STUDIES ON LAND USE AND LAND COVER CHANGE IN SERCHHIP DISTRICT, MIZORAM

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Studies on Land Use and Land Cover Change in Serchhip District, Mizoram

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Certificate

This is to certify that the thesis entitled "Studies on Land Use and Land Cover Change in Serchhip District, Mizoram" submitted by Remlalruata for the degree of Doctor of Philosophy in the Department of Geography and Resource Management, of Mizoram University, Aizawl, India, is a record of original investigations carried out by him under my supervision. He has been duly registered and the thesis presented is worthy of consideration for the award of Ph.D. degree.

The present thesis is submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy. As per the Ph.D. regulations of Mizoram University, he has fulfilled all the requirements. The thesis is the result of his own research. This thesis has never been submitted to any other university for any research degree, either as a whole or as part of it.

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CANDIDATE'S DECLARATION

I Remlalruata, hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis did not form basis of the award of any previous degree to me or to do the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other University/Institute.

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(REMLALRUATA)

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Abbreviation

GPS	Global Positioning System
GIS	Geographic Information System
LULC	Land Use and Land Cover
LULC	Land Use and Land Cover Change
IFS	India Forest Survey
USGS	United State Geological Survey
DES	Directorate of Economic and Statistics
ISFR	India State of Forest Report
DEM	Digital Elevation Model
ICAR	Indian Council of Agricultural Research
MIRSAC	Mizoram Remote Sensing Applicatrion Centre
FAO	Food and Agriculture Organization
UNEP	United Nations Environment Programme
GWIB	Ground Water Information Booklet
INRM	Integrated Natural Resources Management
WAD	Working of Agricultural Department

Chapter 1

Introduction

The land is a vital natural resource for human survival and is the foundation for all of the services provided by terrestrial ecosystems (Chen, *et al.,* 2021; Myint, *et al.*, 2010; Otterman, 1974). The term "land cover" refers to the physical features that can be observed on the surface of the Earth. Land Use is created by adding an economic function to it. (FAO, 2005). Land use is the use of all developed and undeveloped land at a given point in time and space (Ahmad, 1985; Meyer, 1995; Meyer, 1996; Singh, 1989). It refers to the varying uses of land in a given area, such as forest, pasture, agricultural land, and even non-agricultural use, which can vary at any time (Pattanayak and Diwakar, 2016; Sati, 2018). Human use of land involves modifying and managing the natural environment or wilderness into a built environment, such as fields, pastures, and settlements (Begum, *et al.*, 2010; Pabis, 2007; Sati, 2023). It also has been defined as, “The arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it” (FAO, 1997; FAO/UNEP, 1999). Land use and land cover change (LULCC) is the modification of Earth's terrestrial surface caused by human activities (Hassan, *et al.*, 2016). Land degradation has been a widespread issue in the world as a result of changes in land use and land cover (LULC) (Ewunetu, *et al.*, 2021; Woien, 1995). Land Use and Land Cover (LULC) patterns and change detection are a concern of scientists worldwide because of the importance of land resources for environmental security and sustainability (Xiubin, 1996). Since land use and land cover change impact local, regional, and global climate conditions, the carbon cycle, biodiversity stability, clean water, agriculture, and food security, it plays a significant role in spatiotemporal environmental stability (Meer and Mishra, 2020; Erle and Pontius, 2007). Thus, it is imperative to understand the process of environmental change and the problem to be addressed to improve living conditions and standards sustainably (Anderson, *et al.*, 2001) (Dhinwa, *et al.,* 1992; Lu, *et al.,* 2004). Though humans have been modifying land to obtain food and other essentials for time immemorial, current rates, extents, and intensities of Land Use and Land Cover Change (LULCC) are far greater than ever in history, driving unprecedented changes in ecosystems and environmental processes at local, regional and global scales (Ellis, 2007; Ellis, 2011). Consequently, public agencies and private organizations can identify what is happening, plan for their future interventions, and design effective land management policies and procedures (Lambin, *et al.*, 2003; Müller, *et al.*, 2009). As a result, timely information about LULC changes and their dynamics is vital for better understanding the interaction between human and natural phenomena and for better managing the resources that provide the main source of livelihood for the poor rural population (Birhanu, *et al.,* 2019; Ololade, *et al.*, 2008).

LULC mapping and change detection across the globe have recently been enhanced by the use of geographical information systems (GIS) and remote sensing (Mohamed, *et al.,* 2020) (Chitade and Katiyar, 2010; Dewanan and Yamaguchi, 2007; Macleod and Congalton, 1998; Duncan and Kuma, 2009; Gondwe, *et al.*, 2021). The development of advances in remote sensing, such as the implementation of digital image processing algorithms, has increased the use of satellite imagery, such as Landsat data, in studies concerning changes in LULC across multiple spatial and temporal scales (Bunyangha, *et al.,* 2021; Bisht and Kothyari, 2001; Sarma, *et al.*, 2005). For mapping LULC changes at various spatial scales, several image classification algorithms have been developed (Aplin and Atkinson, 2004; Byeong-Hyeok and Kwang-Hoon, 2006). A variety of remote sensing attributes, including spectral, spatial, multi-temporal, and multi sensor information, can be used to classify images (Al-Doski, *et al.,* 2013; Chen, *et al.,* 2012; Elvidge, *et al.,* 2004).

The landscape of India is diverse with substantial heterogeneity in the climate and soil, as well as different socio-economic factors that may influence the LULC changes (Mishra and Misra, 2002; Bhattarai and Conway, 2008; Sati and Singh, 2016). In India, different studies regarding the land use and land cover change have been undertaken (Ram, 2002; Sala, *et al.*, 2000). The increase in Indian population (200 million to 1200 million) and economic growth (especially after the 1950s) during the 20th century have resulted in transformations in the LULC sector (DES, 2010). According to Richards and Flint (1994), forest area decreased from 100 million hectares to 81 million hectares, while cropland area increased from 100 million hectares to 120 hectares during 1880-1950. There is a strong correlation between the temporal pattern of deforestation during the period 1880–2000 and the temporal pattern of carbon emissions resulting from land use changes (Chhabra and Dadhwal, 2004). Currently, land use and land cover statistics and mapping are insufficient and do not provide updates regarding the changing pattern of land cover. There have been several efforts made over the years by various government agencies and departments, both at the state and federal levels. There is noteworthy organization by the Survey of India, the National Atlas and Thematic Mapping Organization, the National Bureau of Soil Survey and Land Use Planning and others in publishing thematic maps and statistical data.

The North-eastern region is characterised by a different and diverse agro-climatic condition, with different soil types and irregular physical features and this region is in a developing state (Seitinthang, 2014; Sati, 2012). Consequently, land use and land cover changes are diverse and different from other parts of the country due to different cropping patterns and topographical features (Ritse, *et al.,* 2020; Shimrah, *et al.,* 2021). It is important to note that the majority of inhabitants of the north-eastern region are tribal, and as a result, the land use in these regions has changed (Sati, 2019). A major occupation of the people living in this region is agriculture, which leads to a significant decline in forest cover and an increase in deforestation (Sati, 2018). The total geographical area of Northeast India is around 2,62,179 km^2. India State of Forest Report (ISFR) 2019 shows that there is around 1,70,541 km^2 of forest cover which comprises of 65.05% of the total geographical area. However, over the past 18 years, India’s greenest region, North East has consistently lost tree cover (Sati, 2017). Net loss of tree cover between 2000 and 2018 in India is around 16,744 km^2. Out of this, 70.4% (which is 12,523 km^2) were from the North Eastern region. The total cropped area in the north-eastern regions was 53,000 km^2 in 2018 (Agriculture statistics, 2018).

Mizoram is the fifth smallest state of India with an area of 21,087 km^2 (Sati, 2015). Tropical and sub-tropical climate prevail with dry winters from November to February. March and April, there are thunderstorms with limited rain (Sati, 2022). Monsoon rain occurs from May to September (Sati, 2017). Rainfall is heavy July and August, accounting for approximately 78% to 80% of the total amount of rainfall each year (Uttam, *et al.*, 2018; Sati, 2019). In Mizoram, the topography is rugged, with mountains and hills dominating the landscape (Sati, 2019). In 2011, about 60% of the total population of Mizoram was engaged in agriculture and its allied activities (Sati, 2020). About 63% of the total crop area is under Jhum Cultivation (ESM, 2012; Sati, 2015). The main driving force of changing land use land cover in Mizoram is its cropping pattern and its primitive agriculture practices (Sati, 2021; Sati, 2018; Sati, 2019). In 2005, according to ISFR the total forest cover area was 18,684 km^2 which comprises of 89.24% of the total geographical area of Mizoram. In 2015, the total forest cover area was 18,748 km^2 which is 88.93% of the total geographical area. In 2015, dense forest covered an area of 138 km^2, moderately dense forest covered an area of 5,858 km^2 and open forest covered an area of 12,752 km^2.

1.1 Statement of the Problems

Land use and land cover change (LULCC) becomes a hot topic in both national and international. With the improvement of technology like Remote Sensing and GIS, in-depth study of LULCC has becoming an important subject. Land use and land cover change is important in every area because of the difference in land use causes land cover as well as land cover difference causes the pattern of land use.

In Mizoram, majority of the populations are depending on the agriculture production and the cropping pattern is largely shifting cultivation. Many families are still practicing shifting cultivation which causes forest degradation. Therefore, land use and land cover changes will also occur in Serchhip district.

1.2 Scope of the Study

Land use and land cover change are very comprehensive terms that have been discussed for many decades. In this study, the focus will be on changes in land use and land cover in Serchhip District, Mizoram. It will also examine the causes and consequences of land use and land cover change within the study area. Additionally, this study will provide recommendations for the government and policymakers.

Considering the lack of scientific work on land use land cover change, this study will provide insight into the new findings and provide precise understanding to cope with the threat of land use and land cover change.

1.3 Objectives

1. To study the major land uses in Serchhip District

2. To analyse land cover change from 2000 to 2018

3. To examine the main drivers of land use land cover change and their consequences

4. To suggest policy for sustainable use of land resources

1.4 Study Area

Serchhip District extends between 23°35'N and 23°00'N latitude and between 92°41'E and 93°10'E longitude. It is located in the central part of the state. Serchhip district is surrounded by Aizawl district in the North and Northwest part - Lunglei in the southern part, Myanmar in the southeast, and Khawzawl district in the east. Serchhip district lies between the Tuikum River and Mat River. It covers an area of 1,421 km^2 of the total geographical area. The district covers around 42 villages and two Rural Development Blocks. According to Census of India, 2011, Serchhip district has a population of 64,937, of which 32,851 are male and 32,086 are female. The average density of population was 46 persons per km^2. The literacy rate of the district was 97.91%, which is higher than the state average of 91.58%. Serchhip district comes under the tropical monsoon climate zone in India.

1.5 Methodology

1.5.1 Source of Data

Both qualitative and quantitative methods were used to conduct this study. Data were gathered from primary and secondary sources. For gathering primary data, a case study of 10 villages- 4 from Serchhip R.D. Block and 6 villages from E. Lungdar R.D. Block of Serchhip district was conducted. The villages were selected based on their accessibility and population size. A total of 467 households were surveyed from the study villages, covering around 47% samples from each study village. According to 2011 census, there were 6074 people living in the study villages. Using a structured questionnaire, the author asked with the heads of each surveyed household about the types of cropping pattern they practice, variety of crops and the production and the knowledge about land use and land cover change. Besides, age, sex, education, income, and occupation were also enquired. Moreover, latitude, longitude, and altitude of each village were measured using a Global Positioning System (GPS).

For this study, Landsat Thematic Mapper (TM) 4-5 C1 level-1 satellite images for each year were used, such as 2000, 2010 and Landsat 8 OLI/TIRS C1 level-1 images for 2018. These images can be found on the Landsat archive of the United States Geological Survey (USGS) website (https://glovis.usgs.gov/) (https://earthexplorer.usgs.gov/) (Chavez et al., 1991; Gutman et al., 2008). In this case, satellite images were used to categorize land uses and land covers (Tucker, *et al.*, 1985).

1.5.2 Data Analysis

A variety of statistical techniques, such as mean, median and percentiles were employed. Data were represented graphically using bar diagrams. A variety of secondary data sources were also used, including government reports, archives and the latest census data (2011). A supervised classification method with a maximum likelihood algorithm was used to generate three LULC maps using ArcMap 10.4® software. Accuracy assessment was taken out using different matrices like user accuracy assessment, producer accuracy and overall accuracy, as well as the Kappa coefficient.

$$Users\ Accuracy = \frac{Number\ of\ Correctly\ Classified\ Pixels\ in\ each\ Category}{Total\ number\ of\ CLassified\ Pixels\ in\ that\ Category\ (The\ Row\ Total)} x100$$

$$Producers\ Accuracy = \frac{Number\ of\ Correctly\ Classified\ Pixels\ in\ each\ Category}{Total\ number\ of\ Refrence\ Pixels\ in\ that\ Category\ (The\ Column\ Total)} x100$$

$$Overall\ Accuracy = \frac{Total\ Number\ of\ Correctly\ Classified\ Pixels\ (Diagonal}{Total\ Number\ of\ Reference\ Pixels}\ x\ 100$$

$$Kappa\ Coefficient\ (T) = \frac{(TS\ x\ TCS) - \sum(Column\ Total\ x\ Row\ Total)}{TS^2 - \sum(Column\ Total\ x\ Row\ Total)} x100$$

1.6 Organization of the Thesis

The study is organized in the following seven chapters:

Chapter I: Introduction

This chapter describes the concept of land use and land cover change. It discusses Land use and land cover at different levels i.e., international, national, and state level. Then the chapter explains statement of the problem, research questions, scope of the study, objectives, methodology, and the study area.

Chapter II: Review of Literature

Literature reviews are conducted at several levels, including international, national and state levels. A variety of literatures on land use and land cover change are discussed.

Chapter III: Geographical Background and Socio-economic Profile

In this chapter, the geographical setting of Serchhip district is described, including its physiography, geology, major landforms, drainage system, climatic conditions, natural vegetation, demographic characteristics, agriculture practices and economic condition.

Chapter IV: Case Study

This chapter highlighted a case study of the study area; a detailed data interpretation was taken out including its demographic profile, area, production and productivity of the different crops of the study villages.

Chapter V: Land use and Land Cover Change

This chapter examined the land use and land cover change of Serchhip district for the year 2000, 2010 and 2018.

Chapter VI: Factors Affecting Land Use and Land Cover Change

This chapter explains the different factors affecting land use and land cover change of Serchhip district.

Chapter VII: Conclusions

This chapter presents a conclusion and also provides some recommendations to control land use and land cover change rates in the study area.

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Chapter 2

Review of Literature

Land use land cover change has become a burning issue particularly in the wake of growing population and economic development. Many studies have been conducted on land use land cover change worldwide by the scholars. Similarly, in India also, the study on various land uses and changing patterns has been conducted. North East India including Mizoram obtains a significant change in land use and land cover. Some studies have already conducted on these issues. The present study is conducted in the Serchhip district of Mizoram. Since, no specific study has been conducted on land use and land cover change, the present study will be milestone. In this chapter, a large literature on land use land cover was reviewed and presented.

Some of them are like Otterman (1974) while conducting research on land use land cover change during the mid-1970s, recognized that changes in land cover have an impact on the surface albedo as well as surface atmospheric energy exchanges, which in turn have an effect on regional climates. It means that land use land cover change not only has the impact on food and nutrition but it has impact on the climatic conditions.

Anderson (1976) described a remote sensing device that records a response based on the land surface, including natural and artificial cover. Using elements such as tone, texture, pattern, shape, size, shadow, site, and association, an interpreter is able to determine the type of land cover. Data and images derived from various types of sensors flown at different heights above the terrain and at different times of the day and year cannot be simply classified. A single classification cannot be used for all types of images and scales. It has been successfully developed a general purpose classification scheme that is compatible with remote sensing data and is also known as the United States Geological Survey classification scheme (USGS).

Olorunfemi (1983) argued that satellite imagery is perhaps the only reliable method of collecting data in inaccessible regions on a cost-effective basis since it allows data to be collected more frequently on a regular basis than aerial images. In spite of the fact that aerial photographs may provide a more accurate map in terms of geometry, their coverage and cost are limited. As the case study of Ilorin in Nigeria, Olorunfemi realized the importance of remote sensing technique while using traditional methods of surveying, such as aerial photography, to monitor urban land use in developing countries.

Ahmad (1985) has highlighted different geographical landforms and land use land cover change at the global level and noticed substantial changes in land use due to enormous human activities. A change detection technique described by Singh (1989) is the comparison of two or more temporal images of a given study area, in order to detect the transformation of objects or phenomena in the same study area. Hayes and Sader (2001) also pointed out that the change detection techniques can be used for a wide range of applications, including the monitoring of forest and vegetation changes. These change detection techniques are based on multi-date images acquired with remote sensing applications.

Tucker *et al.,* (1985) conducted an analysis using data from the advanced very-high-resolution radiometer sensor on NOAA's operational meteorological satellites to classify land cover and monitor vegetation dynamics in Africa over a 19-month period. The research revealed a significant correlation between the density and extent of green-leaf vegetation and seasonal rainfall patterns associated with the movement of the Intertropical Convergence Zone. Regional variations, including the 1983 drought in the Sahel region of western Africa, were observed during the study period. By integrating weekly satellite data over 12 months, the researchers estimated primary production based on green-leaf biomass density and duration. Moreover, the study utilized eight sets of composite data over 11 months to create a reliable land-cover classification that demonstrated significant correspondence with existing maps.

Crosta and Moore (1989) presented a detailed account of utilizing Landsat Thematic Mapper (TM) imagery for geological mapping in a region of southeast Spain characterized by complex tectonic conditions. The study area encompasses the metamorphic basement rocks of the Betic Cordillera and the sedimentary strata within an intermontane basin. A comprehensive analysis of the TM data revealed that combining bands 1, 3, and 5 into a color composite offered the most effective means of distinguishing between different rock types in the semi-arid study region. By employing a combination of spectral and textural characteristics, the authors successfully identified and mapped various rock types present in the Nevado-Filabride and Alpujarride basement complexes, as well as the sedimentary strata within the Neogene Tabernas-Sorbas Basin and Quaternary drift deposits. The study also utilized digital convolution with a directional filter to enhance the visualization of structural features. This led to the identification of a previously undocumented fault and fracture belt in the northern part of the Tabernas Basin. The accuracy of the geological interpretation derived from the enhanced TM imagery was further validated through field observations conducted in the study area.

Chavez *et al.,* (1991) investigated the merging of Landsat Thermatic Mapper (TM) and Satellite Pour l'Observation de la Terre (SPOT) panchromatic data using three different methods: Hue-Intensity-Saturation (HIS), Principal Component Analysis (PCA), and High-Pass Filter (HPF). The goal is to assess the impact of each method on preserving the spectral characteristics of the high-frequency resolution data during merging. Statistical, visual, and graphical analyses are employed for comparison. The results show that the HIS method distorts the spectral characteristics of the data the most. In contrast, the HPF method causes minimal and hardly detectable distortions, making it the most suitable for preserving spatial integrity during merging these datasets.

Congalton (1991) examined the crucial factors and available methodologies involved in the assessment of accuracy of remotely sensed data. The review encompasses significant aspects such as the classification system, sampling scheme, sample size, spatial autocorrelation, and assessment techniques. The primary analytical tool employed throughout the assessment is the implementation of an error matrix or contingency table. Exemplary matrices and corresponding analysis outcomes are presented to illustrate practical applications. Furthermore, the paper discusses future trends, including the imperative to evaluate accuracy for diverse forms of spatial data. The insights and findings presented in this paper serve as a valuable resource for researchers and professionals engaged in the meticulous evaluation and validation of remotely sensed data.

Dwivedi and Rao (1992) identified the most suitable three-band combination of Landsat Thematic Mapper (TM) reflective bands data for effectively delineating salt-affected soils in the Indo-Gangetic alluvial plain, a quantitative methodology was employed. The analysis involved assessing the standard deviation and correlation coefficients of the TM data to calculate a statistical parameter known as the 'Optimum Index Factor' (OIF), which reflects the information content or variance of the data. After evaluating all 20 possible three-band combinations, it was determined that the combination of bands 1, 3, and 5 exhibited the highest information content. Interestingly, the commonly used combination of bands 2, 3, and 4 ranked significantly lower in terms of information content. This conclusion was validated by assessing the accuracy of delineating salt-affected soils using the same data. The results showed a mixed relationship between the rankings based on OIF values and the accuracy estimates. This indicates the need for further investigation in similar terrain conditions.

