.1	2.1-2.8	>2.8
Population (person per 200 m^2)	<19	44-20	80-45	326-81	>326

Source- Risk category formed by Pendleton

The present study is an attempt to categorize the coast of Sindhudurg according to its coastal vulnerabilities. The variables under consideration are sea level change, coastal slope, regional elevation, tidal range, significant wave height, and population density. A total of 298 km of shoreline are ranked in the study. About 68.65 km of the shoreline is very highly vulnerable category and 79.26 km of shoreline is highly vulnerable category of the remaining shoreline, 59.14 km and 91.04 km are of moderate and low vulnerable categories, respectively.

Table No.5. 4: CVI For Location

Location	Max.	Min.	Average	Sd
Tarkarli	9.48	3.67	6.28	1.87
Malvan	7.34	3.67	5.20	1.46
Devgad	7.74	1.73	5.34	1.65
Chivala	8.00	2.44	5.89	1.21
Achra	9.79	6.00	7.78	2.41

Source – Field Survey -2019

Table 5 shows variation of CVI for each *location*. The coasts of Malvan fall under high risk category and all other places are under moderate risk. The CVI in the present study was primarily influenced by the risk ranking of the

shoreline change rate, population, and the coastal slope. It was observed that coasts of Malvan, Chivala, and Achra were under erosion with an average value of 0.21, 0.13, and 0.14 m per year, respectively, while for another Places accretion was observed. The sensitivity of the CVI to the socioeconomic variable "population" was examined and it was found that CVI significantly decreased in the *talukas* of Malvan and Tarkarli, on omission of variable and on a relative basis. The coastal slope was observed to be steep in beaches, that is, in Devgad, and Chivala, while Devbag,, and Malvan had mild slope topography. This was primarily because in Tarkarli, and Chivala we find the headlands and cliffs very close to the coast and southern beaches have more open beaches.

5.6 CONCLUSION

In the view of the rising sea levels and other coastal hazards, an assessment of coast for its vulnerability to these threats is necessary in order to take suitable actions to protect the people and property. Sindhudurg district has 121 km sea coast length. It was observed that 20 km of the shoreline of the study area was under very highly vulnerable category and 15 km of shoreline is highly vulnerable category while 26 km and 40 km of coast are of moderate and low vulnerable categories, respectively. Present study also evaluated the transformation of the Sindhudurg coastline using Landsat satellite images. We have observed that, most populated and tourist location like, Tarkarli, Malavan, Chivala, Devabg and Acahra beaches are presented with vulnerable situation. The CVI developed in the present study provides an understanding about the vulnerability of the Sindhudurg Coast to erosion, coastal flooding, and relative sea level change and as well as facilitates policy options for coastal planners and authorities with regard to prioritizing coastal areas for mitigation.

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CHAPTER – VI
CONCLUSION

6.1 SUMMERY

zone having lot of coastal landforms such as sand dune, beach, shore line, coral reef, Rocky shore, delta, estuaries, tidal inlets, flood plains coastal plains and salt marshes at these landforms also developed by various forces of erosion and depositional as caused by waves tide, winds and river discharge. The interaction between this process and coastal environments produce a variety of landforms.

Sindhudurg district has near about 125 KM coastline and it is highly vulnerable and experiencing the adverse consequences of hazards related to climatic silver and human activities there are various coastal landforms are very dynamic in character due to the erosion and acceleration patterns also vary in time. There are highly developed economical activities such as fishing, tourism which is also impact on coastal line and creates many problems later to the coastal ecosystem.

Remote sensing provide information over a large area has proved to be a very useful in identifying and monitoring various costal features toward a sustainable action plan to achieve the development in any question area. Geographical information system is a computer-based system which is carried out collecting checking integration and analyzing the spatial and non-spatial data of the Earth surface the advantages of GIS techniques for the data acquisition from satellite data and collect all data are significant in arriving at integrated coastal zone management.

Sindhudurg District, especially the important physiographic unit. Sindhudurg district is broadly divided into three small sub-divisions based on the elevation and local topography. The main Sahyadri with its their plateau scarps and hilly buttresses (Hilly Sahyadri Region), The low-level lateritic

plateau (the Central zone or Valati), and The riverine and estuarine leveled surfaces. (Coastal zone or Khalati).

There are eight important rivers nearly Shak river, Devgad River, Kadvi river Terekhol river and Tilari river all of the rivers originate from the Sahyadri ranges all the rivers are flow with east west direction and drains in the Arabian sea. The highest annual normal rainfall is in Kankavli tehsil that is 4000 mm and the lowest normal annual rainfall is in Devgadh tehsil that is 1000 mm. The average rainfall of Sindhudurg district is 3000 mm.

The above table reveals the January is the coldest month with the mean daily minimum temperature at 16.6 degree C and mean daily maximum at 33.5 C. The temperature is slightly low in December and February. In the month of January mean daily minimum lowest temperature is recorded 16.6 C.

Sindhudurg district has 8,48,868 (Male-4,16,695, Female-4,32,173) population as per 2011 census. Within the district highest population was recorded in Kudal tehsil (155624) fallowed by Sawantwadi tehsil (147466). Whereas a lowest is in Vaibhavwadi tehsil (43845).

6.2 CONCLUSION

The total geographical area of the Sindhudurg district is near about 503950 hectares. About 38643 hectares (7.6 %) of the total geographical area of the Sindhudurg district is under the forest during the year of 2002-2003. It is the lowest proportion out of the total geographical area of study region. The area under the forest presents with varies from tahsil to tahsil. The highest area under forest is found in Kudal tahsil (25.4 %) whereas the lowest forest area is found in Malvan tahsil (0.7 %) due to the physical setting and existence of the Arebean Sea.

Total 62637 hectares (33.2%) land is under the net sown area. The highest area under the net sown area found in Vengurla + Sawantwadi tahsil

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(24.8%). The highest proportion of area under the net sown area (33.1%) and the lowest area found in under the uncultivable land (6.9%). The highest area under the forest is found in Kudal Tahsil (25.4%) and the lowest area under the forest found in Malvan tahsil (0.7%). The highest area under not available for cultivation categories presented in Devgarah district is 35077 (24.4 %) and the lowest area of not available for cultivation is found in Vaibhavwadi tahsil (6.1%) and Kankavali tahsil (8.9%).

The impact factors of vulnerability n Sindhudurg district. The vulnerability are having close relationship with natural condition as well as human activities, hence those are studied briefly. The future land use and landcover conditions are predicted for the prevention of environment.

All the study there is several changes occurred in the general coastal land use land cover and its pattern with changes in the Sindhudurg district during year 1990 to 2020. Chapter fifth deals with affecting factors of vulnerability in the Sindhudurg district. For this study used primary data which carried out by questionnaire scheduled. Present study reveals that, the natural factors as well as socio-economic factors and activities affected the general vulnerability pattern of Sindhudurg district. Physiographic setting of the area, climate, agricultural practice, increasing population, industrialization and tourism are the main factors affects the land use and land cover and formed the vulnerability situation. Out of 400 respondent 40 percent respondents claimed physiographic condition reflected in vulnerability in the area of beaches and coasts included Malvan, Tarkarli, Achara, Devbag and Chivala coastal region. In this region presented most famous tourist centers.

Out of 1000 respondents total 780 people claimed that, vulnerability affects the all-natural phenomenon such as agriculture, natural vegetation and environment. 670 respondents said the growth of population and urbanization affects the land use in the coastal area affects the vulnerability in this region. 961 respondents said another affecting factor is tourism growth. 86 percent

respondents said the land use management policy need, and in sustainability towards protect the high use of land consumptions. They also said that we most policy a head about biodiversity protection.

In the view of the rising sea levels and other coastal hazards, an assessment of coast for its vulnerability to these threats is necessary in order to take suitable actions to protect the people and property. Sindhudurg district has 121 km sea coast length. It was observed that 20 km of the shoreline of the study area was under very highly vulnerable category and 15 km of shoreline is highly vulnerable category while 26 km and 40 km of coast are of moderate and low vulnerable categories, respectively. Present study also evaluated the transformation of the Sindhudurg coastline using Landsat satellite images. We have observed that, most populated and tourist location like, Tarkarli, Malavan, Chivala, Devabg and Acahra beaches are presented with vulnerable situation. The CVI developed in the present study provides an understanding about the vulnerability of the Sindhudurg Coast to erosion, coastal flooding, and relative sea level change and as well as facilitates policy options for coastal planners and authorities with regard to prioritizing coastal areas for mitigation.