Meyer and Turner (1994) highlighted the challenges of comprehending global patterns of land use and land cover change due to their complexity. To tackle this issue, the authors emphasize the need for drastic simplification, where key aspects are emphasized while less significant details are minimized. Expert judgments and decisions play a crucial role in this process, knowing that other perspectives may also be valid. The study serves as an initial step towards enhancing understanding of global land-use changes, with the expectation that it will prompt further research and exploration in this field.

McNeil (1994) developed methodology utilizing satellite images to detect land cover changes in 1997, 2002, 2012, and 2017, with a focus on fast-growing urban areas. The land cover categories examined included built-up area, plantation, waterbody, agricultural land, and pastureland. The results revealed a significant increase in urban or developed land from 8.12% to 52.4% of the total area over the 20-year period, while agricultural land, plantation, waterbody, and pastureland decreased from

91.88% to 47.6%. The study demonstrates the efficiency of remote sensing and GIS techniques in analyzing population expansion and evaluating the impact of urbanization using satellite imagery. The findings provide valuable insights for land management decisions and serve as a cost-effective means to monitor land cover changes over time.

Richards and Flint (1994) collected a data on south and southeast Asia during 1880, 1920, 1950, 1970 and 1980. The database for South and Southeast Asia covers an extensive land area of 8 million square kilometers and includes 13 countries. Over a 100-year period, a significant land use change occurred, with 107 million hectares of forest and woodland converted to lower biomass categories, representing 13.5% of the study region's total area. The carbon content in live vegetation steadily decreased from 59 billion Mg in 1880 to 27 billion Mg in 1980. Forests consistently held the largest carbon stock, although their share declined from 81% to 73% during the study period. The database, created using a sequential bookkeeping model, incorporated data from diverse sources and provided land use and carbon information for 94 ecological zones and national totals.

According to Riebsame *et al.,* (1994), land use affects land cover and changes in land cover affect land use. However, changes in either of these factors do not necessarily follow from a change in the other. A change in land cover as a result of land use does not necessarily indicate degradation of the land. Among the many changing land use patterns, driven by a variety of social causes, are the changes in land cover. These changes have an impact on biodiversity, water and radiation budgets, as well as other processes that affect the climate and biosphere.

Meyer (1995) demonstrated that land cover is also affected by external factors other than anthropogenic forces. For instance, natural events such as weather, flooding, fire, climate fluctuations, and ecosystem changes can also influence land cover. Other human activities may have incidental impacts on land cover, such as acid rain from fossil fuel combustion damaging forests and lakes and tropospheric ozone produced by automobile exhaust damaging crops near cities.

Meyer and Turner II (1996) discussed the effects of land use land cover change on the climate and different environmental degradation. They focus on the relationship between climate change and the rate of land cover change.

Accroding to Xiubin, (1996) land use and land cover change (LUCC) has become a significant area of research since 1990, driven by its impact on global environmental change and sustainable development. The International Geosphere-Biosphere Programme (IGBP) and the Human Dimensions of Global Environmental Change Programme (HDP) initiated the joint core project LUCC, emphasizing the need to understand the dynamics of land use and cover changes. LUCC research involves studying the influence of land cover changes on global environmental changes, examining the response of LUCC to environmental shifts, and exploring the relationship between LUCC and sustainable development. Modeling LUCC is challenging due to its complexity, requiring an integrated approach that combines onsite case studies, remote sensing observations, and regional/global economic modeling. By addressing these complexities, researchers can gain insights into future global environmental changes and support sustainable land use practices.

Graumlich (1997) studied the dynamics of land use land cover change in the Hindu-Kush-Himalaya in which the interactions of land use land cover to the biogeochemistry which will affect the climate change in the future. Comparision of the study area to the other regions was also taken out which is very helpful for further understanding of the land cover change.

Accroding to Edet *et al.,* (1998) Groundwater exploration in Cross River State, Nigeria faces challenges due to limited funds and resources, resulting in a high failure rate of 80%. To overcome this, a study utilized black and white radar imagery and aerial photographs to analyze hydrological and hydrogeological features. Lineament and drainage patterns were assessed using length density and frequency, revealing variations in groundwater potential. The study delineated areas of high, medium, and low groundwater potential. Correlations were found between lineament and drainage patterns, lithology, water temperature, conductivity, well yield, transmissivity, longitudinal conductance, and groundwater occurrence. These findings offer valuable insights for future groundwater development, guiding resource allocation and exploration efforts in the absence of extensive site investigations.

Macleod and Congation (1998) identified four critical aspects of change detection that must be considered when monitoring natural resources. These include identifying the changes that have occurred, identifying the nature of the change, measuring the area extent of the change, as well as assessing the spatial pattern. As a result of changes in land cover resulting in changes in radiance values, remote sensing data can be used for change detection. The increasing versatility of manipulating digital data and increased computer power has resulted in the development of numerous techniques to detect changes in satellite imagery.

Jensen and Cowen (1999) described conventional ground methods of land use mapping as labor-intensive, time-consuming, and infrequent. In today's rapidly changing environment, these maps quickly become outdated. The development of satellite remote sensing technology in recent years has proven to be of enormous use in creating precise maps of land use and cover and tracking changes over time. Although urban environments present challenges in terms of spatial and spectral heterogeneity, remote sensing appears to be a suitable source of accurate data about the many aspects of urban environments.

DANIDA (2000) examined the changing dynamics of shifting cultivation in the Chittagong Hill Tracts (CHT) of Bangladesh and identifies three distinct land-use systems based on intensity and diversification. Factors such as institutional support, resource availability, and proximity to markets and services influence the development of these systems. Population pressure and government restrictions on encroachment have led to shorter fallow periods and environmental degradation. Sustainable land-use practices like agroforestry and horticulture have emerged in areas with favorable support and facilities, while shifting cultivation remains dominant in areas with insecure land tenure and limited access to services. The study suggests providing necessary institutional support and services to facilitate a gradual shift towards environmentally and economically suitable land-use practices to ensure sustainable land management and livelihoods.

HARS (2000) analyzed two sample villages, one relatively successful and the other relatively unsuccessful. It examined the impacts of a forest-based settlement project on community livelihoods. The findings revealed that while traditional forestry practices (shifting cultivation) were insufficient to sustain participants' livelihoods year-round, the settlement project positively influenced their income and livelihoods. Many project participants completely abandoned customary forestry practices and adopted diversified income-generating strategies. However, variations in project outcomes between villages were observed due to disparities in budget allocations. In addition, there is inconsistency in raising awareness about project benefits, and inconsistencies in monitoring and motivation. Several underlying factors were identified that contributed to the success or failure of the settlement project in achieving its objectives. The study recommends effective stakeholder participation to enhance ownership, strengthen collective management, and ensure long-term project sustainability.

Sala *et al.,*. (2000) shown that changes in land use and the resulting changes in cover have a much broader range of impacts on ecosystems, goods, and services. Of primary concern are impacts on biotic diversity worldwide.

Anderson *et al.,* (2001) outlined a national land use and land cover classification system designed for remote sensing data. It caters to the needs of federal and state agencies, providing a uniform and up-to-date overview of land use and cover across the country. The system utilizes existing widely used classification systems compatible with remote sensing sources and allows flexibility for agencies to develop more detailed classifications while maintaining compatibility with each other and the national system. The system underwent revision based on extensive testing and review to enhance accuracy and effectiveness.

Bisht and Kothyari (2001) conducted a land cover change analysis of the Gurur Ganga watershed in Uttaranchal. The study between 1963 and 1996 indicates a significant increase in agricultural areas and settlement areas, while there has been a decline in forests and barrens. A study by Dhinwa *et al.*, (1992) found that during 1986 to 1989, forest cover had been reduced in Bharatpur district, whereas wasteland undulating terrain with or without scrubs and rock out crops had been increased.

Laldailova (2001), 'Land Use Change' highlighted the unfavourable physiographic condition of Mizoram which impose scarcity of land for the increasing population. He also discussed the socio-economic factors influencing land use changes over the past decades.

Lambin *et al.*, (2001) challenged a common simplification in understanding land-use and land-cover change causes and offers alternative perspectives supported by case study evidence. It disputes the notion that population growth or poverty alone are the main drivers of such changes worldwide. Instead, the research suggests that people's responses to economic opportunities, influenced by institutional factors, play a significant role in driving land-cover changes. The study emphasizes that the interplay between local and national markets, policies, and global forces shapes land-use change. By presenting a more nuanced and comprehensive understanding of these drivers, the article calls for a reevaluation of environment-development policies to address the complex and diverse factors contributing to land-use and land-cover change.

Zeleke and Hurni (2001) studied land use and land cover changes and their implications for mountain resource degradation. They suggested that analysis of land use change should involve questions such as the extent and degree, the consequences of the changes, the future trends of changes and the overall implications of such changes at the micro and macro level. Their analysis on the spatio-temporal changes in the land use presented that vegetation cover has completely declined, the loss rate has become higher and that soil productivity is dwindling.

Mishra and Misra (2002) have made an attempt to look for potentials of development through sustainable agricultural practices in Northeast India and showed that shifting cultivation is the predominant form of agriculture prevalent in the region which accounts for 1.5% of the total geographic on an annual basis. It also highlighted the different agro-based industries and this causes the different pattern of land use in Northeast India.

Ram (2002) has carried out selection of suitable land use in Haryana by dividing the state into 5 (five) physiographic units such as (i) Shivalik Hills (ii) Piedmont and Rollin Plains (iii) Alluvial (iv) Aeolian Plain and Sandunes and (v) Aravealli Hills. He has made investigations on these physiographic zones and studied the land use patterns and the interchanging relationship between physical features, land utilization and the cropping pattern. He concluded that for any success in land use planning especially in agricultural land uses, farmers participatory approach and site suitability approach are essential as the plan has to be 'User Specific' and 'Location Specific'.

Weng (2002) presented a study on rapid land use changes in coastal regions of China, with a specific focus on the Zhujiang Delta. This is over the last two decades due to increased industrialization and urbanization. By employing satellite remote sensing, geographic information systems (GIS), and stochastic modelling technologies, the research investigates land use change dynamics. The findings indicate significant and uneven urban growth and cropland loss between 1989 and 1997. There is no sign of stability in land use change. The integration of satellite remote sensing and GIS proves to be an effective approach to analyzing land use change direction, rate, and spatial patterns, while the addition of Markov modelling further enhances the understanding and analysis of this process. The study underscores the value of integrated approaches to comprehending and managing land use changes in the rapidly developing coastal regions of China.

Lambin *et al.*, (2003) highlighted the complexity of land use and land cover change, particularly in tropical regions, and proposes a framework for better understanding the issue. It summarizes recent estimates on various aspects of land use change and identifies the drivers of change, including resource scarcity, market opportunities, policy intervention, and social factors. The passage emphasizes the interaction between climate-driven land cover modifications and land use changes, as well as the feedback loop between changes in ecosystem goods and services and the drivers of land use change. It suggests that a combination of agent-based systems and narrative perspectives is necessary for comprehending land use and land-cover change, and argues for systematic analysis of local scale studies to uncover general principles that explain and predict new land use changes.

Rinawma's (2003) book, 'Geomorphology and Agricultural Development in Mizoram' provided some information about the impact of morphometric elements on agricultural land use in Lunglei District.

Zha *et al., (*2003) proposed a novel method for automated mapping of built-up areas in urban and suburban regions using remotely sensed imagery. The approach leverages the Normalized Difference Built-up Index (NDBI) to exploit the unique spectral response of built-up areas and other land covers. By manipulating re-coded Normalized Difference Vegetation Index (NDVI) and NDBI images derived from TM imagery, the method effectively maps built-up areas. The study's application in Nanjing, eastern China, yielded promising results, with an accuracy of 92.6%, demonstrating its reliability for fulfilling the mapping objective. Compared to the traditional maximum likelihood classification method, the proposed NDBI offers a valuable alternative for quickly and objectively mapping built-up areas, making it a significant advancement in land cover change detection in urbanized environments.

Aplin and Atkinson (2004) developed a technique to improve per-field classification accuracy by predicting incomplete field boundaries. The method involved comparing within-field modal land-cover proportions and local variance. The study used Compact Airborne Spectrographic Imager (CASI) data at 4-m and 20-m spatial resolutions to evaluate classification accuracy with multispectral Ikonos and Satellite Pour l'Observation de la Terre (SPOT) High-Resolution Visible (HRV) imagery. The process included per-pixel and per-field classification, and the implementation of the missing boundary detection technique. The results showed that using the missing boundary flag significantly enhanced classification accuracy. This was achieved with simulated Ikonos imagery performing better than simulated SPOT HRV imagery for this purpose.

Chhabra and Dadhwal (2004) conducted a study which focused on estimating carbon pools and fluxes in Indian forests, including phytomass, soil organic pool, litter, and carbon fluxes due to land use changes. Phytomass in Indian forests was estimated to be between 3.8 and 4.3 PgC, while the soil organic pool in the top 1m depth was estimated at 6.8 PgC. Litterfall carbon flux was estimated to be 208.8 MgCha–1 yr–1. The cumulative net carbon flux resulting from land use changes in Indian forests from 1880 to 1996 was estimated at 5.4 PgC. The study highlights the importance of accurately quantifying carbon pools and fluxes in understanding the contribution of Indian forests to carbon emissions and their potential for carbon sequestration.

Elvidge *et al.,* (2004) observed that remotely sensed imageries provide an efficient means of obtaining information on temporal trends and spatial distribution of urban areas needed for understanding, modeling and projecting land changes.

According to Eva *et al.,* (2004) a digital map depicting South America's land cover has been created using remotely sensed satellite data captured between 1995 and 2000. The map is based on a spatial resolution of 1 km, determined by a grid-cell scale. Multiple satellite data sources were used to incorporate specific land cover characteristics and map various land cover classes according to a predefined legend. The map legend was designed to meet regional climate modeling and land cover change requirements. Additionally, the legend aligns with a larger global land cover mapping initiative, aiming to characterize the Earth's land surface for 2000. The validation process began with the assessment of the humid forest domain using high-resolution satellite imagery, providing a preliminary validation step. The resulting map reveals notable agriculture expansions into forested regions, highlighting significant transformations of South America's grasslands into extensive agricultural areas.

Hall *et al.,* (2004) assessed the use of Remote Sensing and GIS in Argentina to provide proof of the concept that Remote Sensing data, especially synthetic aperture radar and ground-based GIS data can be successfully integrated for planning purposes. The results suggest that the approach used is reasonable and that with future refinement, it offers planners and decision makers a timely and cost-effective means to locate and monitor changes in the landscape or land cover.

According to Olsonm *et al.,* (2004) improving the understanding of land use and land cover change (LULC) is essential for effective land management and projecting future land use dynamics. This study aims to evaluate the impact of induced small-scale irrigation practices on land use changes in Mai-dimu Kebele, Tigray, northern Ethiopia. Utilizing Remote Sensing (RS) and Geographic Information System (GIS), LULC dynamics and land cover changes from 1995 to 2015 were analyzed. The accuracy assessment demonstrated strong agreement between classified land cover classes and observed land cover/use. Cultivated land coverage increased over the years, with a notable rise in irrigated land by 2015. Settlements, dams, cultivated land, and irrigated land expanded significantly, leading to decreased grassland, bushland, bare or rocky land, and forest land. The introduction of irrigation practices proved beneficial, enhancing yield production during the dry season and improving community livelihoods.

A relationship analysis of the distribution of land use and elevation was done by Yusuf Kurucu *et al.,* (2004) in the Soke region of Turkey based on generation of Digital Elevation Model (DEM) coupled with Landsat-5 satellite imagery interpretation. They cited that planning for land use should be based on slope inclination, slope facets and elevation above sea level and that there is a direct relationship between slope and soil-depth and erosion which are the basic soil features. Through their observation of landuse-slope-elevation relationship, they found that the slope gradients of 0-2%, 2-8%, 8-16% and above 18% are largely dominated by the land use types of irrigated cotton, orchards with citrus and vineyard, olive groves with figs and shrubs with a mixture of forests respectively. They stressed that the use of DEM provides quick and more reliable results as compared to conventional methods.

Zhao, *et al.,* (2004) focused on the preservation of cultivated land in China's strategic policies. It also focuses on the need for timely land use monitoring to ensure sustainable land management. The research aims to develop an effective procedure for detecting changes in cultivated land in the Yellow River delta region using digital satellite remote sensing techniques. Four detection methods were assessed, and the results revealed challenges in dealing with spectral confusion caused by soil salinization and complex land use patterns in the study area. Among the methods, knowledge-based visual change detection and classification-result overlay methods were found to be more appropriate than the multi-temporal composite, classification, and image ratio methods. However, the latter two methods can be efficient with suitable remote sensing data from distinct seasons and clear spectral characteristics of land use types. The study indicates a decrease of 5321.8 hectares in cultivated land between 1987 and 1998. This decrease is primarily concentrated in the central paddy field and northeast dry land regions at an average annual reduction rate of 483.8 hectares. These findings offer valuable insights into cultivated land management and conservation strategies in the Yellow River delta region.

Foley *et al.,* (2005) reported that more than six billion people demand food, fiber, water, and shelter on a global scale, which drives changes in forests, farmlands, waterways, and air. There has been an exponential growth in the area of croplands, pastures, plantations, and urban areas in recent decades. This growth has been accompanied by an increase in the consumption of energy, water, and fertilizer, as well as a significant loss of biodiversity.

Sarma *et al.,* (2005) investigated the impact of coal mining on land use and land cover in Meghalaya, India using remote sensing and GIS techniques. LANDSAT data from 1975, 1987, 1999 and 2007 were used to determine that the mining area increased fourfold between 1975 and 2007, whereas the forest area decreased threefold. Land cover/use mapping was based on visual interpretation techniques for four different years of data.

Byeong-Hyeok *et al.,* (2006) conducted an interesting study on forest reclamation monitoring in the abandoned mine in the Samtan coal mining area located in the southern part of Jeongseongun, Gangwon-do, Korea. Using multi-temporal satellite data, the effects of vegetation health on abandoned and recovered forests were evaluated. A three-temporal Landsat 5 and 7 satellite data set was used to analyze vegetation and forest health. The results of the NDVI map indicated that the natural forests have recovered their vegetation, thus indicating that they are recovering their health.

To develop a sustainable land use planning decision and to forecast possible future changes in growth patterns, an attempt was made by Dewan and Yamaguchi (2007) to evaluate land use and expansion of land degradation in Bangladesh using satellite images and socio-economic data. Spatial and temporal dynamics of land use changes were quantified using change Detection Technique in GIS. The analysis revealed that substantial growth of built-up areas resulted in significant decrease in the areas of water bodies, cultivated lands and vegetation.

Ellis (2007) highlighted the land use land cover change in a different form, studying major drivers and its consequences in a different region. Some of the consequences it shows were that of climate change and increase of pollution amongst others. It also highlighted methods and certain policy measures for land use land cover change.

According to Erle and Pontius (2007) the escalation of population growth and economic endeavors has significantly pressured land resources. As a consequence, human activities have resulted in a profound transformation of the terrestrial biosphere, giving rise to anthropogenic biomes, also known as anthropomes. This study examines the dynamics of urban land use and land cover changes in Srinagar, a city situated in the valley of the Jammu and Kashmir hill state. Through a comprehensive change detection analysis spanning a 30-year period, the study investigates the nature, extent, and rate of land use/cover changes and transformations within the region. The findings reveal substantial city expansion, resulting in non-built-up land depletion. Notably, the study observes not only the expansion of the city's boundaries but also substantial interchanges of land among different land use/cover categories across the study area.

Fan *et al.,* (2007) explained Land use and land cover change which hold significant importance within global environmental change, especially in rapidly developing regions around the world. Guangzhou, a prominent metropolis in South China, has witnessed a significant transformation in land use and land cover (LULC) over the past three decades due to economic development, population growth, and urbanization. Rapid LULC changes have led to ecosystem degradation and adverse environmental impacts. It is crucial to monitor these changes and analyze their consequences to provide policymakers with valuable information to support sustainable development. This study utilized two Landsat TM/ETM images captured during the dry season to detect LULC patterns in 1998 and 2003. It also examined the changes during this five-year period. Detailed analyses, employing the post-classification method, were conducted to determine the type, rate, and spatial patterns of LULC changes in five counties within Guangzhou Municipality. LULC conversion matrices were generated for each county to investigate and elucidate urban expansion and cropland loss. These were identified as the most prominent LULC change types. Furthermore, the study examined the specific land use conversion matrices for each county, shedding light on the underlying dynamics of land use change. The results revealed a consistent and steady rate of urban expansion across the five counties. In contrast, a substantial decline in cropland area was observed during the study period. Notably, there was a significant conversion between cropland and orchard land, with forest areas being the primary source of new croplands.

Pabis (2007) has shown that there is a changing land cover in Ghana which is mainly due to the agriculture and cropping pattern in the study area. Studies have been taken out through GIS techniques to understand the rate of the changing of land in the study area.

Prakesh, *et al.,* (2007) documented a viable methodology for deciding alternative land use options in a watershed of river Chintapatla, Andhra Pradesh. Considering the existing land use land cover, soils, slope and geomorphology, development plan for agriculture in the watershed was worked out. The works, unlike many others, adopted the methodology in which assessment of soil and water degradation came first and was then followed by planning of alternative land use practices. This new approach was found to be very useful as it first considers the evaluation of degradation factors. It take into consideration that the plan for new land use practices could fairly reduce further degradation to land and water resources. Furthermore, the land use plan would result not only in agricultural development but also menace degradation problems without incurring extra-cost for management of resource degradation.

According to Turner *et al.,* (2007), the various land use changes are viewed as interconnected. Many of the ecological consequences associated with land use changes reflect interactive effects resulting from different land use changes. For example, deforestation has negatively affected freshwater habitat through siltation of rivers, which results in the degradation of freshwater habitat. A similar dynamic exists in the role of the Asian forest as a carbon sink and source due to the interactive effects between deforestation, afforestation, and reforestation. It is therefore important to understand how different land uses interact in relation to each other on their change trajectories in order to gain a better understanding of the land use change issue. Human environmental sciences face a research challenge by examining how changes in land and ecosystems affect global environmental change and sustainability.

Bhatti and Conway (2008) examined the effects of socio-economic and demographic factors on land use and forest cover dynamics in the Bara district of the Central Tarai region in Nepal using remotely sensed data. The studies suggested that there has been an attempt to convert hitherto non-agricultural land to agricultural land and the image analysis inferred a rapid increase in the number of farm plantations. These tree plantations on farmland are a way to diversify household activities to minimize financial risks in the monsoon dependent farming system and also the favourable actions with high potentiality for their development. Their findings suggested that land use dynamics have been influenced by several factors, including economic incentives for farm plantation, shortages of farm labour and environmental awareness in response to loss of forests cover.

Using Landsat images, Ololade *et al.,* (2008) conducted a land use land cover mapping study and detected changes in the Rustenburg Mining Region using remote sensed data, Landsat MSS 1973 (4 bands), TM 1989, 1997, 1998 (6 bands) and ETM 2002 (6 bands) were used as reference base maps of the region. A supervised classification was conducted using the maximum likelihood method. Data collected from satellites and field surveys were used to identify land-use classes, including woodlands, grassland, cultivated land, bare soil, rivers, dams, water ponds, built-up areas, tailing dams, and opencast mines. The expansion of the built-up area can be attributed to the expansion of the transportation network and the migration of mine workers into the area which contributed to the development of settlements over time. Consequently, the landscape became highly disturbed due to increased mining and agricultural activities.

Hood and Bayley (2008) examined the influence of temperature, precipitation, and beaver activity on open water areas in wetlands. It was conducted over a 54-year period in east-central Alberta, Canada. The findings revealed that beavers had a significant impact on maintaining open water areas, explaining over 80% of the variability observed. Climate variables played a lesser role in comparison. Furthermore, beavers resulted in a nine-fold increase in open water area during wet and dry years. These results highlight the crucial role of beavers in wetland preservation, particularly in extreme drought conditions. Given the drying climate and the significance of wetlands, beavers removal should be considered a disturbance to be avoided.

A detailed study was conducted on Edward *et al.,* (2009) work on open pit gold mining and land use changes in the Bogosu-Prestea area, south west Ghana. During the period 1986 - 2006, Golden Star Resources Bogoso Prestea Limited (GSRBPL) conducted an analysis of land use change due to mining operations. It was found that mining in the area increased by 12.1% in land over from 1986 to 2006, whereas agricultural land use decreased from 97.8% to 82.7%. A rural-to-urban migration resulted in an increase of settlements from 0.45 % in 1986 to 4.95 % in 2006.

Kuemmerle (2009) observed that cropland in Arges County in Romania was being converted to grassland as a result of rapid socio-economic, demographic, and institutional changes after 1989. According to Kebrom Tekle and Hedlund (2000), open areas and settlements grew at the expense of shrub lands and forests in Kalu District between 1958 and 1986. A similar increase in homesteads has also been reported by Woien (1995) in studies conducted in the central highlands between 1957 and 1986.

Anil (2010) examined the impact of open cast coal mines in Chandrapur district on the land use and land cover of the district using remote sensing and geographical information systems. A land use/land cover map of the area was prepared using multi-temporal satellite data (IRS-P5 data of 2009 and 2010 and LANDSAT-5 data of 1990), which showed an increase of 67% in mined land.

Kumar (2010) through his case study of Tuichhuahhen watershed, Mizoram, has made an attempt to highlight the significance of watershed as a planning unit especially in hilly terrain where mobility of people, commodity and resource utilization are controlled and directed by the topographical attributes. He has also highlighted that the advantage of planning at watershed level lies in the fact that hierarchic system of smaller basins fits exactly in the next larger basin and care has to be taken to safeguard the interest of the people living down-stream. Furthermore, he has stated that watershed management strategies are eco-friendly. He adds that labour intensive strategies involving primarily local manpower, available technology and resources provide better chances of success. It envisages involvement and active participation of local communities in resource management hence evolution of development plans from the grassroots level.

Lalchamreia and Pachuau (2010) in their work, "Land use/cover change in Tuichhuahhen Watershed, Kolasib District of Mizoram" highlighted the rate of changes within twenty years which elucidate that the increase in population and occupation activities adjusts and alters LULCC.

LIU and XIA (2010) focused the advantages and limitations of object-oriented classification compared to pixel-based classification in remote sensing image analysis. The study introduces an innovative measure to quantify the negative impact of under-segmentation errors on object-specific classification accuracy. By examining multiple segmentation scales, the research reveals that segmentation accuracy declines as the scale increases. This is associated with significant negative impacts observed at larger scales. The study also highlights the trade-off between object-based classification advantages and limitations, emphasizing that overall effectiveness are determined by this trade-off and depend on the chosen segmentation scale. The findings, based on analysis of a QuickBird satellite image, contribute to a better understanding of the potential benefits and constraints of object-specific classification techniques.

Mark and Kudakwashe (2010) observed an increase in cropland in Shurugwi district, in the Midlands Province of Zimbabwe. The study attributed the increase to the Land Reform and Resettlement Program. A variety of farm activities were carried out by clearing forests for new farming plots, wood for fuel, poles for the construction of homes and cattle pens, among others. Begum *et al.,* (2010) also observed that over the past 40 years, Davangere city, Karnataka, India's built-up area has almost doubled, at the expense of the agriculture and scrub lands around the water bodies.

Myint *et al.,* (2010) in their work, “Patterns and rates of Land Use Land Cover Change: A Case Study ofAmbosNogaes (Arizona and Sonora) 1985-2004” studied land degradation, deforestion and urban growth results in the land use land cover change in the study area.

According to Prakasam (2010), major changes have been observed in land use and land cover in Kodaikanal Taluk in Tamil Nadu. The area under built-up and harvested land has increased, whereas the area under forest and water bodies has decreased. Javed and Khan (2012) examined the land use and land cover changes resulting from mining activities from 2001 to 2010. According to the study, significant decreases in dense forest area, cultivated land, and water bodies have been observed. However, settlement, wasteland land, and uncultivated land have been on the rise due mainly to human activity.

Su *et al.,* (2010) introduced an innovative supervised classification method for synthetic aperture radar (SAR) images, incorporating multiscale region connection calculus (RCC) and conditional random fields (CRF). The proposed approach begins by oversegmenting the SAR image into multisuperpixels through an image pyramid. Spatial logic relationships among these superpixels are then described using the multiscale RCC model. To achieve accurate classification results, the method employs CRF reasoning, learning and reasoning over multiscale RCC relationships. Notably, an iteration strategy is applied to CRF reasoning to enhance classification detail. Experimental validation on DLR ESAR images demonstrates the efficiency and effectiveness of the proposed approach, yielding promising results.

Wang *et al.,* (2010) explored the impact of the physical environment, man-made pollution, and nutrition on human health and disease occurrences. To understand the spatial distribution of disease determinants, the study proposes four geographical detectors: the risk detector identifies areas of high risk, the factor detector identifies the responsible factors, the ecological detector assesses their relative importance, and the interaction detector examines their interactions. The study focuses on neural tube defects (NTD) in the Heshun region of China and finds that the primary physical environment, including watershed, lithozone, and soil, strongly influences NTD occurrences. Basic nutrition was found to be more critical than man-made pollution in controlling spatial NTD patterns. Moreover, ancient materials released from geological faults and spread along slopes significantly increased NTD risk. These findings provide valuable insights into developing disease intervention strategies in the region.

Ellis (2011) observed that human populations have radically transformed most of the terrestrial biosphere into an anthropogenic biome as a result of their use of land. Throughout the last 8000 years, this kind of transformation has led to the emergence of a variety of new ecological patterns and processes.

Ingle and Kaul (2012) conducted a study in the Jalgaon District in which a land cover mapping and monitoring was conducted in order to preserve natural resources and to understand the causes and consequences of the overexploitation of soil and water resources. Based on satellite images taken in March and November 2007, Land Use Land Cover (LULC) and supervised classifications were computed. The LULC classification consisted of seven classes. An accuracy assessment was conducted using a classification error matrix and KAPPA analysis. All land cover and land use classes were analyzed for the detection of changes between the two images.

Magesh and Ch (2012) introduced an automated extraction tool developed in the ArcGIS environment using the model builder technique to delineate basin morphometry. With SRTM data and a pour point shapefile as inputs, the tool processes the data and generates essential parameters for morphometric analysis. These parameters include stream network (Strahler's method), aspect, slope, DEM, drainage density, hill shade, and basin boundary measured in square meters. Users can specify the minimum upstream area for stream delineation, allowing customization. The tool's simplicity and efficiency make it valuable for professionals in terrain analysis, hydrology, and watershed analysis, as it enables the generation of a reliable morphometric database with a single click.

Like the studies conducted on land use land cover by the scholars worldwide, Sati, VP also conducted numerous studies on various aspects of land use land cover, cropping patterns, climate change impact on agriculture, food security, and on shifting and permanent agriculture in the Himalayan region in general and in Mizoram in particular. He conducted studies on agriculture and land use in the Himalayan region (2012, 2014, 2014, 2016, 2017, 2017, 2018, 2018, 2019, and 2023). Further, studies on various issues of agriculture, food security, and land use land cover change in the state of Mizoram by him (2014, 2015, 2015, 2015, 2016, 2017, 2017, 2017, 2017, 2017, 2018, 2019, 2019, 2019, 2020, 2020, 2021, 2022, 2022, and 2022).

According to Al-Doski *et al.*, (2013) image classification is a crucial process in remote sensing for producing accurate Land Use and Land Cover (LULC) maps. It involves categorizing pixels in an image based on their spectral characteristics. The process includes preprocessing, feature extraction, training data collection, classifier selection, and classification with accuracy assessment. Two common techniques used in image classification are the K-means Classifier and Support Vector Machine (SVM). The K-means Classifier is an unsupervised clustering algorithm that assigns pixels to clusters based on spectral values, while SVM is a supervised learning algorithm that finds an optimal hyperplane to separate different classes. These techniques contribute to the effective management of remote sensing data and the production of reliable LULC maps for various applications.

According to Hussain *et al.,* (2013), Lu *et al.,* (2004), and Chen *et al.,* (2012), different change detection techniques have been developed and reviewed in the past few decades, and they are roughly divided into two categories: pixel-based and object-based methods. A pixel based approach to change detection involves examining the difference in spectral response between pixels in the same area, but from different times, to detect a change. The object-based mode of change detection is based on the comparison of objects at different times in order to detect changes. These image objects are grouped pixels that represent objects in the real world, such as vegetation of buildings.

A study conducted by Lallianthanga and Lalbiakmawia (2013) examined the landslide hazard zone (LHZ) of Serchhip town using high resolution satellite data. By using remote sensing data and geographic information systems (GIS), various thematic layers were generated, including slope morphometry, geological structures such as faults and lineaments, lithology, geomorphology, and land use land cover. Based on the relative importance of different causative factors, weightage rating systems are applied to the different classes of thematic layers.

Tamouk *et al.,* (2013) analyzed the most accurate land cover classification method among parallel piped, minimum distance, and chain methods. The study also explores band combination optimization to improve classification results. The chain method outperforms the others with an overall accuracy of 79%, surpassing the minimum distance (67%) and parallelepiped (65%) methods. Additionally, the research identifies band 4 (from Landsat 5TM's seven bands) as highly effective in enhancing the accuracy of combined bands for land cover detection. These findings hold significant implications for land management and environmental monitoring. They enable informed decision-making and effective conservation strategies to safeguard valuable land resources.

Seitinthang (2014) conducted a study on The North Eastern Region of India, characterized by diverse agro-climatic conditions and irregular physical features, was once a major contributor to the country's food production. However, it has now faced a decline in agricultural productivity and started importing agricultural products from other parts of the country. The region predominantly practices shifting cultivation and settled agriculture, with rice and maize being the primary crops. With a significant portion of the population relying on agriculture, the study focuses on analyzing the changing cropping patterns in the region based on secondary data sources.

Showqi *et al.*, (2014) conducted a research in Jhelum Basin, in which through the use of Remote Sensing technology land use land cover change was detected. The analysis of the changing data, different LULC types was observed. They found out that there is a numerous decrease in the forest cover over the past 13 years.

Jamir (2015) conducted a study on northeast India. His analysis indicates that annual forest cover has been decreasing in Nagaland and Manipur, but increasing in six other states. Various forest cover data, such as dense, open, scrubs, and non-forestlands, were collected and analyzed to determine the causal factor. Unlike shifting cultivation, population growth is positively correlated with forest cover and urbanization. Furthermore, monsoon rainfall and temperature variables decreased significantly, reflecting change in land cover and land use.

Mwaniki (2015) aimed to overcome challenges in geological mapping caused by vegetation cover. It also identified suitable bands for geospatial applications in a study area with both semi-arid and highland characteristics. Landsat 7 (ETM+, 2000) and Landsat 8 (OLI, 2014) data were compared to determine the optimal bands for geological mapping. The methodology involved principal component and factor loading analysis, IHS transformation, decorrelation stretch, band rationing, and knowledge-based classification. The results showed that band combinations (5, 7, 3) for Landsat 7 and (6, 7, 4) for Landsat 8 exhibited the highest contrast and were enhanced by decorrelation stretch. Band ratios (3/2, 5/1, 7/3) for Landsat 7 and (4/3, 6/2, 7/4) for Landsat 8 provided improved contrast for geospatial information and were used as input data for knowledge-based classification. Linear visualization was achieved through IHS transformation and a saturation band combination. The results were compared to existing geological maps, demonstrating their superiority and potential for updating existing geological maps.

Rawat and Kumar (2015) demonstrated the efficacy of digital change detection techniques using multi-temporal satellite imagery to analyze the spatio-temporal dynamics of land use/cover in the Hawalbagh block, Almora district, Uttarakhand, India. Landsat Thematic Mapper (TM) images from 1990 and 2010 were employed for a 20-year analysis, applying supervised classification with the maximum likelihood technique in ERDAS 9.3 Software to categorize the study area into vegetation, agriculture, barren land, built-up areas, and water bodies. The findings indicate a substantial increase in vegetation and built-up land by 3.51% (9.39 km2) and 3.55% (9.48 km2), respectively, while agriculture, barren land, and water bodies experienced reductions by 1.52% (4.06 km2), 5.46% (14.59 km2), and 0.08% (0.22 km2), respectively. This study emphasizes the significance of digital change detection techniques in revealing the nature and location of changes in the Hawalbagh block's landscape over time.

Tilahun and Teferie (2015) assessed the accuracy of land use and land cover classification in Kilite Awulalo, Tigray State, Ethiopia, for 2014, using Google Earth and Landsat-8 OLI_TIRS imagery. The supervised classification scheme categorizes various land use and land cover types. These include Agriculture land, Settlement land, Grazing land, Forest land, Bush land, Water bodies, and Bare/stone land. After classification, 100 random points are generated in ArcGIS and converted to KML for verification in Google Earth. The overall accuracy of the classification is 82%, with a Kappa (K) accuracy of 77.02%, indicating an acceptable level of accuracy for the study.

Hassan *et al*., (2016) aimed to evaluate land use and land cover changes in Islamabad city and its surroundings from 1992 to 2012 using geospatial techniques such as remote sensing and GIS. The analysis revealed an increase in agricultural, built-up, and water areas, while forested and barren areas experienced a decline. Economic development, climate change, and population growth were identified as the driving forces behind these changes, with rapid urbanization and deforestation leading to environmental impacts and habitat degradation.

Laldintluanga *et al.,* (2016) conducted a study where water quality is a critical aspect of sustaining various uses and processes, but it is under stress globally. Access to clean water is crucial for human health and the environment. A study conducted in rural areas of Mizoram State, India, examined water samples from three districts to assess water quality. The study focused on physical parameters, inorganic or chemical factors, and toxic metals present in the water sources. It was found that while the pH value of spring water was within the acceptable range, the reservoir water had a pH value below the permissible limits. The research highlights the importance of addressing water quality issues and their impact on public health and the environment.

Pattanayak and Diwakar(2016) highlighted that understanding of the changing land use/cover change can be done through Digital change detection. Using Remote Sensing technology, studies has taken out in Delhi, aiming to detect the rates of deforestation, urban sprawl and other.

Wubie *et al.,* (2016) conducted a survey in the Gumara watershed of Lake Tana basin, Northwestern Ethiopia, and aimed to investigate land use/cover changes over 48 years. It also investigated their underlying factors. The research utilized aerial photographs from 1957 and 1985, as well as a multispectral Spot5 image from 2005, to generate GIS-based land cover maps. Socio-economic surveys, focus group discussions, and field observations were also employed to understand the drivers and consequences of these changes. The findings revealed a significant expansion of cultivated and settlement land, along with substantial declines in forest, shrub, grassland, and wetland areas. Population pressure, resource demands, agricultural expansion, and policy and tenure insecurity were identified as the primary driving forces behind land use/cover changes. Consequently, these changes have led to environmental degradation, soil and biodiversity loss, and forest cover decline, resulting in poverty and environmental challenges. To mitigate these issues, the study suggests implementing strategies that involve local participation in resource management and adopting appropriate land use planning. This will ensure sustainable land management and conservation efforts.

According to Elhag (2017) remote sensing practices, utilizing satellite data such as Landsat OLI-8, present extensive possibilities for generating reliable information. In this particular study conducted in Greece, Landsat OLI-8 data acquired over summer 2013 in the Halkidiki peninsula were examined. This was done to assess their effectiveness in classifying different natural resource categories based on spectral band combinations. Statistical calculations were performed to evaluate the spectrum information contained in each channel. This established a foundation for the classification of the study area's designated regions. Among the spectral band combinations analyzed (4-5-6/ 3-4-5/ 3-4-5-6/ 4-5-6-7), those yielding the highest overall accuracy for forest classification were identified, ranging from 7.85% to 96.29%. Notably, the combination of spectral bands 3-4-5-6-7 achieved the highest overall accuracy of 98.15%. Conversely, the 4-6 spectral band combination yielded the poorest results at 68.52%. Although individual spectral band 6 exhibited the most effective performance, the combination of bands 5 and 6 proved most effective for classifying each category.

According to Uttam *et al.*, (2018) human activity is undeniably driving a climate crisis globally, affecting all land uses and posing a threat to health, security, and livelihoods, particularly for marginalized communities. In Mizoram, a state in India, forests are being impacted by climate change, leading to changes in ecosystem services due to temperature increases and irregular rainfall patterns. This study examines the effects of climate change on Mizoram's forests and proposes adaptive strategies to mitigate risks. The research highlights rising temperatures, changing rainfall patterns, decreasing forest cover, and the perceived impact on health, environment, and income. It emphasizes the need to incorporate traditional forest management practices, local knowledge, and adaptive co-management strategies to ensure sustainable forest management under changing climatic conditions. While more research is needed, action must be taken promptly to address the urgent challenges posed by climate change.