6.3 SUGGESIONS AND RECOMANDATION

The recommendations made for protecting the Sindhudurg coast from potential coastal risks include creating embankments and breakwaters, ridge afforestation, mangrove restoration and management, intermittent beach nutrition, and ridge reforestation. Only some settlements that have a significant danger of accumulation are allowed to build embankments. The unified strategy for managing the coastal zone is still not entirely operational. It needs to place greater emphasis on the construction parameters, urban growth development, expansion of recognized capability, local community

involvement, aggregating public attention, and should be built on long-term tenable progressive projects.

Coastal vulnerability and morphological changes in the research area's coastal surroundings as a result of climatic changes, namely sea level rise and shoreline erosion, are assessed using the data and methods utilized in this study. Using this method, coastal vulnerability maps are created that serve as a general indicator of hazards to those who live there. In comparison to other factors, the sea level rise and tides are more controlling to vulnerability. This is an objective way to describe the risk associated with coastal hazards, and coastal managers and supervisors may use it successfully to improve planning to reduce losses from hazards and to determine which regions should be evacuated first in case of a disaster.

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"APPICATION OF REMOTE SENSING AND GIS IN COASTLINE CHANGES STUDY OF SINDHUDURG DISTRICT, MAHARASHTRA."

Personal Details

1. **Name:**---

2. **Age:** ---

3. **Gender:**---

4. **Village/ City:**---

5. **Tehsil:**---

6. **District:**--

7. **Marital Status: Unmarried   Married   Widow / Widower**

8. **Education: Educated:- -------------------------   Illiterate:-------------------**

Primary Edu.	Post-Graduation
Secondary Edu. (Up to 10 class)	Medical
Higher Secondary (up to12 Class)	Engineering
Graduation	Law
Other	

9. **Occupation:**

Farmer	House wives
Civil Servant	Labor
Businessman/Merchant	Unemployed
Students	Law
Retired	Other

10. **There is forest (natural vegetation) here? Yes / No**
                    If Yes: How much?
                  Name of the Forest:
11. **There is Sea side or lake? Yes / No**
                    If Yes: How long/ area in km?

Name of the river or lake:

12. There is barren land? Yes / No

    If Yes: How much?

13. There is uncultivated land? Yes / No

    If Yes: How much?

14. How much of the settlement / built-up land spread here?

15. How much Coastal is there in your village?

16. What has changed in Sea area in the last 20 years?

Increased: If Yes:

How much increased?

In which direction/ place?

In which site?

Decreased: If Yes:

How much decreased?

In which direction/ place?

For what purpose?

Hotel/ Dhaba	Petrol pump	Ceramic & granite
shops	Canal	reservoirs

 Neutral: If Yes:

        Why:

Decreased: If Yes:

How much decreased?

In which direction/ place?

For what purpose?

Settlements	Industries	road network
Hotel/ Dhaba	Petrol pump	Fuel
For Building	Canal	reservoirs

17. Do you think there has been change in Coastal area? Yes/No

If Yes:

How much?

Low	Medium	Too much/Very High

How much do you rate about land use change?

1	2	3	4	5	6	7	8	9	10

18. What factors are influencing vulnerability in your area?

➢ Physical setting- Mountainous region, steep slope, plain region , plateau coastal features

➢ Wind ,Climate/ Rain, Soil distribution, Availability of water, Tourism

➢ Urban population, Settlements, Industrialization, Transport/ road network, Other

19. How tourism effects on land use and land cover?

➢ Increasing in road network, Increasing in Hotel / restaurant

➢ Creation of gardens , Settlements increasing

20. What solution should the government find?

21. What solution should the government find?

Appendix II

Photo Plates

Place- Malvan Beach

Place- Achara Beach

Place- Chival Beach

Place- Devbag Beach

Scopus Preview

Q

Source details

Feedback ⟩   Compare sources ⟩

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ANALISIS OF LAND-USE PATTERN IN SINDHUDURG DISTRICT : A GEOGRAPHICAL ANALYSIS

Mr. Govardhan Subhash Ubale

Assistant Professor, Department of Geography, Vivekanand College, Kolhapur (Autonomous) Maharashtra

Abstract

Land is the basic and limited natural resource. Land plays the key role in the determination of man's economic activities as well as social and cultural progress. All agricultural, animal and forestry production depend on the quality and productivity of the land. The terrestrial ecosystem which comprise of food, energy needs of livelihood. Land use is a special context is essential to understand a regional zonation of the area of optimum land use degraded areas etc. Land use of region is a combiner easel of the natural setup and human dynamism within social economic setup and technological development. In this research paper an attempt has been made to analyse the general land use pattern in Sindhudurg district. Study of land is pattern important for the development of agriculture sector, industrial sector as well as keep balance in environmental condition. This study plays vital role in the point of view the planning and development of the region.

Keywords: Land use pattern, Human Dynamism, National Planning, Underdeveloped.

Introduction

Land use is the surface utilization format of all developed and vacant land on a specific point, at a given time and region. Day to day the importance of the land use land cover study is increasing with continuous increase in population as well as urbanization also. After the industrial revolution, the world population is increasing at a progressively faster rate affecting the nature of earth surface. Human use of land resources gives rise to land use which varies with the many purposes it serves *(Briassoulis, 2000)*. Land cover is the biophysical state or the natural state of the earth's surface particularly immediate surface *(Terner et al., 1995)*. In this contest most, previous natural resources have used better life resulted, most changes in land use land cover pattern on the earth surface. There is observed, agricultural area being converted in to urban uses, forested land convert into agricultural practice in all over the world. In this situation most of the positive and negative changes occurred on the earth surface. That does why there is necessary to planning and regulation for minimize negative impact on natural environment. Land resource is very important for human being because direct and indirect many types of processes as like economical processes depend upon it. Land resources are natural wealth and property of a country. So, there are proper utilization of natural resources such as land resources is most important because of near about 70% population depend upon directly and indirectly on land for livelihood.

In Sindhudurg district utilisation of land increasing with increase in population, increasing in agriculture, increasing in industrialisation and mining also. It shows varies is from tahsil to tehsil. The utilisation of land is need to have a general framework of strategic and effective management and analysis of their characteristics and also used for developmental planning in the study area.

Study Area

Sindhudurg district is the southern part of coastal area that is known as the Konkan. Sindhudurg district situated between 15^0 17' north latitude to 16^0 40' North latitude and 73^0 19' longitude to 74^0 13' East longitude. It is bordered by Ratnagiri district on the north, Arabian sea on the west, Goa state on the south, Belgaum district of Karnataka state and Kolhapur district on the east also. The total area of the district is 5087 sq. km. Physiographically Sindhudurg district has divided into three section that is Khalati, Valati and Sahyadri hills region respectively. The coastal strip is called Khalati and its adjacent area called Valati. Sindhudurg district has 8,48,868 (Male-4,16,695, Female-4,32,173) population as per 2011 census. Mean monthly minimum temperature near about 16^0 C. and maximum temperature near about 33^0 C. Annual rainfall range is 2000 to 3000 mm.

Objectives

1. To study the general land use pattern in the study area

2. To study the impact of physical setting and social economic factors on the land use pattern in the study region

3. To study the utilisation of land use in the study area.

Data Base

The present study based on secondary data which is obtained from social economic abstract of Sindhudurg district 2012 and gazetteer of the Sindhudurg district. For the calculation used the simple statistical techniques and calculated the proportion of every and each type are land use category.

Explanation

General land use pattern in Sindhudurg district is shown in chart with tehsil wise utilisation of land.

I) Area under Forest

The total geographical area of the Sindhudurg district is 503950 sq. ha. Out of this area 38643 sq. ha. is under the forest during the year 2012. It is the lowest proportion in the study region. The area under the forest presented with a varies from tehsil to tehsil the highest area under forest is found in Kudal tehsil (25.4%), where the lowest forest area is found in Malvan tahsil (0.7%) due to the physical condition and existence of the Arabian sea. Below 10% area of forest is found in Devgad (7.7%), Vaibhavwadi (7.7%) and Dodamarg (7.7%) tahsil general we have to experience the area under forest is a very less in Sindhudurg district.