Quintero-Gallego *et al.,* (2018) investigated Land Use and Cover Changes (LUCC) and their main drivers in the Andean mountains, focusing on a rural area in Quindío, Colombia, from 1954 to 2009. Aerial photographs and GIS were used to create LUCC maps, and driver information was collected systematically. The study found that pastureland dominated the area with over 60% coverage throughout. Secondary and mixed forests experienced significant contraction, declining from 23% to 9% of the total area. Secondary forests were particularly affected, losing 86% of their initial area due to deforestation and transformation processes, while crops expanded by 410%. Socio-economic factors, such as livestock farming, agriculture, and market prices, were identified as significant drivers of landscape modification. The findings emphasize the importance of understanding LUCC and their drivers to inform sustainable land management policies in the Andean region.

Belay and Mengistu (2019) examined the land use/land cover changes in the Muga watershed of the Upper Blue Nile basin over the past three decades (1985-2017) and their implications for the surrounding environment. Using a combination of Landsat imagery, household surveys, focus group discussions, key informant interviews, and field observations, the research aims to detect and analyze the magnitude, pattern, and drivers of these changes. The results indicate a notable increase in cultivated land and urban areas by 12% and 270%, respectively. In contrast, grasslands, forest lands, and shrub-bushlands show declining trends of 40%, 21%, and 12%. Socio-economic factors, including population growth, land tenure policy, and climate variability, alongside activities such as tree cutting for fuelwood and construction, were identified as influential drivers of land use/land cover changes. The study underscores the urgent need for alternative income sources for youths and landless peasants. It emphasizes the significance of integrated watershed management in mitigating the adverse effects of land use/land cover changes. It also safeguards the Muga watershed's natural resources.

Birhanu *et al.,* (2019) conducted a study in the Northwestern Highlands of Ethiopia and utilized satellite imagery and topographic data to map land use and land cover changes from 1986 to 2017. The findings revealed a significant increase in agricultural land, which accounted for 93.3% of the total area in 2017, compared to 85.4% in 1986. The study also observed a decrease in forested, grazing, and shrubland areas. The changes predominantly occurred in areas with slopes between 0 and 30°. This research provides valuable insights for regional managers and planners and contributes to the understanding of topographic influences on land use/land cover changes in the region.

Hu and Hu (2019) addressed the scarcity of research on land changes and driving mechanisms in ecologically sensitive Central Asia. Utilizing Google Earth Engine, Landsat satellite imagery, and the random forest algorithm, the research conducted land classification and obtained annual land cover datasets from 2001 to 2017. The results indicate reliable and highly accurate land datasets, with an overall accuracy of 0.90 ± 0.01. Grassland and bare land emerge as the dominant land cover types, with bare land decreasing by 2.6% over the 17-year period. Conversely, natural vegetation (grassland, forest, and scrubland), cultivated land, water bodies, and wetlands show increasing trends at different rates. The study identifies precipitation and drought as key drivers of natural vegetation changes. In contrast, the patterns of cultivation are influenced by precipitation and anthropogenic factors. Expanding urban regions are driven by increasing urban populations and industrial development. The research highlights methodological advantages and uncertainties in land mapping and change detection and discusses driving mechanisms complexity.

Marchang (2019) examined the transition of livelihood systems among Scheduled Tribes (STs) in the North Eastern Region, moving away from agriculture-based to non-agriculture-based livelihoods. While agriculture remains significant, non-agricultural households are increasing in rural areas and rapidly growing in urban regions. Agricultural employment has declined, particularly among cultivators, while non-agricultural employment has improved, driven by development and education. The study demonstrates the convergence of STs' livelihoods from subsistence agriculture to diverse modern market-oriented employment and economy. This shift is evident through the decline of agricultural households and income, coupled with the rise of other -agricultural households and income, as well as the transition of employment from farming to non-agricultural activities.

Peng *et al.,* (2019) highlighted the importance of the Normalized Difference Vegetation Index (NDVI) for understanding ground surface processes and climatic changes. Using the Geographical Detector, a spatial statistical approach, the research quantifies the individual and interactive influences of natural factors on NDVI changes in Sichuan province. The findings indicate that regions with high vegetation cover increased significantly, while areas with medium vegetation cover decreased. Spatial and temporal variations in vegetation cover were observed, with high vegetation cover concentrated in the northeast part of the Sichuan Basin and northwestern Sichuan Plateau. Natural factors such as soil type, elevation, and annual mean temperature were identified as key drivers of vegetation changes. The interactive influence of natural factors showed mutual and nonlinear enhancement, amplifying individual factors' effects on NDVI changes. The study emphasizes the importance of considering natural factors' synergistic effects in managing and adapting to vegetation changes in the region.

Phiri *et al.,* (2019) investigated the factors driving long-term land cover change (LCC) in Zambia over 44 years (1972-2016). Using remotely-sensing imagery and a classification tree approach, two analyses were conducted to identify factors influencing overall LCC and changes from forests to other land covers, and reversion to forests from non-forested areas. The study revealed that the major factors driving LCC were the percentage of area under agriculture, distance to water bodies, change in crop yield, mean temperature, and elevation. Human population density, crop yield per hectare, and mean crop yield influence forest cover losses, while protection status is crucial for forest reversion and recovery. The findings provide valuable insights for developing effective policies to mitigate the negative impacts of LCC and promote forest reversion and recovery through protected area management. The study's results can also help predict and understand future LCC scenarios.

Alijani *et al.,* (2020) examined the changes in land use in Chalous, Iran, driven by the increasing global population. It also examines its significance for environmental studies and land use management decision-making. By utilizing multi-temporal satellite images, Geographic Information Systems (GIS), and semi-structured interviews, the research quantifies land use/cover changes over a 20-year period (1996-2016) and identifies the geophysical and socio-economic drivers behind these changes. The findings reveal a reduction in agricultural land by 11.09% and an increase in built-up areas by 15.89% during the study period. Economic factors and the tourist industry were identified as primary contributors to the shift from agricultural lands to built-up areas, exacerbated by inadequate government and government ministry support. The study underscores the necessity of understanding the complexity of socio-ecological relationships and their interactions with land use change drivers for sustainable planning, development, and policy decisions.

According to Harris *et al.,* (2020) CRU TS v4 is a widely used climate dataset that covers land areas worldwide, except Antarctica, on a 0.5° latitude by 0.5° longitude grid. It has been updated to span the period from 1901 to 2018, incorporating additional station observations and will be updated annually. The interpolation process has been improved using angular-distance weighting (ADW), enhancing traceability and allowing for more informative diagnostics. The revisions in CRU TS v4 provide users with better insights into dataset quality variations across different geographic regions, while secondary variables have been adjusted to align with the ADW approach.

Li *et al.,* (2020) focused on the critical issue of land use and cover change (LUCC) and its implications for the global environment, climate change, and sustainable development. Using Gansu Province as a case study, the research explores LUCC patterns and driving mechanisms from 1980 to 2018. It predicts future land use and cover in 2030. The integrated LCM model and satellite remote sensing data are used. The results indicate that the LUCC pattern in the second stage (2005 to 2018) was more reasonable due to extensive ecological engineering efforts that protected green lands. Natural factors predominantly influenced LUCC in Gansu from 1980 to 2018, with limited impact from socioeconomic factors due to slow economic development. Landscape indices analysis suggests that land use and cover in 2030, under an ecological protection scenario, will be more favorable than the historical trend scenario. The study offers valuable insights into land use planning and management and presents an innovative methodology reference for LUCC analysis in arid and semiarid regions.

Meer & Mishra (2020) examined Land Use and Land Cover (LULC) changes in the Baramulla district of Kashmir using remote sensing and GIS. The analysis reveals a decline in dense forest and water bodies, leading to reduced evapotranspiration and precipitation. Consequently, a shift from agriculture to horticulture is observed. Increased horticulture activities contribute to higher black carbon emissions and warming. The study highlights the socioeconomic and environmental impact of these changes on the region.

Mohamed *et al.,* (2020) examined the impact of the armed conflict and socio-economic crisis in Syria on land use and land cover (LULC) changes from 2010 to 2018. Utilizing remote sensing techniques and Landsat images, the study identifies changes in LULC classes. It observes an increase in bare areas, forests, and urban/peri-urban areas, while rangelands and cultivated areas decrease. The analysis attributes these changes to factors such as population displacement, military operations, and resource control. The study provides valuable quantitative and qualitative information on LULC dynamics in Syria, serving as a framework for further research and supporting planning, management practices, and sustainable development in conflict-affected regions.

In response to the expansion of agriculture and infrastructure, Ritse (2020) proposed a long-term investigation of land modification patterns and their underlying contributory factors. A study has been conducted in Kohima and Dimapur districts of Nagaland, India, to monitor LULC changes and assess the process controls. As a result of rapid urbanization and unplanned development activities in these two districts, which encompass the major urban centers of the hilly state, the city is currently experiencing rapid growth. The occurrence of frequent landslides and flash floods in these districts, similar to other LULC changes that have been observed in unplanned and developing cities, are likely to contribute to environmental degradation in these districts.

Bunyangha *et al.,* (2021) conducted a study which focuses on land use and land cover (LULC) changes in the Mpologoma catchment in Africa, aiming to provide valuable information for sustainable watershed management. Historical analysis and future projections using remote sensing and modeling techniques reveal the conversion of grassland to subsistence farming and built-up areas, with a decline in grassland, woodland, and wetland. Farmland and built-up areas have expanded, and projections indicate further decreases in natural cover and increases in built-up and commercial farming. Subsistence farming is expected to remain the dominant land use. These findings emphasize the intensifying land use pressure in the catchment and support land use planners, environmentalists, and policymakers in developing effective management strategies.

Chen *et al*., (2021) highlighted that research on the changes of the spatial and temporal characteristics of land-use landscape patterns can deeply insight the movement of the Earth's surface by human activities, natural factors, and biological factors in time and space. It also highlighted the importance of the land for the survival of mankind.

Ewunetu *et al., (*2021) conducted a study in the north Gojjam sub-basin of the Upper Blue Nile River utilized GIS, remote sensing, and multicriteria analysis to map and quantify land degradation. The findings reveal that significant portions of the area experience high soil loss risk, moderate to high biological degradation, and moderate physical and chemical degradation. The study emphasizes the importance of addressing soil erosion and biological degradation through integrated land management practices to mitigate land degradation, improve soil organic matter content, and enhance vegetation cover in the sub-basin.

A study conducted by Gondwe (2021) examined Blantyre City using Landsat 7 Enhanced Thematic Mapper (ETM+) images from 1999 and 2010 and Landsat 8

Operational Land Imager (OLI) images from 2019. To classify and map LULC types, an Artificial Neural Network (ANN) was used as a supervised classification method. To determine the accuracy of the classification, the kappa coefficient and the overall accuracy were calculated. LULC changes between 1999 and 2019 were detected using a postclassification comparison approach utilizing classified images.

Shimrah *et al.,* (2021) stated that LULC has a significant impact on forest ecology, biodiversity, and natural resources, which in turn facilitates global environmental change. There is a serious conservation challenge associated with forest fragmentation, which contains interdependent components of forest loss and spatial shift patterns. Forest fragmentation and LULC have experienced significant changes in Northeast India over the last few decades. Forest fragmentation patterns and causes are poorly understood due to a lack of information and data. The study examined the change in LULC and forest fragmentation using satellite data from three different time series: 1991, 2005, and 2020 in the Ukhrul district of Manipur, northeast India.

Lalhmachhuana (2022) Land use land cover (LULC) changes were analyzed in Aizawl district of Mizoram, India for 2006 and 2012 by using Geographical Information Systems (GIS) and remote sensing technology. There are three phases in the methodology: Pre field, Field and Post-field works. The study area was classified into fifteen categories as per the NRSC norms. The comparison of LULC in 2006 and 2012 derived from toposheets and satellite imagery interpretation indicates that there is an increase in builtup area, agriculture, forest and wasteland. It is also noted that substantial amount of shifting cultivation areas decrease during the period of study which may be due to introduction of permanent cultivation by the government. The overall trend shows that due to the decrease in shifting cultivation area, forest area tends to increase. A little bit increase or decrease in other classes does not have much effect in LULC change pattern.

According to Singh and Niranjan (2023), the LULC mapping for Lakhimpur district was conducted using Landsat data for a period of 1998 and 2020. Two land use and land cover maps have been prepared with the aid of ERDAS IMAGIN and Arc GIS software after classification of a satellite image has been obtained using the Iso cluster unsupervised classification method. LULC has been classified into six groups, such as agricultural land, forest land, sand bars, settlements, sparse vegetation and water bodies, and the analysis showed both positive and negative changes.

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Chapter 3

Geographical Background and Socio-economic Profile

3.1 Geographical Background

3.1.1 Location and Extension

Serchhip District extends between 23°35’N and 23°00’N latitude and between 92°41’E and 93°10’E longitude (Figure 3.1). It is located in the central part of the state, extending more towards the east. This district is bordered on three sides by Aizawl district in the north and northwest, Lunglei district in the south, Khawzawl and Champhai district in the east. The district also shares a few lengths of border with Myanmar in its south-eastern region. Geographically, it covers an area of 1421 sq.km, and accounts for 6.74% of the total area of the state. Based on the relief, drainage, lithology, and structural characteristics, it has been classified as Moderate linear ridges, Moderate hills and Valley fills (GWIB, Serchhip District). Almost the entire district is occupied by moderate linear ridges with the exception of very limited areas in the southeast and areas of valley fill in the south. There are numerous valleys forming a 'v' shape which divides the hills. There is a great deal of variation in the relief and a moderate degree of steepness to the slopes. Located in the southeast of the district are moderate hills, which differ from moderate linear ridges by not being linear in a definite direction (Figure 3.2). The average elevation is between 500 to 1880 meters above Mean Sea Level (Figure 3.4) (ICAR, 2015).

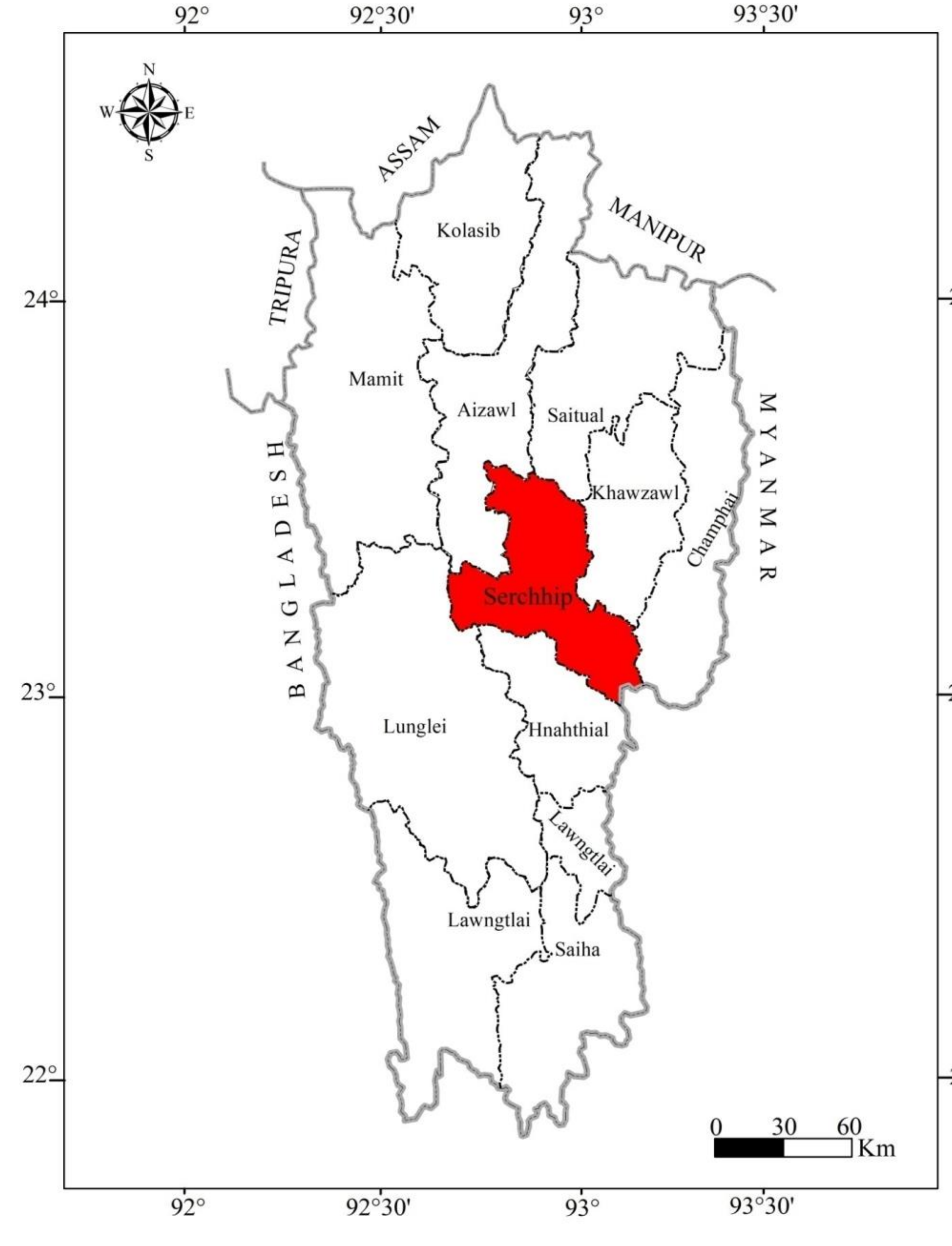

Fig. 3.1: The study area; Source: By author

3.1.2 Physiography

Physiographically, Serchhip District is divided into three broad categories, namely High, Moderate, and Low structural hills, all with elevations above 1000 meters, 500 meters to 1000 meters, and less than 500 meters above mean sea level respectively (MIRSAC, 2006; Rinawma, 2003). Among physiological unit, low structural hill is the highest with 640.65 sq.km which is 45.08% of the total district area, followed by medium structural hill with 568.41 sq.km which is 40%, high structural hill with 169.65 sq.km which is 11.94%, valley fill with 33.61 sq.km which is 2.36% and flop plain with only 8.69 sq.km which is 0.61% of the total area. Considering that high elevated areas are less suitable for occurrence of groundwater, weighting values were assigned to each physiological unit in accordance with this pattern. There are several potential areas for valley fills (Edet, *et al.*, 1998; El-Baz, 1999). The area coverage of different physiological classes is given in Table 3.1 and physiological map of the study area is shown in Figure 3.2. Figure 3.3 shows the panoramic landscape of shifting cultivation.