Tahsil-wise General land use pattern in Sindhudurg District (2012)

(Area under hectares)

Sr.no	Tahsil	Total Geographical area	Area under Forest	Area not available for cultivation	Uncultivable Land	Follow Land	Net sown Area
1	Devgarh	78127	3004	35077	211	20810	16193
2	Vaibhavwadi	41612	2744	8838	730	14635	10847
3	Kankavli	77339	8997	12837	10203	541	28351
4	Malvan	61829	298	22347	8896	5388	21329
5	Vengurla + Sawantwadi	113573	11358	25236	933	6540	40457
6	Kudal	81897	9843	20562	13786	4611	31145
7	Dodamarg	49573	2399	18371	408	5465	14315
	Total	503950	38643	143268	35167	57990	162637

Source – *Socio-Economic Abstract of Sindhudurg District (2012)*

II) Area Not Available for Cultivation

Total 143268 sq. ha. area is under not available for cultivation in Sindhudurg district. The highest area under this category is presented in Devgadh district is 35077(24.4%) the lowest area of not available for cultivation is found in Vaibhavwadi tehsil (6.1%) and Kankavli (8.9%). Above 10% area under the not available for cultivation are found in Malvan (15.5%) tahsil Sawantwadi (17.6%), Kudal (14.3%) and Dodamarg (12.8%).

Tahsil-wise General land use pattern in Sindhudurg District (2012) (Area in %)

Sr. no.	Tahsil	Total Geographical area in %	Area under Forest in %	Area not available for cultivation in %	Uncultivable Land in %	Follow Land in %	Net sown Area in %
1	Devgarh	15.5	7.7	24.4	0.5	35.8	9.9
2	Vaibhavwadi	8.2	7.1	6.1	2.0	25.2	6.6
3	Kankavli	15.3	23.2	8.9	29.0	0.9	17.4
4	Malvan	12.2	0.7	15.5	25.2	9.2	13.1
5	Vengurla + Sawantwadi	22.5	29.3	17.6	2.6	11.2	24.8
6	Kudal	16.5	25.4	14.3	39.2	7.9	19.1
7	Dodamarg	9.8	6.2	12.8	1.1	9.4	8.8

Source – *Compiled by Authors*

II) Other Uncultivable Land (Excluding Fallow Land)

In Sidhudurg district, reveals that, 35167 sq. ha. (6.9%) area under the uncultivated land. The highest area under the category is found in Kudal tahsil (39.2%) whereas the lowest area found in Devgad tahsil (0.5%). Below 5% area of this category is found in Dodamarg (1.1%), Vaibhavwadi (2%), Sawantwadi (2.6%).
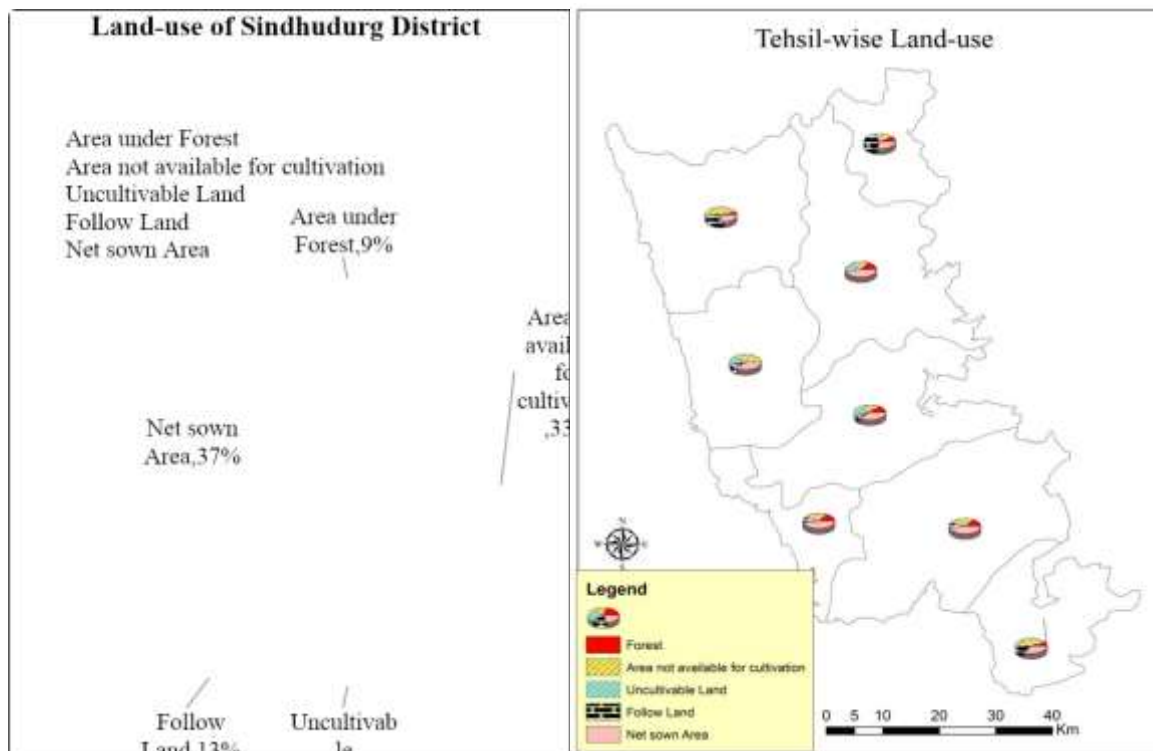
Source – *Socio-Economic Abstract of Sindhudurg District (2012)*

IV) Fallow Land

There is 57990 sq. ha. (11.5%) land is under fallow land. The proportion of fallow land is varies from tehsil to tehsil. The area under this category, below 10% area is found in Kudal (7.9%), Malvan (9.2%), Dodamarg (9.4%). The highest area under this category is found in Devgad tahsil (35.8%) whereas the lowest area under this category are found in Kankavli (0.9%). Above 10% area under the fallowing land is noticed in Vaibhavwadi (25.2%) Sawantwadi (11.2%).

V) Net Sown Area

There is noticed that, 62637 sq. ha. (33.2%) area is under the net sown area. The highest area under the net sown area found in Vengurla and Sawantwadi (24.8%). The lowest area under this category noticed in Vaibhavwadi tahsil (6.6%). It is observed that, below 10% area under this category is found in Dodamarg (8.8%), Devgad tahsil (9.9%). Above 10% area under net sown area presented in Malwani (13.1%), Kudal (19.1%), Kankavli (17.4%).

Conclusion

It is observed that, general land use pattern is varying from tehsil to tehsil due to the physiographic structure, climatic condition and economic activities. There is noticed, the highest proportion of the area under the net sown area 33.1% whereas lowest area found in under the uncultivated land 6.9%. The highest area under the forest is presented in Kudal tehsil (25.4%). There is lowest area under the forest found in Malvan tehsil (0.7%). It is also need and important for a better management of natural resources and development in study region. There are most potentiality for the precious utilisation of land and natural resources.

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Study of Rainfall Variability in Sindhudurg District, Maharashtra

Mr. Govardhan S. Ubale, Assistant Professor, Department of Geography, Vivekanand College, Kolhapur (Autonomous), Maharashtra.
Dr. Rajaram Patil, Assistant Professor, Department of Geography, Arts and Commerce College, Phondaghat, Sindhudurg, Maharashtra.

Abstract :

Water is basic resource for human for the all living organism such as, animal, natural vegetation, human-being and development of agriculture, and also influenced the industrial as well as economical sector of the country. Sindhudurg is the southern part of Maharashtra and also known as Konkan. Rainfall distribution presented with variable and irregular pattern in the study area with spatial variation due to the physical setting, existence of Sahyadri hills and changing in climatically condition.

Introduction:

Water is basic need for human being for drinking as well as for agriculture, for industries etc. Rainfall distribution has influenced the agricultural practice, industrial sector as well as other economic sector in the country. In Indian sub-continent the most important factor i. s. rainfall or precipitation, which has influenced agricultural production and their progress because, Indian agriculture depend upon only on Monsoon. In the study area there is uneven distribution of rainfall presented with variability from tehsil to tehsil. In the monsoon period precipitation having large scale in the study area. So, water utilization is also important to the crop production.

Study Area:

Sindhudurg district is the southernmost part of Maharashtra coastal area that is known as the Konkan. Sindhudurg District situated between 15 37' North latitude to 16 40' North latitudes and 73 19' east longitude to 74 13' East longitudes. It is bordered by Ratnagiri district on the north, Arabian sea on the west, Goa state on the south, Belgaum district of Karnataka state and Kolhapur district on the east also. The total area of the district is 5087 sq. km. the topography of the Sindhudurg district as a part of Kankan. Physiographical Sindhudurg district has also divided in to three section that is, Khalati, Valati and Sahyadry hilly region respectively. The coastal strip of the district is called, Khalati and Valati having width of 20 to 25 km respectively. Sindhudurg district has 8,48,868 (Male-4,16,695, Female-4,32,173) population as per 2011 census. Mean monthly

minimum temperature near about 16.6⁰ C and mean monthly maximum temperature near about 33.5⁰ C. In the study area annual rainfall range is 2500 to 3500 mm.