Table 3.1: Physiography area covered

Physiological Unit	Area (km^2)	%
High Structural Hill	169.65	11.94
Medium Structural Hill	568.41	40.00
Low Structural Hill	640.65	45.08
Valley Fill	33.61	2.36
Flood Plain	8.69	0.61
Total	1421.00	100.00

Source: USGS earthexplorer

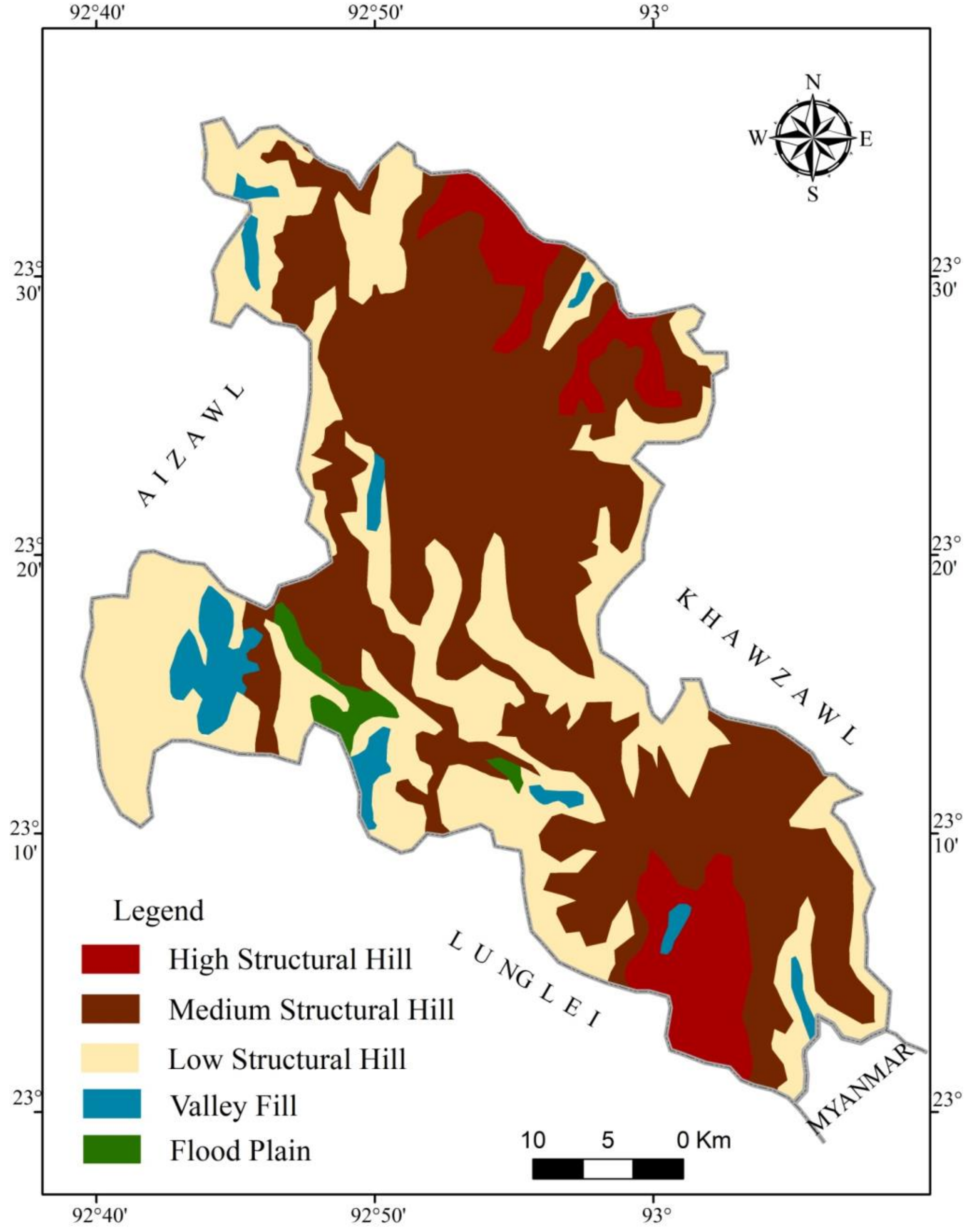

Fig. 3.2: Physiography Map; Source: USGS, developed by the author

Fig. 3.3: Panoramic landscape of shifting cultivation; Source: By author

3.1.3 Altitudinal Zones

The altitude within the region ranges from 500 to 1880 meters above Mean Sea Level (MSL), as indicated in Figure 3.4 sourced from the ICAR report of 2015. This range signifies a considerable difference in elevation and underscores the topographical diversity present in the area. Notably, the study area exhibits distinct altitude patterns in different parts. The northern and southern regions, in particular, stand out for their high altitudes, particularly near the Myanmar border. These elevated areas may be characterized by rugged terrains, steep slopes, and potentially cooler climatic conditions. Geographic features can significantly influence local ecosystems, including vegetation types, wildlife habitats, and microclimates.

In contrast, the western and southwestern parts of the study area display relatively lower elevation degrees. This suggests gentler slopes and flatter landscapes. The lower altitude in these areas may contribute to different environmental conditions, such as temperature variations, precipitation levels, and soil characteristics. These factors, in turn, influence land use practices, agricultural suitability, and plant and animal species distribution. Furthermore, the information highlights a distinct geographical feature in the study area. This is the nearly flat area situated between

Serchhip and Thenzawl towns. These low-lying terrains provide favorable conditions for wet rice cultivation, indicating their suitability for paddy farming. The availability of flat land in this region likely facilitates irrigation practices, making it conducive to rice cultivation, which often requires sufficient water supply.

In summary, the altitudinal variations within the study area contribute to its diverse landscape and environmental conditions. The presence of higher altitudes in the northern and southern regions, as well as the relatively lower elevations in the western and southwestern parts, shapes the area's ecological characteristics. Additionally, the flat areas between Serchhip and Thenzawl town offer opportunities for wet rice cultivation. Understanding these altitudinal variations is crucial for assessing the region's ecological, agricultural, and socio-economic aspects, and for making informed decisions regarding land use, conservation, and development strategies.

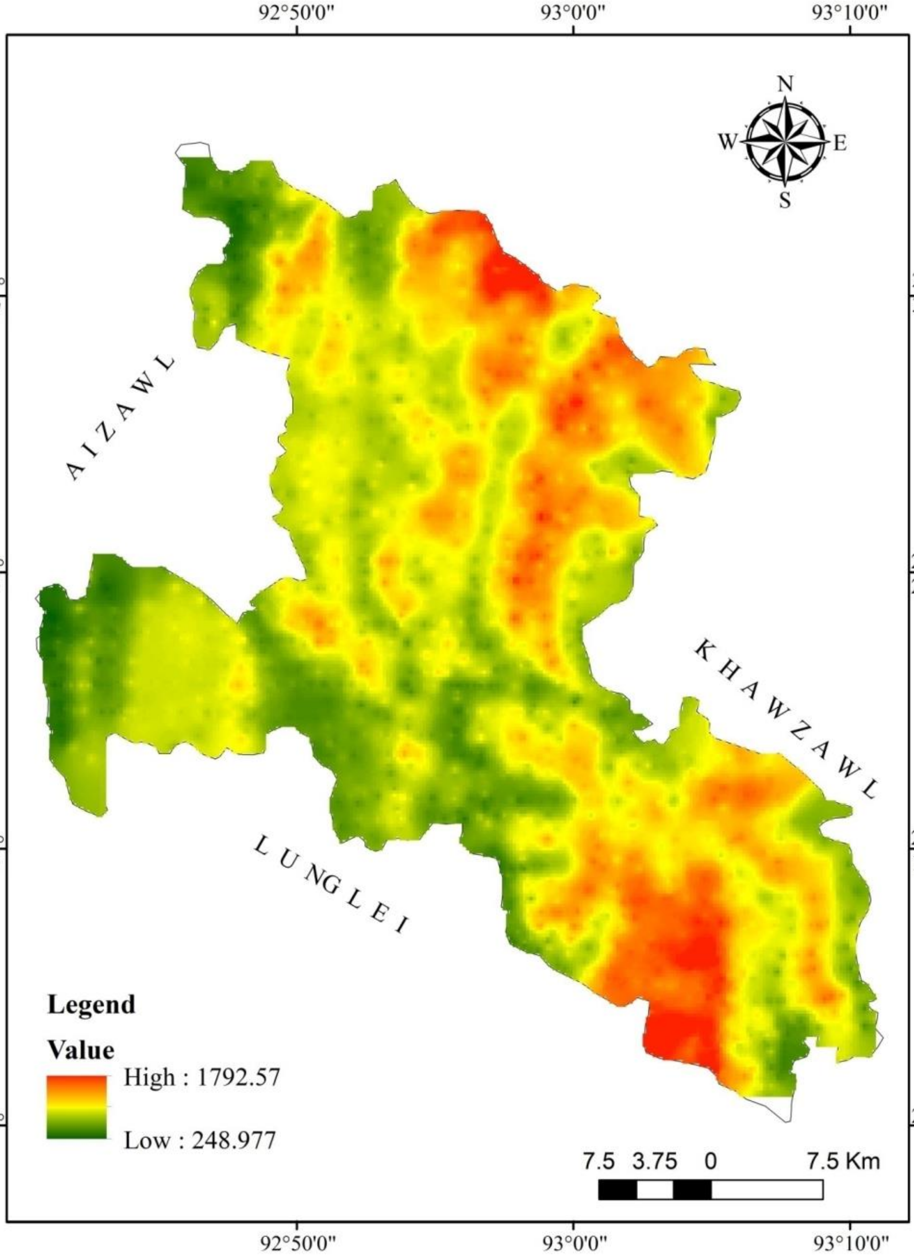

Fig. 3.4: Elevation Map; Source: USGS, developed by the author

3.1.4 Drainage

The district is drained by the Tlawng or Dhaleswari River and the Tuichang River. Serchhip district drainage system was divided into five drainage system that flow through the district, namely Tuipui drainage system, located within Serchhip district. Tuipui drainage system drains only the south-eastern portion of the district. Zawngtah lui, Arsi lui, and lengthuam lui are some of its important tributaries within the district. Zuva lui drainage originates from Lailen mountain near East Lungdar village, which is approximately 1445 meters above mean sea level, and flows southward, parallel to the Tupui river, until it becomes part of Tiau river in the south. A number of smaller tributaries flow into it, the most notable of which are Dilkawn lui, Saisiak lui, Sehung lui, and Mauhak lui. Among the drainage systems in the district, Tuichang I & II is the largest. The river originates from the Darngawn mountain near Khawzawl town at a height of 1449 metres above mean sea level. In the mid-western part of the watershed, Tuikum lui and Tuisang lui are the most important tributaries of Tuichang, while the most important ones in the southern part of the watershed are Varhva lui, Chekawn lui, Tuiphal lui, Maicham lui. Nghalrawh lui, Tuikau lui, Tuiphar lui, Kharzawl lui and Kawlkulh lui are the most important rivers. Mat drainage system originates at a height of 1590 m above mean sea level near Baktawng village in Serchhip district and flows southward until it confluences with Chhimtuipui river in Lunglei district. The river formed a considerable portion of the western boundary of the district with Aizawl district. Within the district, its main tributaries include Hmawngawn lui, Tuicher lui, Lumtui lui, Matvate lui, and Darnam lui. The Tlawng drainage system is one of Mizoram's most important rivers and is the longest river in the state. Flowing northwards, it originates from Zopui mountain, near Lunglei town, at a height of 480 meters above mean sea level. During its course, it passes through five districts of the state, forming district boundary lines in the process. In the south-western part of the district, it formed a boundary between Serchhip and Aizawl districts. Lak lui and Tuihnial lui are important tributaries of Tlawng river before it enters Aizawl district from Serchhip.. The total lengths of perennial streams are 1184.09 km and the total length of non-perennial streams are 5075.66 km. The district does not have any natural ponds or lakes. Parallel and trellis patterns are evident in the major drainage system, a dendritic drainage pattern is predominant, and there is a high degree of dissection (Figure 3.5). Figure 3.6 shows tuichang river which passes near Khawlailung village.

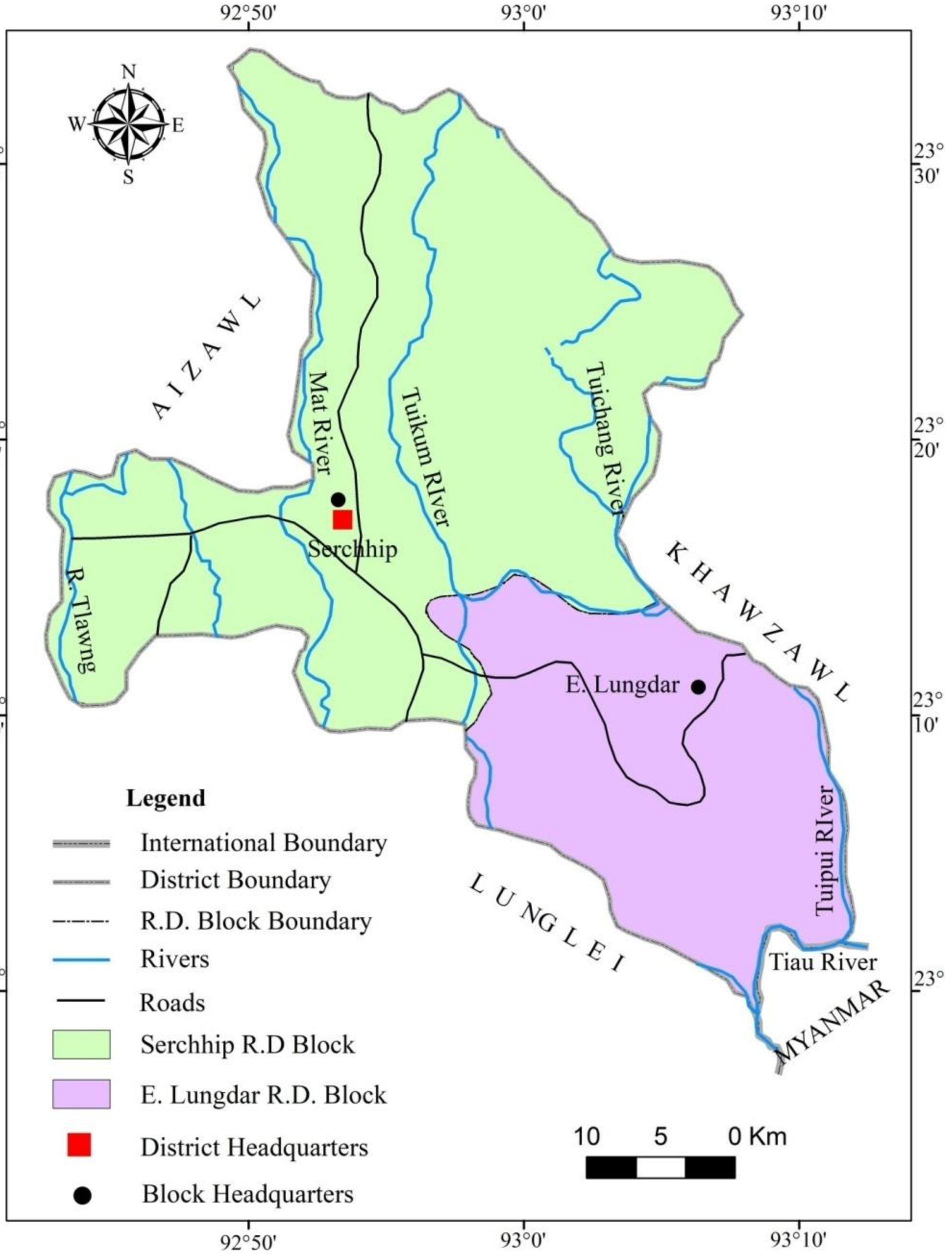

Fig. 3.5: Drainage map; Source: USGS, developed by the author

Fig. 3.6: Tuichang River near Khawlailung village; Source: By author

3.1.5 Climate

Located in the Sub-Tropical Monsoon region, the Serchhip District is influenced by the tropical humid climate with moderate winters and pleasant summers. According to the climate classification by the Department of Environment & Forest, Govt. Mizoram, there are four climate seasons: summer from March to May; rainy season from June to August; autumn from September to October; and winter from November to February (Laldintluanga, *et.al*, 2016; Sati, *et al.*, 2015). Detail descriptions about the climatic conditions of Serchhip such as temperature, rainfall and humidity are given below.

3.1.6 Temperature

The temperature between winter and summer varies between 10^{o} to 28^{o} C (Table 3.2). There is usually a cold and dry winter. Winter temperatures vary between 11^{o} and 13^{o} C in general (INRM, Climate Change Information Portal).

Table 3.2: Temperature data during 2000 to 2018 of Serchhip District

Year	Max (ºC)	Min (ºC)	Average (ºC)
2000	24.9	15.9	22.0
2001	25.4	17.3	22.8
2002	25	16.9	22.5
2003	25.6	16.4	22.4
2004	25.1	16.5	22.4
2005	25.3	17	22.8
2006	25.4	17.7	23.0
2007	25.4	17.2	22.6
2008	25.5	17.2	22.5
2009	25.9	18.3	23.2
2010	25.5	17.1	23.1
2011	25.6	16.2	22.6
2012	25.3	15	22.1
2013	25.4	15.4	22.0
2014	25.3	17.7	22.4
2015	24.9	16.7	22.1
2016	25.2	15	22.6
2017	25.2	17.3	22.4
2018	25.2	15.7	22.0

Source: CRU TS monthly high-resolution gridded multivariate climate dataset

3.1.7 Rainfall

Mizoram generally receives rain from monsoons during the six months of the summer season from May to October. Further in March and April and in November it receives cyclonic rain. Owing to its proximity with the Bay of Bengal the rainfall both monsoonal and cyclonic is heavy. The intensity of rainfall has been markedly influenced by climate disturbances in the Bay of Bengal. Approximately 1688.80 millimeters of rainfall are received annually in the District (Lalzarliana, 2013). Table

3.3 presents annual rainfall data between 2000 and 2017 in which there was an irregularity in the precipitation pattern.

Table 3.3: Annual Rainfall data during 2000 to 2017 in Serchhip District

Year	Annual Rainfall (in mm)
2000	2862
2001	2253
2002	2506
2003	2746
2004	2588
2005	2211
2006	1424.4
2007	2968
2008	1884.4
2009	1493.7
2010	2494.1
2011	1953.2
2012	2163
2013	1952.7
2014	1811
2015	2207.6
2016	1620.6
2017	2292.6

Source: Mizoram State Climate Change Cell

3.1.8 Climatic Zone

Serchhip District is broadly divided into two climatic zones, namely Humid Temperate Sub-Alpine zone and Humid Mild Tropical zone which is shown in Table 3.2 (ICAR, 2015). There was a larger area of the humid temperate alpine zone in the west, northeast, and south-west parts of the district. On the other hand, the humid mild tropical zone is mainly found in the eastern part of the district, with a small portion in the northern part (Figure 3.7).

Fig. 3.7: Agro-climatic map of Serchhip District; Source: USGS, developed by the author

3.1.9 Soils

In the southern portion of the district, valley fills are alluvial and colluvial patches that are unconsolidated and of limited extent. Geologically, the soils in the district are made up of ferruginous sandstone, shale, alluvial and colluvial materials that get transported by rivers and streams (GWIB, Serchhip District). In general, the soil formations have been classified into colluvial soil which is formed along steep side slopes due to accumulation of material on the slope surface, and alluvial soil, which is found in valley fill areas along the river/ stream courses and terraces, is a deep, thick soil which is susceptible to erosion due to its topography (Lallianthanga and Lalbiakmawia, 2013). Rocks are hard, compact, and alternate with soft rock. In Figure 4.7, the geological structure of Serchhip district was depicted, which shows a fault area that was located near Serchhip Town, and this fault zone served as an important geological event. A few of the geological formations that can be found in Serchhp District include the Bokabil formation, the Bhuban formation, and the Barail group.

3.1.10 Geology

The geological structure of Serchhip district can be divided into five parts which are dip, lineament, fault (inferred), Fault (confirmed) and structural trend. A dip can be defined as the maximum angle of slope in a vertical plane measured downwards from a horizontal plane. A dip occurs perpendicular to a strike. It is estimated that dips will range from 20^{o} to 65^{o}, although some local variations may exist below and above this range. A symbol appears on the map to indicate image dips. Lineament can refer to any type of linear structure within or on the surface of the earth that is descriptive and non-genetic. In most cases, it refers to relatively straight or broadly curving lines. Typically, it represents faults or fractures in the strata. There may be a variation in both length and width. A fault (inferred) is a linear feature that is not displaced definitely; however, it is likely to cause faulting and may connect various litho units. Faults (Confirmed) are linear features with displacement that transverse a variety of litho units. This is defined as a fracture in the crust along the plane of which there has been displacement of rock on one side relative to the other. This district is home to the most prominent fault in the state, the Mat fault. Starting from North Mualcheng village in the north-west direction and passing through Keitum village, it extends across Mat River and up to Mamit district for a total length of approximately 45.22 km. Other major faults include the Tuikum lui-Tuichang fault and the Theiva lui fault. Generally, oblique faults follow a NNW-SSE trend. Structural feature consisting of parallel lines that can be precise or circular. The various types of faults can be interpreted as expressions of litho units, parallel fold axes, or fault lines. There is a general trend of NNW-SSE and NNE-SSW in the map, which is represented with symbols.

Figure 3.8, shows that majority of the study area was covered with Bhuban formation, between Serchhip town and Thenzawl town and on the northern part of the district there was a small portion of Bokabil formation and on the southern part of the district a small portion of Barail group was found.

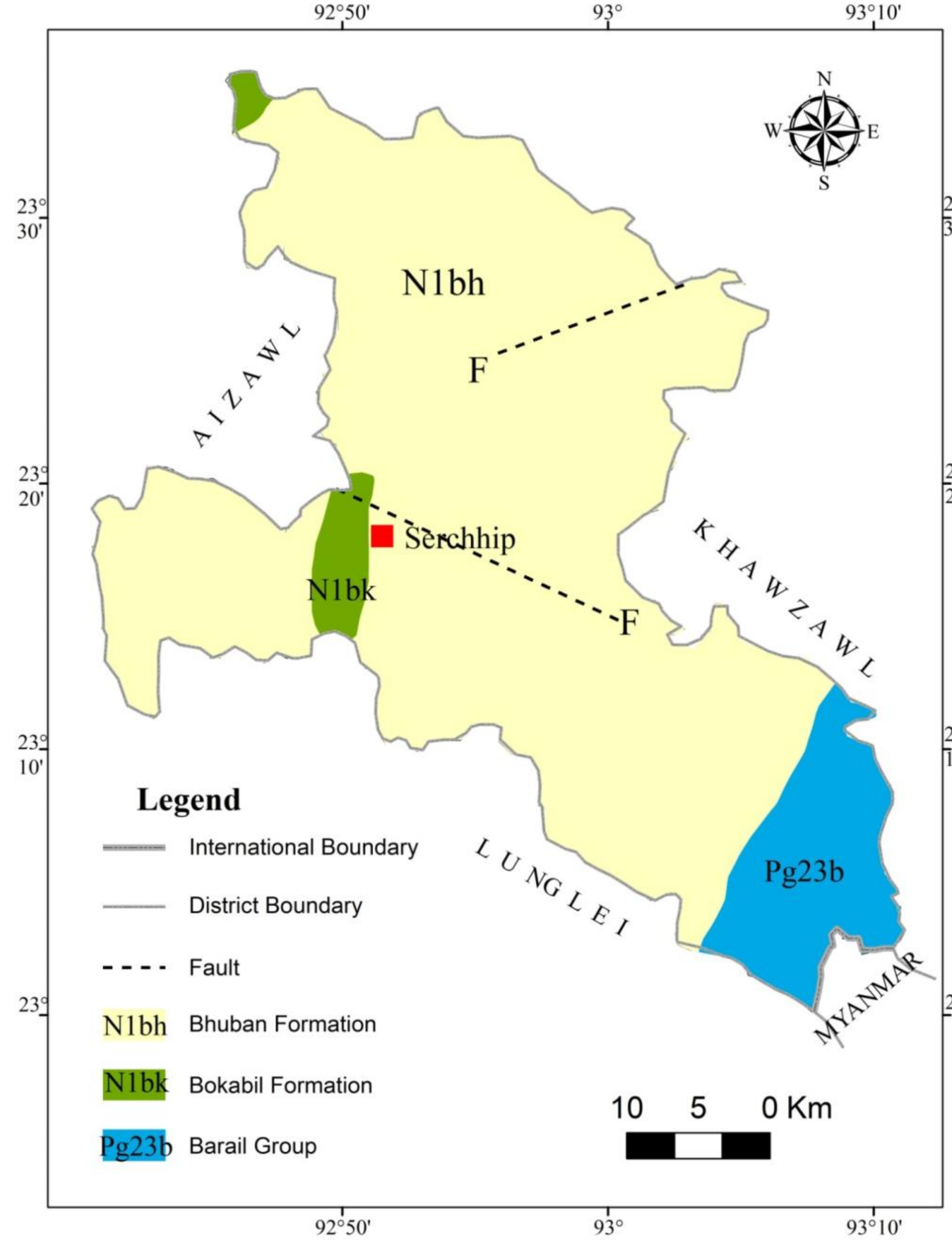

Fig. 3.8: Geological Formation of Serchhip District; Source: USGS, developed by the author

3.1.11 Natural Vegetation

According to the Forest Survey of India's 2019 report, forests are a major natural resource for the people of Serchhip as 81.75 percent of its total area is covered with trees and forests. Upon approval by the Village Council, communities have the right to utilize the land and cultivate in the vicinity of the forest. Table 3.4 shows that 784.07 km^2 of Serchhip's forests fall within open forests (67.5%), 360.70 km^2 (31.1%) within moderately dense forests, and 16.88 km^2 (1.5%) within very dense forests.

Serchhip district forests type are tropical wet evergreen and semi-evergreen forests, montane sub-tropical forests, temperate forests. Forests of tropical evergreen and semi-evergreen species are often found below an altitude of 900 meters and provide a great deal of biodiversity to the State. Generally, these forests are found on steep slopes, along rocky and steady river banks, or in areas not suitable for shifting cultivation. Forests classified as evergreen or semi-evergreen are difficult to differentiate since they occur in areas with similar characteristics. A tropical wet evergreen forest can usually be found in the central and western parts of the study area, whereas semi-evergreen forests can be found in the northern, north-eastern, and central parts of the study area. Most species in this type of forest are evergreen trees with tall trunks. The Cauliflory plant is rather common. There are few epiphytes and parasites. Most species of tree fern, aroid, palm, fern, orchid, bryophyte, and lichen grow in the area. Lianians are prevalent and conspicuous, as are sedges and grasses along the banks of rivers and streams. Musa species are also common along streams and on hilly slopes. A montane sub-tropical forest can typically be found between 900 and 1,500 metres altitude on the eastern fringes of Myanmar's Chin Hills and in cooler areas with little precipitation. Mixed pine forests are characteristic of subtropical vegetation. The common species of these forests are *Castanopsis purpurella Duabanga grandiflora, Myristica, Phoebe goalparensis, Pinus kesiya, Podocarpus neriifolia, Prunus cerasoides, Quercus acutissima, semiserrata, Schima wallichii,* etc. Temperate forests usually occur above the elevation of 1,600m and temperate types of forests are located on the southern part of the district with limited amount. The forests here are not typical temperate forests found elsewhere in the eastern Himalaya. The predominant arboreal elements in the forests are *Pinus kesiya,* *Actinodaphne microptera, Betula alnoides, Exbucklandia populnea, Elaeocarpus serratus, Dillenia pentagya, Michelia doltsopa, M. Champaca, Garcinia anomala, Schisandra neglecta, Photinia intergrifolia, Litsea salicifolia, Myrica esculenta, Lithocarpus dealbata, Rhododendron arboreum,* etc. Figure 3.9 show forest cover of Serchhip district where Dense forest was in a small numbers and located in the northern part, medium dense forest was comparatively higher than the previous one and located on the northern and western part of Serchhip district and lastly open forest was the highest among the three in terms of area where it was distributed all over the study area.

Table 3.4: Forest Cover Area

	Area (in km^2)	%
Open Forest	784.07	67.5
Moderately Dense Forest	360.70	31.1
Dense Forest	16.88	1.5

Source: Forest Survey of India, 2019

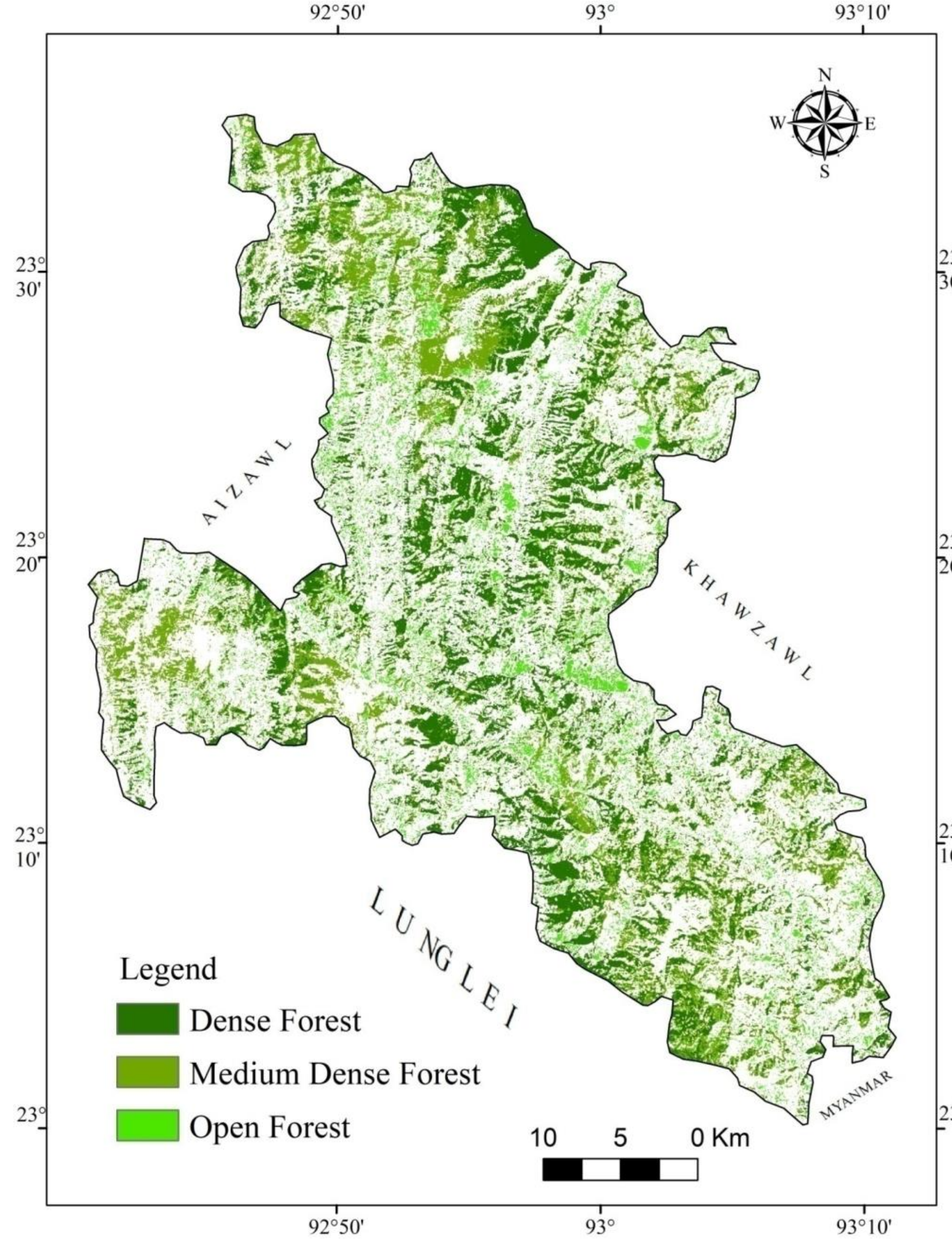

Fig. 3.9: Forest cover map of Serchhip District; Source: USGS, developed by the author

3.2 Socio-economic Profile

3.2.1 Population Structure

According to 2011 census, there are 40 villages and 3 notified towns in the district, two Rural Development Blocks are located within it namely Serchhip and East Lungdar. As shown in table 3.5, Serchhip district has a population of 64,937 out of which 32,851 are males and 32,086 are females with an urban population of 32,019 and a rural population of 32,918. In the period 2001-2011, the rate of decadal growth in population was 20.56 %. The density of the population is 46 persons per km^2. Chhingchhip Village, with a population of 3,741 persons, is the most populous village in this district, whereas Tuichang Village, with a population of 27, is the least populous. The total numbers of workers in this area, including both main and marginal workers are 32397. Serchhip has a total literacy rate of 98.91% with 54,470 total literates. This means that 98.76 out of 100 persons over the age of 6 years are literate. Among the 8 districts of Mizoram and out of the 640 districts of India, it is ranked number one in terms of literacy rate. Among males, the literacy rate of Serchhip stands at 27,598 (99.24%), while among females, it stands at 26,872 (98.28%).

Table 3.5: Demographic features of Serchhip District

	Geographical Area (in km^2)	Population	Sex Ratio	Literacy	Density
Serchhip	1421	64,937	977	97.91	46

Source: Census of India, 2011

3.2.2 Agricultural Practices

There are 21804 cultivators, 1284 agricultural workers, 926 household industry workers, and 8383 other workers among the total population. There are 154.75 km^2. Of gross cropped land in the District with a cropping intensity of 125%. During the Kharif seasons, rice dominates the farmland of the district, occupying 40% of the total area cultivated. Maize represents 9.33% of the total gross crop area. The Kharif season is also a time when soyabeans, pumpkins, and cowpeas are important crops to grow. Mizoram produces an extensive amount of cabbage during Rabi, with Serchhip constituting the largest source of cabbage. There are also other crops that are grown during Rabi, such as brinjal, tomato, carrot, and knol-khol. Among the horticultural crops, orange cultivation is very popular; E. Lungdar Block has produced a large number of oranges that it has become the largest source of oranges in Mizoram. Bananas are also an important crop in the district today. The village of Khumtung is known throughout Mizoram for its banana production. It is said that the Cavendish bananas grown here are of the highest quality in the world. Along with ginger and nimbu, bird's eye chillies are another important crop. In addition, pineapple is very popular because of the Fruit Juice Concentration Plant in Chhingchhip, which is not far from Serchhip, the district capital. In the district, oil palm is another important crop that has recently been introduced. Climate conditions are suitable for growing most subtropical crops, including paddy, maize, and cash crops, such as sugarcane, ginger, chillies, oilseeds, and oranges, other citrus fruits, cabbages, and other winter-season crops. The inhabitants of the district also engage in activities related to animal husbandry, fisheries, small scale industry/cottage industry, and localized trade and commerce. Apart from a few places, small or middle scale irrigation facilities have not been provided to the cultivators, for which Jhum cultivation remains the most popular choice of the people. Figure 3.10 shows the map showing abandoned jhum land, current jhum land and agricultural land.

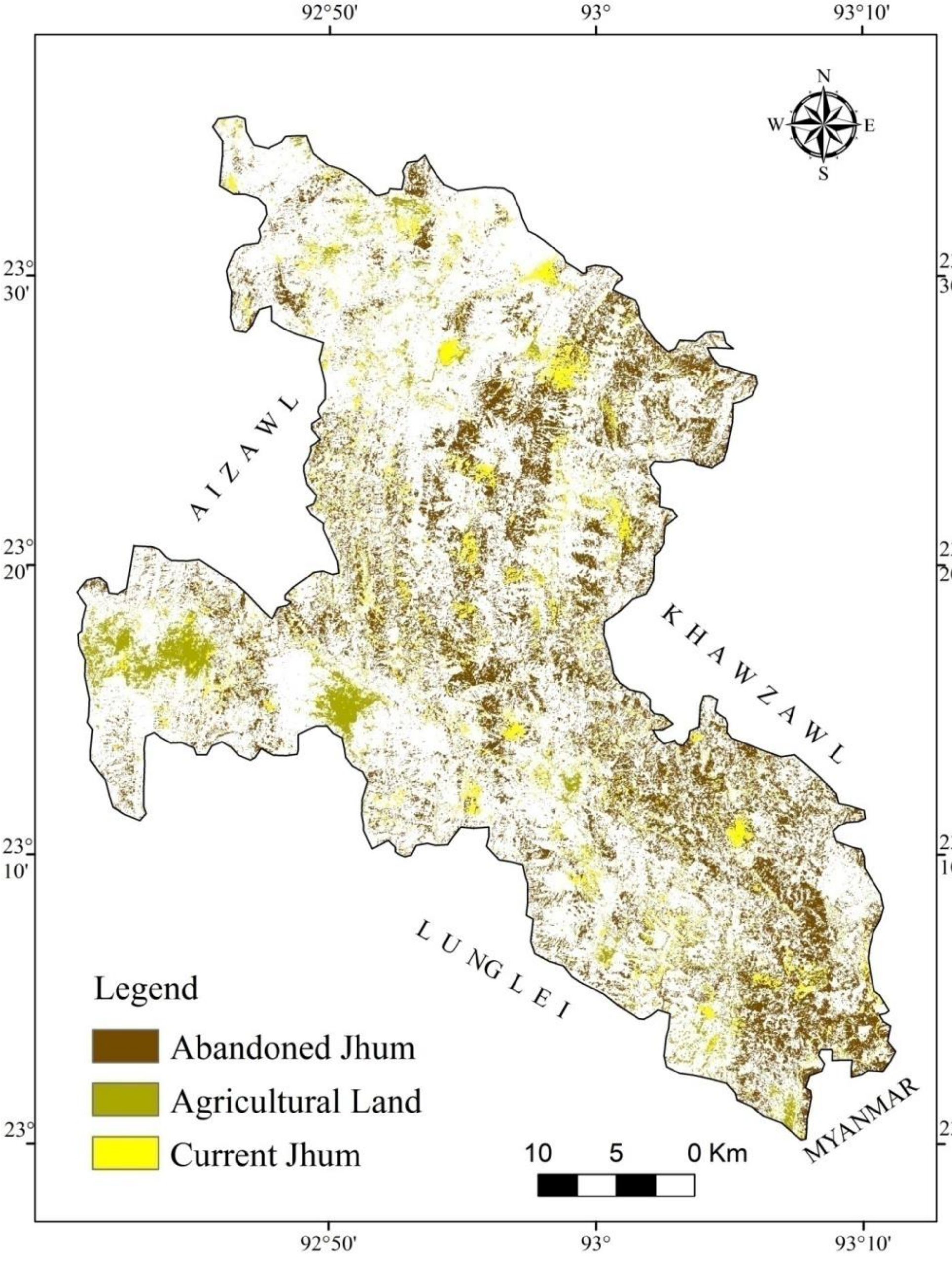

Fig. 3.10: Crop land area; Source: USGS, developed by the author

3.2.3 Economic Development

In India, more than 75% of the population lives in villages and their primary source of income is agriculture. Agriculture and related activities are the main occupations of the people in the District, which is dominated by the primary sector. Serchhip, the largest town, employs nearly half of its workforce in primary activities. A sectoral distribution of output can also be seen as a reflection of the economic condition of these towns. Market-oriented cropping (market-based gardening) and animal husbandry are the two primary activities in small towns with the highest productivity. More than two-thirds of the total output in these towns is attributed to the tertiary sector, which includes public establishments and private enterprises. The public sector plays an important role in creating employment opportunities. It has been observed that in urban economies, government employees and businessmen often plant crops in neighboring areas of the town during their free time in order to supplement their incomes or to obtain food items from farms for their households. There are a number of government employees and businessmen who own agricultural land. There are a variety of occupations available in these towns such as animal husbandry, subsistence farming, animal rearing, foraging, carpentry, etc. Pig farming (only one or two pigs) and poultry farming (only 10-20 hens) are very popular in small towns. There is a strong influence of the urban economy on the rural economy as a result of the complexity of the urban economy. Though the village and the town are separate places, they seem to be entwined through their ceaseless interactions - distance and accessibility are barriers that human beings strive to overcome.

3.2.4 Livestock

Livestock and poultry play a major role in rural economies and are the backbone of agriculture. Similarly, in Serchhip district of Mizoram, the majority of the population is dependent upon animal husbandry and agriculture. There is a high concentration of mono-cropping in this district, and failures of crops result in a complete collapse of the farmer's economy. Due to the fact that the land is kept fallow for approximately six months, mono-cropping does not provide income throughout the year. Therefore, animal husbandry is an important source of income and economic activity in the district that is a viable alternative to growing crops. Due to the large number of non-vegetarians in this region, meat and eggs are in high demand. A variety of animals and birds are traditionally raised in the district for use in religious ceremonies, rituals, and for consumption on a daily basis. The majority of households raise poultry and pigs. Moreover, the importance of cattle and buffalo is increasing due to the expansion of the WRC, where these animals are used as draught animals for plowing. The district has a good demand for beef (ICAR, 2015).

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Chapter 4

Case Study

4.1 Introduction

Serchhip District is located between the latitudes of 23°35'N and 23°00'N and the longitudes of 92°41'E and 93°10'E (Figure 4.1). It is located in the state's centre region, expanding eastward. This district is bounded on three sides by Aizawl district in the north and northwest, Lunglei district in the south, and Khawzawl and Champhai districts in the east. The district also has a few km of border with Myanmar in its south-eastern section. It has a land area of 1421 km^2, accounting for 6.74% of the state's total area. Serchhip district has a total of 43 villages out of which 10 villages were taken for a case study. Bawktlang village has the highest altitude with 1330 metres above sea level and Neihloh village which is located near Thenzawl town is the lowest among the surveyed villages with only 916 metres above sea level. Table 4.1 shows the detail geographical information about the study villages.