Objectives:

1) To study the rainfall distribution in Sindhudurg district.
2) To study the tehsil wise variability of rainfall distribution in Sindhudurg district.

Data Base And Methodology:

In the present study mostly used secondary data collected through socio-economic abstract of Sindhudurg district (1981- 2005) and used years of 1995 to 2005 annual rainfall dada for the investigation. Gazetteer of Sindhudurg district also used for basic information. To understanding the distribution of rainfall and its characteristics and also used simple statistical method such as mean and percentage, and calculated the tehsil wise variability it is calculated by deviation from average rainfall. For the showing variability of rainfall also used choropleth map technique.

Rainfall distribution in Sindhudurg district (from 1995 to 2005)

Sr. No.	Years	Devgad	Vaibhavwadi	Kankavli	Malvan	Vengurla	Kudal	Savantwadi
1	1995-96	2226	4300	3400	2098	9714	3273	3700
2	1996-97	2426	4378	3500	2498	2914	3473	3760
3	1997-98	2661	4217	3678	2640	3031	3711	3894
4	1998-99	2423	5645	3827	2383	3251	3027	4702
5	1999-00	2489	4909	3529	2620	3291	3266	4497
6	2000-01	2994	3328	2891	3313	3489	2824	3926
7	2001-02	1740	3233	2480	2684	2159	2404	3076
8	2002-03	2137	3096	2275	2337	2198	2132	2937
9	2003-04	2289	4049	2509	2617	2694	2785	3198
10	2004-05	2553	4405	2670	2463	2874	2916	3671
11	2005-06	2524	4272	3246	2001	2425	2218	4028
	Average	2402.90	4166.5	3091.3	2514	3458.1	2975.3	3704.5

Source- Indian Metrological Department (IMD), Pune

Scanned with CamScanner

Rainfall distribution and Rainfall variability in Sindhudurg district
(from 1995 to 2005)

Average Rainfall distribution of Sindhudurg District

Tahasilwise Rainfall Variability in Sindhudurg District in %
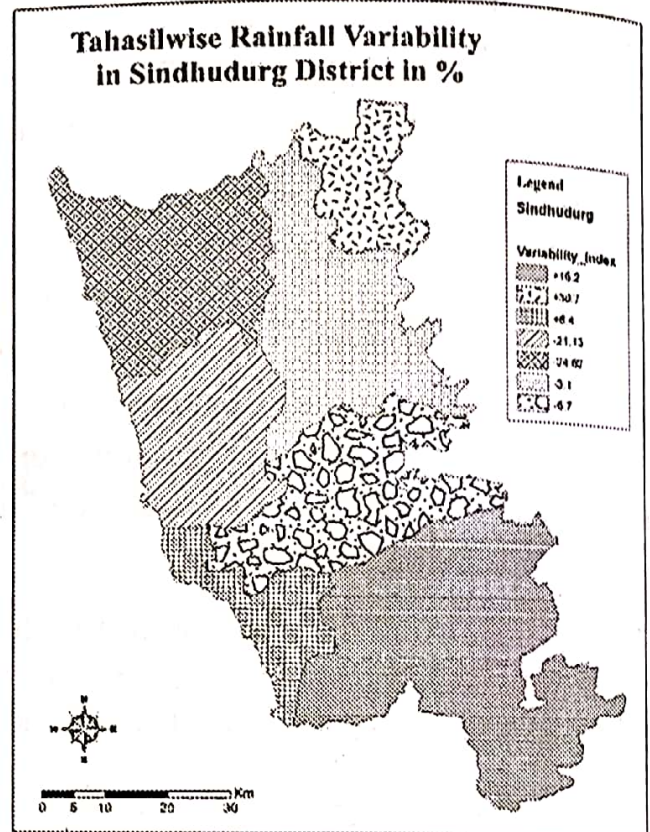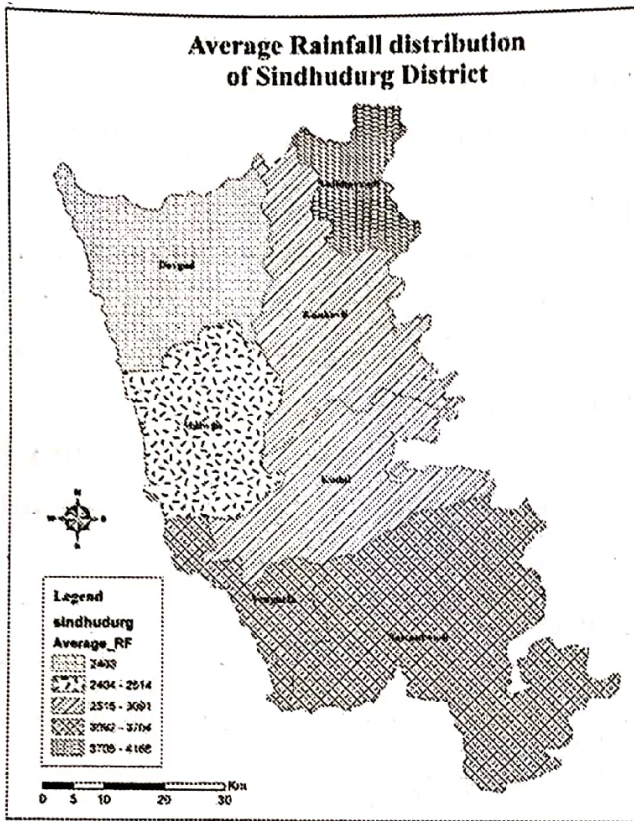
Source- Indian Metrological Department (IMD), Pune