Table 4.1: Geographical information

Village	Altitude (m)	Latitude	Longitude
Bawktlang	1330	23º08’41”	93º04’10”
Vanchengte	1240	23º20’08”	92º53’17”
Lungchhuan	1349	23º08’50”	93º00’52”
Lungpho	1301	23º22’44”	93º00’04”
N.Mualcheng	1133	23º11’04”	93º03’13”
Neihloh	916	23º14’05”	92º42’23”
Sailulak	1215	23º07’13”	93º08’47”
Sialhau	1057	23º21’42”	92º55’19”
Sialsir	1201	23º10’16”	92º59’23”

Source: Primary Survey

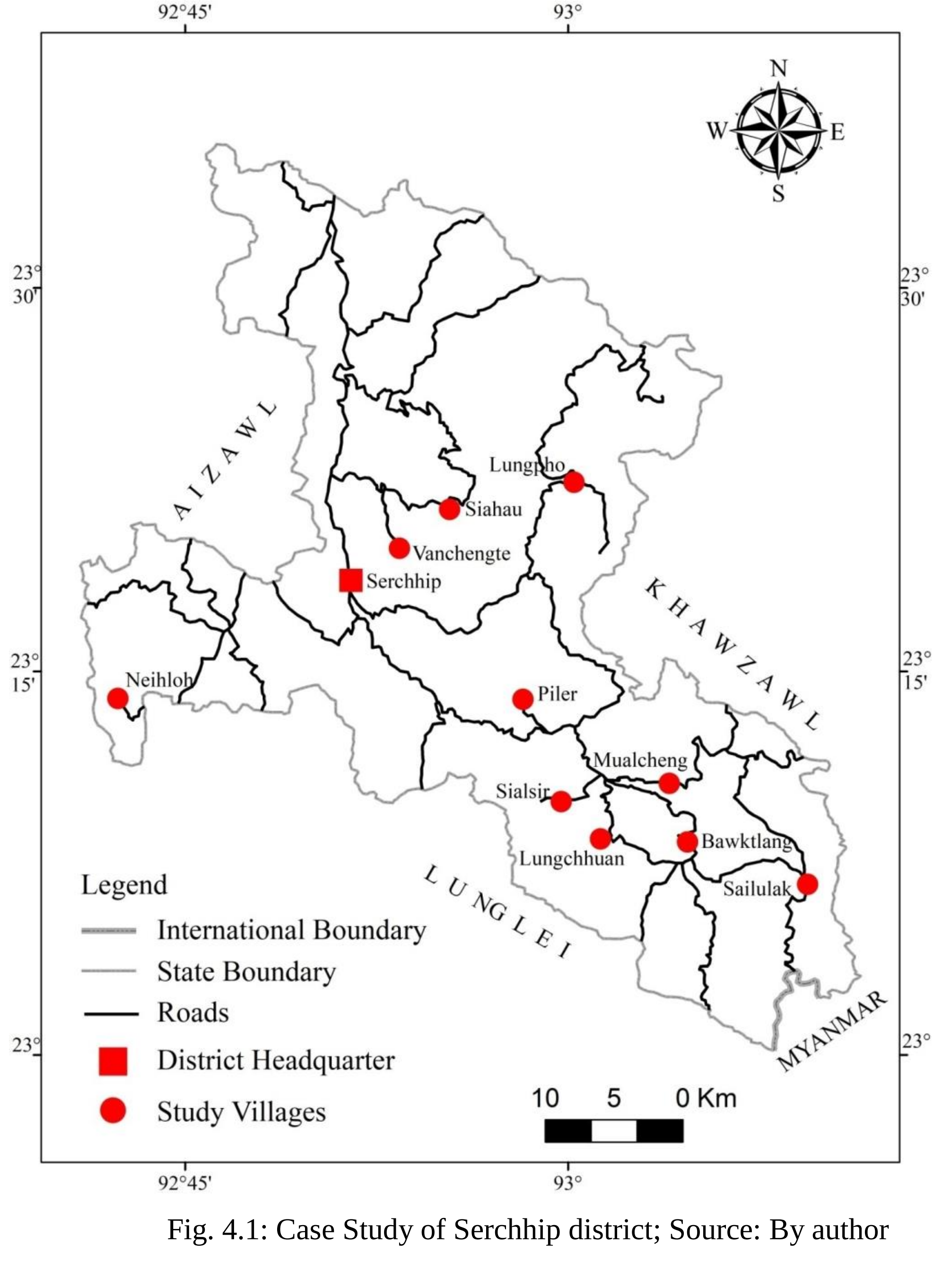

Fig. 4.1: Case Study of Serchhip district; Source: By author

4.2 Data Collection and Analysis

This study relies primarily on the collection of empirical data from household surveys. An analysis of ten villages in the Serchhip district, four villages in the Serchhip R.D. Block and six villages in the East Lungdar R.D. Block. The survey was conducted between September 2020 and April 2021. Different characteristics of the villages can be seen in their geographical location, altitude, number of people and level of development. A total of 467 households (40.93% of the total households) were surveyed using the random sampling method. Several structured questionnaires were designed and questions were framed pertaining to socio-economic status, such as family size, education, occupation, income and agriculture - the area, production, and yield of the principal crops that are grown in shifting cultivation systems. For each household, at the time of the interview, a literate or the head of the family was chosen to answer the questions. Two research questions concerning the production and area of the principal crops in 2000 and 2018 were asked. Figure 4.2 shows the scholar observing a paddy field in the Sialsir village. The purpose of this study is to identify the changes in cultivation areas and other related changes that result in changes in the land use and land cover in the study area. During the study, altitude data and village locations were collected using the Global Positioning System (GPS). Using descriptive statistics, sum, mean, and standard deviation were used to analyze data collected at the village level regarding the area, production, and yield of the principal crops. Area, yield, and production share of the main crops, arable land - at the household level and per capita - as well as production of the main crops were examined. Bar diagrams were used to display data on area and production at the household level. An analysis was conducted of the areas, production, and yields of the principal crops in the case study villages from 2000 to 2018 (18 years). Additionally, a detailed description of the per capita income from each of the main crops of shifting cultivation is provided.

Fig. 4.2: The scholar is observing a paddy field in Sialsir Village; Source: By author

4.3 Demographic Profile

According to the 2011 census, the total population of Serchhip district was 64,937, of which 32,851 were males and 32,086 were females. Among the ten villages selected, namely Bawktlang, Vanchengte, Lungchhuan, Lungpho, N. Mualcheng, Neihloh, Sailulak, Sialhau, Sialsir and Piler, the combined population is 6074 which accounts for around 9.35% of Serchhip's total population. There are around 1141 households out of which 472 households were surveyed (Table 4.2). Among the study villages, North Mualcheng has the highest number of households and also has the highest number of surveyed households, while Vanchengte has the lowest number of households with only 27 out of which 20 households were surveyed households. Among the study villages, Sailulak has the highest ratio of females to males, with 110.3 females for every 1000 males, and the average ratio is 100.5 females for every 1000 males, which is higher than the state ratio of 976 females for every 1000 males. Average family size was 5.4 persons. Out of the total surveyed population of 2539 persons, 219 persons remain illiterate, 1127 have primary education, 886 have high school education, 210 have higher education, and 97 have graduate education.

Table 4.2: Demographic Features of Study Villages

Village	Total Population	Total Households (2011 Census)	Surveyed households	% of total households	Sex Ratio (Female/thousand Male)	Family Size
Bawktlang	319	64	42	64.1	93.3	4.79
Vanchengte	130	27	20	70.4	78.8	4.65
Lungchhuan	710	138	50	36.2	106.7	5.54
Lungpho	1015	181	51	27.6	100	5.41
N.Mualcheng	1423	267	80	29.6	109.7	5.16
Neihloh	345	62	38	59.7	101.7	6.21
Sailulak	850	170	46	26.5	110.3	5.3
Sialhau	630	111	67	59.5	109.2	5.4
Sialsir	333	57	41	70.2	109.7	5.83
Piler	319	64	37	62.5	85.8	5.68
Total/average	6074	1141	472	47	100.5	5.40

Source: Primary Survey

Among the total working population as shown in table 4.3, around 96.88% were engaged in primary activities, including shifting cultivation and livestock farming, there are 2.95% of the population employed in the secondary sector - small-scale handicrafts at the village level. A total of 0.17% of the workforce was employed in the tertiary sector, mainly in government services. Income level of the households varies from Rs. <27,000 (2.54% households), 27,000-50,000 (25.63% households), 50,000-75,000 (44.49% households), 75,000-1,00,000 (27.33% households). Figure 4.3, 4.4 and 4.5 shows Lungpho village, Piler village and Sailulak village respectively which are some of the selected villages for household level survey.

Table 4.3: Socio-economic status of households in the study villages

Variables	Mean	Std. deviation
Sex Ratio (n= 10 villages) (female/thousand male)	100.52	11.15
Total working population (%) (n= 1761)	176.1	64.21
Primary activity (%) (n= 1706)	170.6	63.71
Secondary activity (%) (n=52)	5.2	3.39
Tertiary activity (%) (n= 3)	0	0
Number of households with income <Rs 27000 (n= 12)	1.1	2.51
Number of households with income Rs 27000 to Rs 50000 (n= 121)	12.1	8.03
Number of households with income Rs 50000 to Rs 75000 (n= 210)	21	11.95
Number of households with income Rs 75000 to Rs 100000 (n= 129)	12.9	9.8
Illiterate (n= 219)	21.9	13.47
Primary (n= 1127)	112.7	54.49
High School (n= 886)	88.6	55.24
Higher Education (n= 210)	21	11.72
Graduate (n= 97)	9.7	10.14

Source: Primary Survey

Fig. 4.3: Lungpho village; Source: By author

Fig. 4.4: Piler village; Source: By author

Fig. 4.5: Sailulak village; Source: By author

Table 4.4 depicts the data about the area, production, and yield of crops at the village level (10 villages) were collected from the surveyed households and analyzed using descriptive statistics. Furthermore, the yield of crops was determined. There are five crops grown in the study villages - paddy, chili, tobacco, ginger, and orange - which are under shifting cultivation. Paddy (rainfed) was the most important crop with an area of 312.7 ha in 2000 (Table 4.4). In 2018, this area increased to 351.72 ha. Based on data collected at the village level (10 villages), the average area under paddy crop in 2000 was 8.57 ha and in 2018 it was 9.76 ha. In all villages studied, paddy is grown. The second most important crop is ginger, which had 144.50 hectares in total area in 2000, but increased to 196.45 hectares in 2018. In the ten villages that were surveyed, only nine grew ginger. There are other crops as well, such as chili crop, which has increased from 154.85 ha in 2000 to 172 ha in 2018, orange plantation, which increased from 51.5 ha in 2000 to 63 ha in 2018, and tobacco, which has decreased from 17 ha in 2000 to 14.25 ha in 2018. Only four villages cultivate tobacco. As shown in Table 4.4, paddy produced the most in both years (6,03,262 kg), followed by ginger (3,12,780 kg) and oranges (73,150 kg). There is less than 50,000 kilograms of production from other crops and tobacco. Tobacco production was the lowest in both years. It is noted that in 2000, paddy had the highest yield (8854.80 kg/ha), followed by ginger (6104.80 kg/ha). The yield of other crops is less than 3000 kilograms per hectare. In 2018, all crops except ginger and orange have decreased in yield per hactare. The yield of ginger has increased slightly (6939.67 kg/ha), whereas the yield of paddy has decreased (8504.71 kg/ha). Figure 4.6 and 4.7 shows a forest land which were cutting down and burned for jhum cultivation. Figure 4.8 shows a paddy field near Vanchengte village.

Table 4.4: Area (ha), production (kg) and yield (kg/ha) of principal crops under shifting cultivation in the case study villages

Item	Crops	2000.00			2018.00			Change
		Sum	Mean	Std. deviation	Sum	Mean	Std. deviation	2000-2018
Area (ha)	Paddy (n= 10)	312.75	8.57	4.51	351.72	9.76	5.66	38.97
	Chillie (n= 8)	154.85	6.62	2.88	172.00	5.41	5.66	17.15
	Tobacco (n= 4)	17.00	2.11	0.92	14.25	1.44	0.61	-2.75
	Ginger (n= 9)	144.50	6.72	7.09	196.45	14.87	17.89	51.95
	Orange (n= 8)	51.50	4.28	2.12	63.00	5.81	3.13	11.50
Production (kg)	Paddy (n= 10)	261148.00	7037.53	2523.37	342114.00	7508.45	2689.13	80966.00
	Chillie (n= 8)	16185.00	692.72	381.58	16405.00	571.69	305.59	220.00
	Tobacco (n= 4)	1325.00	157.08	69.63	2175.00	284.12	130.35	850.00
	Ginger (n= 9)	125400.00	5377.72	1907.36	187380.00	7334.21	2902.74	61980.00
	Orange (n= 8)	21250.00	1715.08	1309.11	30650.00	2700.92	2941.74	9400.00
Yield (kg/ha)	Paddy (n= 10)	8854.80	798.27	183.19	8504.71	989.10	802.14	-350.09

	Chillie (n= 8)	924.16	103.71	51.72	852.81	106.60	42.80	-71.35
	Tobacco (n= 4)	340.85	113.62	23.58	329.30	109.77	10.01	-11.55
	Ginger (n= 9)	6104.80	890.44	261.67	6939.67	881.74	289.19	834.87
	Orange (n= 8)	2076.08	415.22	231.18	3398.69	485.53	329.66	1322.61

Source: Primary Survey, 2022

Fig. 4.6: Land degradation due to shifting cultivation near N. Mualcheng village; Source: By author

Fig. 4.7: The forest land is keeping ready for shifting cultivation near Sialhau village;

Source: By author

Fig. 4.8: Paddy field near Vanchengte village; Source: By author

4.4 Conclusions

Shifting cultivation, characterized by its practice of clearing land, cultivating crops for a limited period, and subsequently moving to new plots, remains the predominant occupation among rural communities in Mizoram, despite its inherent limitations in terms of low production and yields for principal crops (Sati, 2019; Sati, 2022; Sati, 2020; Sati, 2017). Although there has been a slight increase in the overall area under crops during the study period, certain crops have experienced decreased production and yields (Sati, V. P and Vangchhia, 2017; Sati, 2008; Sati, 2015; Sati, 2017). Of particular concern is the decline in paddy yield, which can be attributed to the shortened fallow cycle, now reduced to eight years (Sati, 2014). The reduction in the fallow periods can be attributed to the significant increase in population over the past few decades, leading to diminishing available land for cultivation and necessitating more frequent plot turnovers (Patro and Panda, 1994). This shift in land management practices has rendered shifting cultivation economically unsuitable (HARS, 2000; Sati, et al., 2017), and has also resulted in notable changes in the land cover within the study area. Researchers such as Knudsen and Khan (2002) contend that shifting cultivation is neither economically viable nor environmentally sustainable.

Despite the substantial decrease in overall crop production and yields, shifting cultivation persists as the predominant agricultural practice, surpassing alternative cultivation methods in prevalence (Table 4.3). This may be attributed to factors such as traditional practices, cultural significance, and limited knowledge or access to alternative farming techniques. Furthermore, the study highlights the environmental consequences of reduced fallow periods. The shorter cycles disrupt the land's natural regeneration processes, leading to detrimental impacts on soil fertility, biodiversity, and overall ecosystem health. The study underscores the urgent need for the adoption of alternative and sustainable agricultural practices to address the economic and environmental challenges posed by shifting cultivation in Mizoram. In the midst of these challenges, it is worth noting that some crops, such as oranges, have experienced increased production. This is primarily due to limited production during 2000 as a result of premature planting of orange plantations. However, this isolated success does not outweigh the overall decrease in crop production and the declining economic feasibility of shifting cultivation as a whole. Thus, there is a pressing need to explore and promote alternative agricultural approaches that can ensure long-term economic stability and environmental sustainability in rural Mizoram.

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Chapter 5

Land Use and Land Cover Change (2000-2018)

5.1 Introduction

Land use and land cover change (LULCC) is the process of changing the earth's surface by human activity (Gondwe, *et al.*, 2021). Humans have been altering land for thousands of years to get livelihoods and other necessities, but today's extent, intensity, and rate of LULCC are higher than ever (Graumlich, 1997; Jamir, 2015). Globally, these changes are driving unprecedented changes to ecosystems and environmental processes on a local, regional, and global scale (Showqi, *et al.,* 2014; Tekle and Hedlund, 2000). It is thus crucial to analyze LULC changes today in order to prepare forecasts and decision-making on ecological management and future environmental planning based on data available on these changes. (Zhao, *et al.,* 2004; Dwivedi, *et al.,* 2005; Erle and Pontius, 2007; Fan, *et al.,* 2007). The change in land use and land cover is perhaps the most visible form of global environmental change since it impacts our daily lives on a spatial and temporal scale (Turner, *et al.,* 2007). There is a technical distinction between changes in land use and changes in land cover (Olorunfemi, 1983; Mark and Kudakwashe, 2010). A change in land use or land cover means a quantitative change in the area of a given land use or land cover (increase or decrease). In addition to anthropogenic factors, there are also environmental and climate driven factors that play a role in changing land use and land cover (Liu et al, 2010; Lalchamreia & Pachuau, 2010; Laldailova, 2001; Lalhmachhuana 2022). Land use change in various spatial and temporal domains is an example of the material expression of these changes, and it also depicts the dynamics of the environment and the development of the human species in relation to land availability (Lambin, *et al.,* 2003; Jenson and Cowen, 1999). A number of empirical studies conducted by researchers from a wide variety of disciplines have shown that changes in land use/land cover have become key to a wide range of applications, including agriculture, the environment, ecology, forestry, geology, and hydrology (Weng, 2002; Riebsame, *et al.,* 1994). Aside from changing the physical dimensions of the spatial extent of the land use and land cover classes, land use and land cover changes also influence large numbers of secondary processes that lead to the eventual degradation of earth's ecosystem (Sati, 2014). The most significant impact of changes in land use and land cover is the reduction of vegetation cover (Sati, 2020; Zeleke and Hurni, 2001). Consequently, the loss of vegetation cover has many deleterious effects on the environment, including loss of biodiversity, climate change, changes in radiative forcing, pollution of other natural ecosystems with a reduction in their quality, and changes in hydrological regimes (Hayes and Sader, 2001).

5.2 Data Preparation

Three LULC maps were developed using a supervised classification method with a maximum likelihood algorithm (Rawat and Kumar, 2015). The Landsat sensor data is used to produce multi-sectoral supervised classification maps of land cover for the selected years (Lucas et al., 2007; Hall et al., 2004). Satellite images from Landsat 5 (TM) and 8 (OLI_TIRS) contain seven and eleven bands, respectively, which have been compiled into a composite image (Zha, *et al.*, 2003; Kaul and Ingle, 2012). A supervised classification requires the completion of basic processing steps such as composite band, raster copy, removal of clouds, mosaics, extraction by mask, and maximum likelihood image classification (Su, *et al.*, 2010; Hussain, 2013; Javed and Khan, 2012). With the help of the software ArcMap 10.4®, the entire process was completed. Using a transparent background, we removed the copy raster features from the images' backgrounds. Pre-processing was performed on this section in order to classify the images. In this section, haze reduction was carried out. A technique of image enhancement was selected for the purpose of equalizing the histograms in this study (Hayes and Sader, 2001; Singh and Bhattacharjee, 2023). It is acceptable that there is no cloud cover or haze because all images show zero or there is a little cloud cover or hazeUsing ArcMap 10.4® software, an image mosaic was created from the Landsat images in order to develop an accurate aerial representation of the study area (Hood and Bayley, 2008). A mask extraction tool was used to cut at the desired location (Magesh and Ch, 2012; Ramírez-Villegas and Bueno Cabrera, 2009).

5.3 LULC Classification

In this study, images were classified into 10 major classes; abandoned jhum, agriculture land, bamboo, current jhum, dense forest, medium dense forest, open forest, scrubland, settlements and water body. The study utilized Landsat 5 TM satellite images with 7, 4, and 2 bands in the form of a false color composite. As a result of this combination, a "natural" appearance is achieved. Green represents healthy vegetation, grasslands appear green, pink represents barren soil, oranges and browns represent sparsely vegetated areas, water appears blue, and urban areas appear magenta (Crosta and Moore, 1989; Tamouk, *et al.*, 2013; Dwivedi and Rao, 1992).

For Landsat 8 TM false-color composite, natural colors (4, 3, 2) are used to replicate what an eye sees in true color (Kurucu, *et al.*, 2004; Anderson, 1976). There were areas of healthy vegetation that were green and areas of unfortunate vegetation that were darker in color. The urban highlights appeared white and dim, and the water appeared dull or dark in color (Elhag, 2017; Mwaniki, *et al.*, 2015; Tamouk, *et al.*, 2013; Dwivedi and Rao, 1992). In this study, a significant number of pixels were selected in order to train for the selection of each land use and land cover category. It has been determined that approximately 150 training data sets have been created for each class, and the minimum distance allowed for each class is 30 metres. Finally, ArcGIS software was used to apply supervised image classification using maximum likelihood. As part of this study, the areas under different categories were calculated using the following Eq. 1 (Eva et al., 2004):

$$Area = \frac{(Counted\ Pixels) \times (Pixel\ Size)^2}{10^6} \qquad (1)$$

5.3.1 Post Classification

In this study, Arc GIS 10.4®, Google Earth Pro and Excel software was used to process, analyze, and detect changes to those classified images. Lastly, the area differences from 2000 to 2018 were calculated in order to determine the Land use and land cover change (LULCC) of the study area.