As per above bar-graph are showing the rainfall distribution in Sindhudurg district for year of 1995 to 2005. It has also showed the highest rainfall in this period in the Vaibhavwadi tehsil, and follow by high rainfall regarding at Savantwadi and Vengurla Tehsil respectively. The lowest rainfall accrues in Devgad tahsil and average rainfall of Sindhudurg District is about 3187.5 mm. It has shown the tehsil wise rainfall distribution in Sindhudurg district for year of 1995 to 2005 with choropleth map. Up to 3000 mm rainfall also found in Devgad (2402.9), Malvan (2514) and Kudal (2975.3) tehsil. Kankavali (3091.3), Vengurla (3458.1) and Sawantwadi (3704.5) tehsil has accrues rainfall between 3000 mm to 4000mm. One of the tehsils has accurse above 4000 mm rainfall i.s. Vaibhavwadi tehsil (4166.5).

Rainfall Variability:

Variability of rainfall is calculated by the computing the rainfall data for 11 years (1995 2005) at every tehsil of Sindhudurg district. Variability also calculated average rainfall of district to average rainfall of tehsil, and variability calculated by using the following formula.

Variability of Rainfall = X -- % of precipitation from mean x100
Here,

X = Mean of Rainfall of Sindhudurg district during 1995 to 2005

Tehsil wise Variability Index in Sidhudurg District

Sr. No.	Name of the Tehsil	% of Precipitation from Mean (X)	Variability in %
1	Devgarah	75.38 %	-24.62
2	Vaibhavwadi	130.7 %	+30.7
3	Kankavli	96.9 %	-3.1
4	Malvan	78.87 %	-21.13
5	Vengurla	108.4 %	+8.4
6	Kudal	93.3 %	-6.7
7	Sawantwadi	116.2 %	+16.2

Source- Compiled by researcher

In this chart shows the tehsil wise rainfall variability in Sindhudurg district. It has also showed the rainfall, rainfall accurse in uneven form with varies from tehsil to tehsil. The less rainfall or the highest variability found in Devgad tehsil (75.38), which is nearabout -25% from average rainfall of district. In Malvan tehsil variability of rainfall is high i.s. -21%. The lowest Variability in the tehsil of Vaibhavwadi i.s. + 30.7 %. Followed by Sawantwadi tehsil (+16.2), then another tehsil accurses, Kankavali (-3.1%), Vengurla (+8.4%), and Kudal (-6.7%) during the 1995 to 2005.

Conclusion:

In the study region we are found high rainfall range, spatial distribution of rainfall is varying tehsil to tehsil because, the intensity and regularity of monsoon is varying. The annual and monthly rainfall presented with varies form. It has reveals that, the highest rainfall in the Vaibhavwadi tehsil. The lowest rainfall accrues in Devgad tahsil and average rainfall of Sindhudurg District is about 3187.5 mm. The highest variability in rainfall found in Devgad tehsil which is nearabout -25% from average rainfall of district. In Malvan tehsil variability of rainfall is high i.s. -21%. The lowest Variability in the tehsil of Kankavali (-3.1%), Vengurla (+8.4%), and Kudal (-6.7%) during the 1995 to 2005.

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