5.3.2 Land Use Land Cover

Land use land cover of the Serchhip District in three times scale – 2000, 2010, and 2018 were gathered from the United States Geological Survey (USGS) website (https://glovis.usgs.gov/) (https://earthexplorer.usgs.gov/) (Table 5.1).

Table 5.1: Land use land cover changes data from 2000, 2010 and 2018 (km^2)

LULC Classes	2000		2010		2018	
	Area (km^2)	Percentage (%)	Area (km^2)	Percentage (%)	Area (km^2)	Percentage (%)
Abandoned Jhum	144.54	10.17	126.39	8.89	59.12	4.16
Agricultural Land	23.04	1.62	45.34	3.19	48.93	3.44
Bamboo	451.11	31.75	410.99	28.92	403.69	28.41
Current Jhum	146.73	10.33	69.38	4.88	44.44	3.13
Dense Forerst	228.94	16.11	221.43	15.58	247.50	17.42
Medium Dense Forest	185.94	13.09	223.39	15.72	217.95	15.34
Open Forest	164.48	11.57	206.09	14.50	224.20	15.78
Scrubland	56.20	3.95	96.40	6.78	149.26	10.50
Settlement	11.71	0.82	13.52	0.95	17.10	1.20
Waterbody	8.31	0.58	8.08	0.57	8.79	0.62
Total	1421.00	100.00	1421.00	100.00	1421.00	100.00

Source*:* USGS earth explorer

Table 5.1 depicts the area of each land use land cover category of the three different years. In 2000, abandoned jhum was 10.17% of the total area. After ten years, this abandoned jhum has decreased almost 1.28% in 2010 and in the next eight years abandoned jhum has decreased almost 4.73% from the total area. Agriculture land in 2000 was 1.62% of the total area and in 2010 it increased with around 1.57%. In 2018, agriculture land was increased with only 0.25% of the total area. In 2000, bamboo covered an area of 31.75% of the total area. In 2010, bamboo forest was decreased almost 2.83% and in 2018 it decreased with 0.51% of the total area. Current jhum land in 2000 was 10.33% of the total area, while in 2010 it decreased with 5.45% and in 2018 current jhum land again decreased with 1.75% of the total area. Dense forest in 2000 was 16.11% of the total area and in 2010 it cover an area of 15.58% of the total area. In 2018, dense forest was increased with 1.84% of the total area. Medium dense forest in 2000 was 13.09% of the total area. In 2010, medium dense forest was increased with 2.63% from the previous surveyed year. In 2018, medium dense forest was decreased with 0.38% of the total area. Open forest in 2000 was 11.57% and in 2018 it increases with 4.21% of the total area. Scrubland during 2000 to 2018 increased with 6.55% of the total area. In 2000, settlement area was 0.82% of the total area and in 2018 increases to 1.20% of the total area. Lastly, waterbody in 2000 was 0.58% and in 2018 it increases to 0.62% of the total area. Figure 5.1 shows the land use and land cover change status during 2000 to 2018 of Serchhip district and it shows the changed of different LULC classes during the study period.

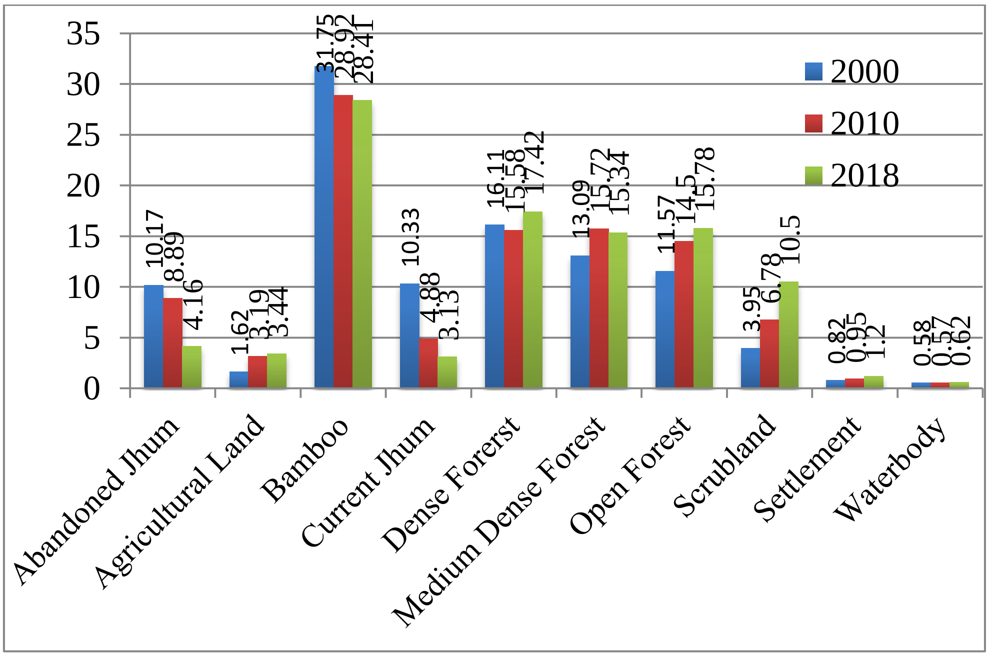

Fig. 5.1: LULC change status during 2000 to 2018 of Serchhip district (in %); Source: By author

Figure 5.2 shows the forest cover area which was cleared for shifting cultivation and Figure 5.3 shows the abandoned jhum land. Figure 5.4, 5.5 and 5.6 shows the land use and land cover change in Serchhip district during 2000, 2010 and 2018 respectively. The landsat data was downloaded from United States Geological Survey (USGS). LULC classes was divided into 10 classes, which are Abandoned Jhum, Agriculture Land, Bamboo, Current Jhum, Dense Forest, Medium Dense Forest, Open Forest, Settlement, Scrubland and Waterbody. Figure 5.4, shows the land use and land cover change during 2000 where the highest area coverage was Bamboo forest and dense forest was largely concentrated on the northern and southern parts of the district. In figure 5.5, again majority of the land was covered by Bamboo forest, among forest cover, dense forest cover declined, while medium dense forest and forest was increased. There was an increasing of scrubland which can be seen in all parts of the study area. Figure 5.6 shows the land use and land cover change of Serchhip district in 2018, where there was an increasing of forest cover including dense forest, abandoned jhum and scrubland are colliding with each other therefore, it shows a large cover area especially in the south-western parts of the district. LULC maps of 2000, 2010 and 2018 shows that majority of the study area was covered with Bamboo forest.

Fig. 5.2: The forest land is cleared for shifting cultivation near Piler village; Source: By author

Fig. 5.3: Abandoned Jhum land near N. Mualcheng village; Source: By author

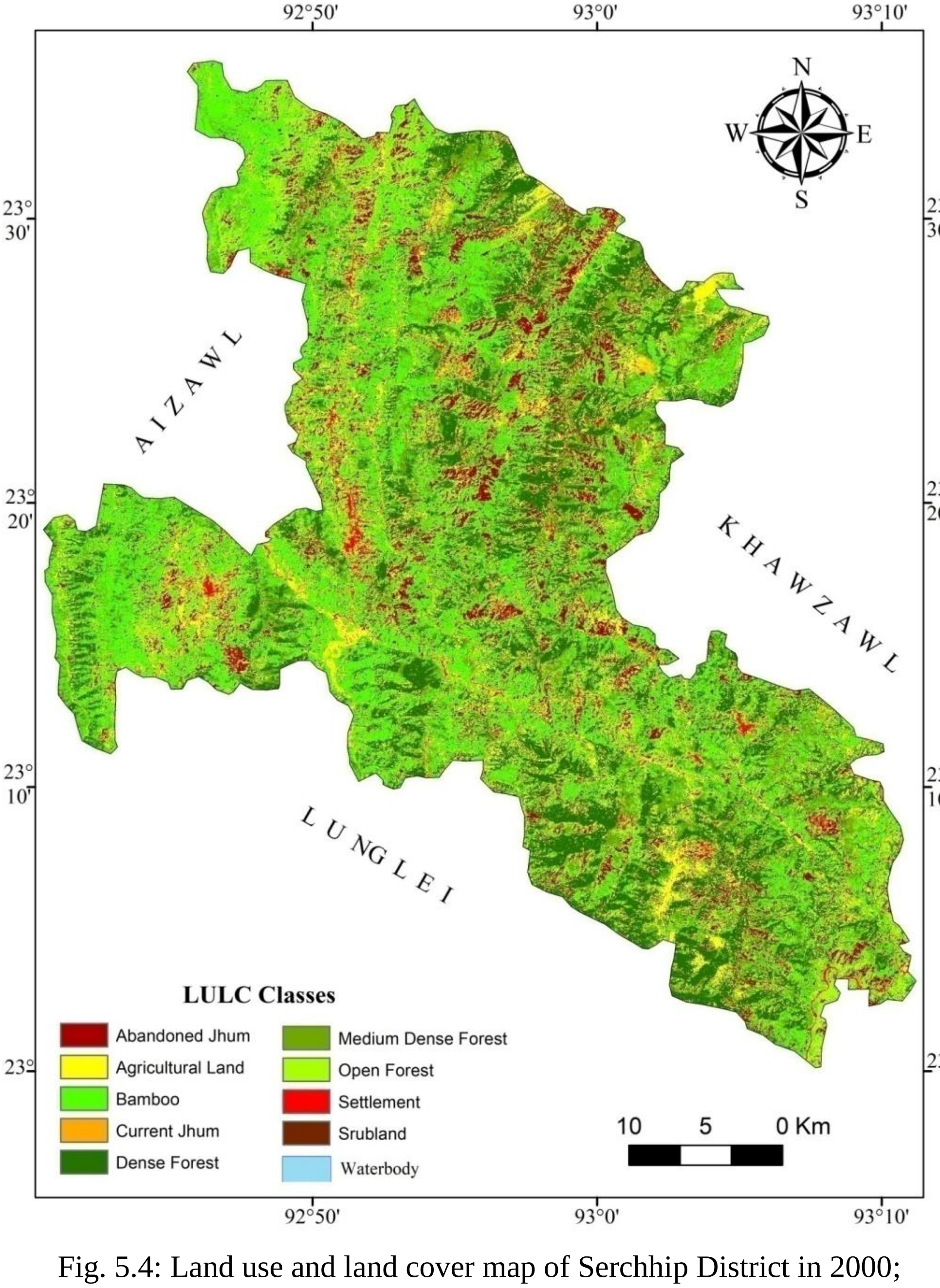

Fig. 5.4: Land use and land cover map of Serchhip District in 2000;

Source: USGS, developed by the author

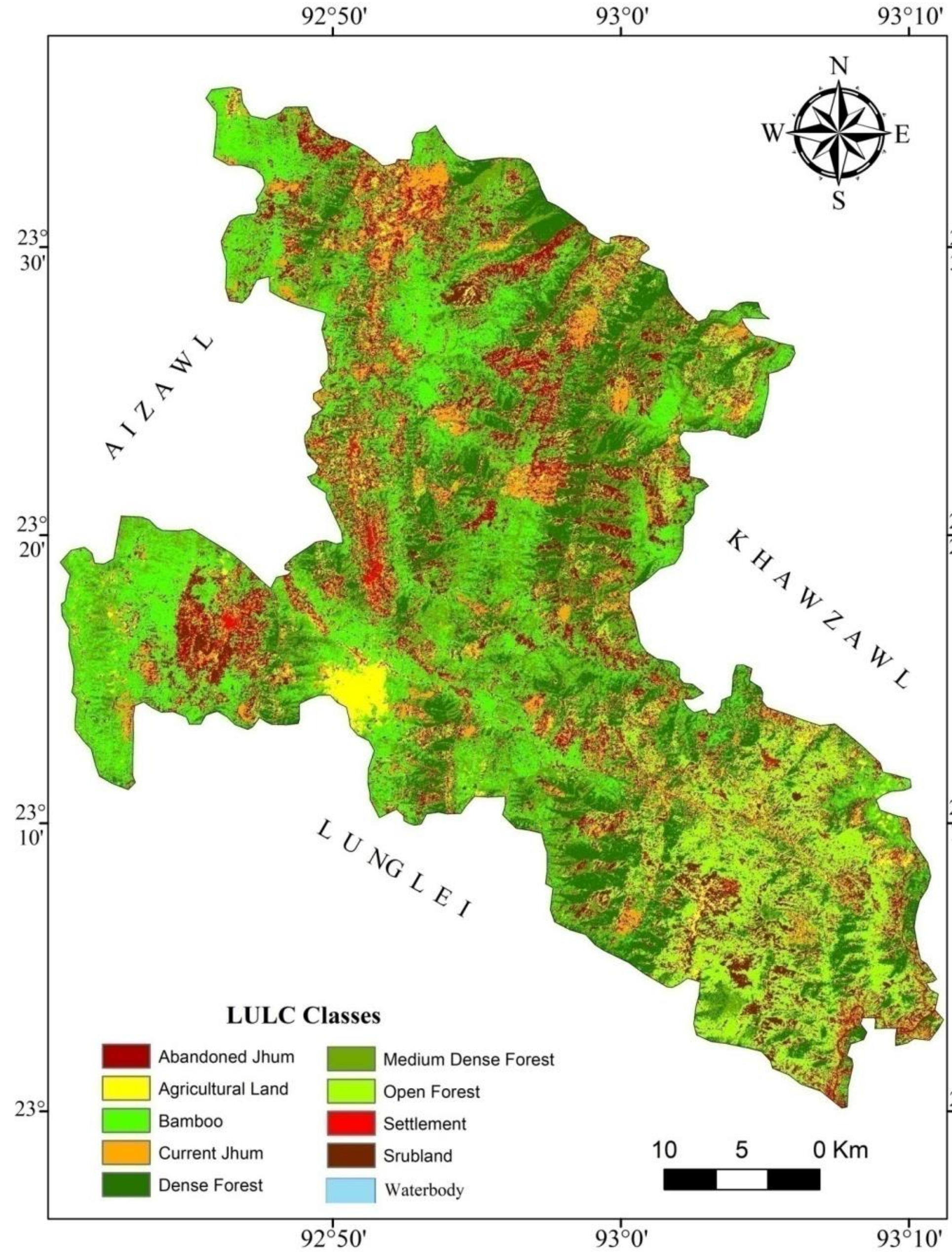

Fig. 5.5: Land use land cover map of Serchhip District in 2010;

Source: USGS, developed by the author

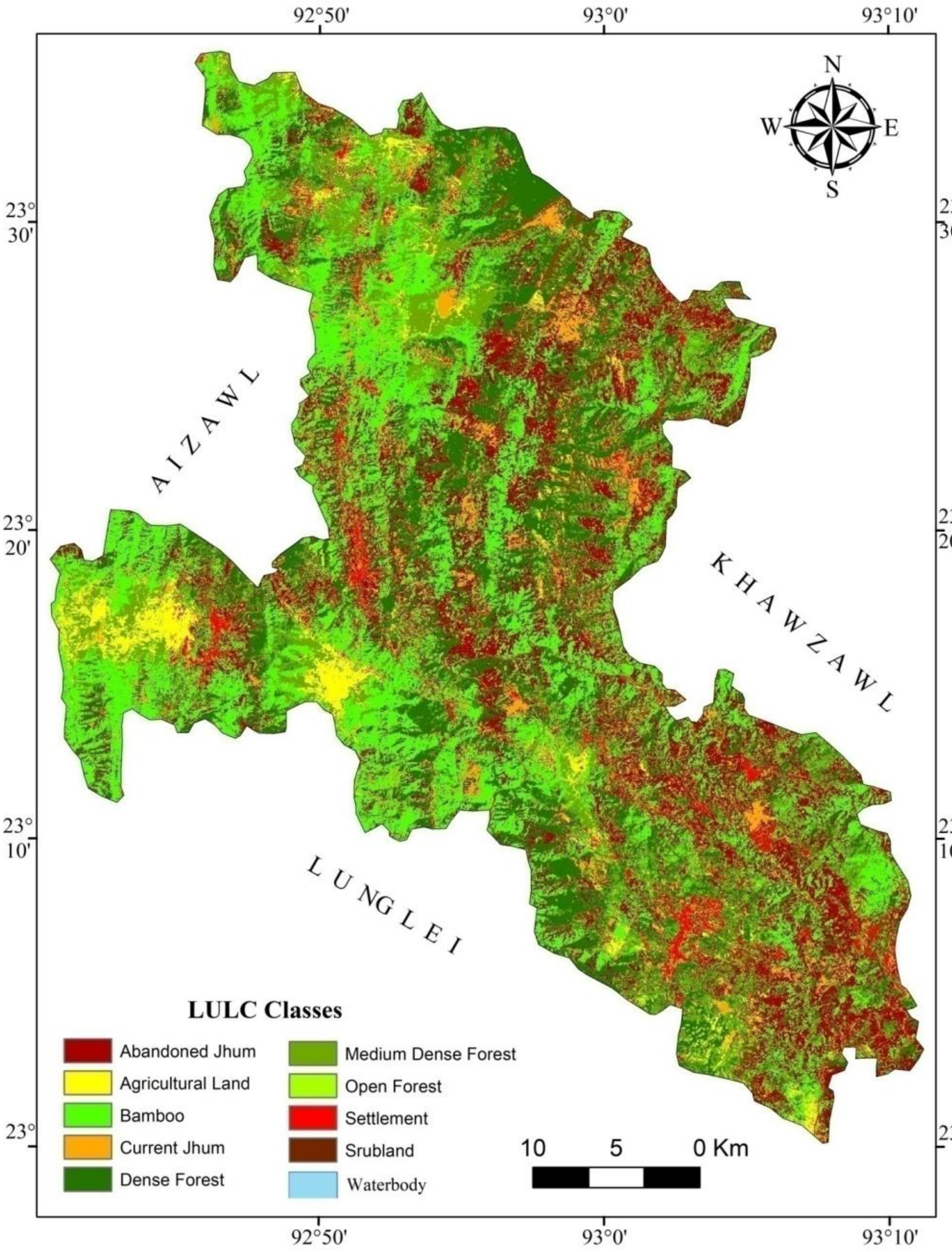

Fig. 5.6: Land use land cover map of Serchhip District in 2018;

Source: USGS, developed by the author

Table 5.2 show the area change analysis of different land use and land cover classes from 2000 to 2010, 2010 to 2018 and during 2000 to 2018. It shows that the area gained for a particular LULC type includes the converted land cover area which previously belonged to another LULC type. Accordingly, the lost area of any LULC type was changed to some other types. From 2000 to 2018, there is a striking negative change observed for the current jhum land. Among the decreasing of land cover abandoned jhum land was decreased with 85.42 km^2 during 2000 to 2018 and Bamboo forest was also decreased with 47.42 km^2 during 2000 to 2018. A positive changed can be seen on the increasing of forest cover especially among the dense forest cover with positive 18.56 km^2, and medium dense forest also increased with 32.01 km^2 and open forest increased with a huge number of 59.72 km^2.

Table 5.2: Land use land cover change of Serchhip district (in km^2)

LULC Classes	2000 - 2010	2010 - 2018	2000 – 2018
Abandoned Jhum	-18.15	-67.27	-85.42
Agricultural Land	22.3	3.59	25.89
Bamboo	-40.12	-7.3	-47.42
Current Jhum	-77.35	-24.94	-102.29
Dense Forerst	-7.51	26.07	18.56
Medium Dense Forest	37.45	-5.44	32.01
Open Forest	41.61	18.11	59.72
Scrubland	40.2	52.86	93.06
Settlement	1.81	3.58	5.39
Waterbody	-0.23	0.71	0.48

Source: USGS Earth Explorer

5.5 Accuracy Assessment

The accuracy assessment was undertaken using the following matrices: user accuracy, producer accuracy, and overall accuracy, as well as the Kappa coefficient. For each class, approximately 150 random points were created and a minimum distance allowance of 30 m was established. Measurements were conducted using Eq. 2, 3 and 4. User accuracy was measured using Eq. 2 (Tilahun and Teferie, 2015):

$$Users\ Accuracy = \frac{Number\ of\ Correctly\ Classified\ Pixels\ in\ each\ Category}{Total\ number\ of\ CLassified\ Pixels\ in\ that\ Category\ (The\ Row\ Total)} x100$$

$$Producers\ Accuracy = \frac{Number\ of\ Correctly\ Classified\ Pixels\ in\ each\ Category}{Total\ number\ of\ Refrence\ Pixels\ in\ that\ Category\ (The\ Column\ Total)} x100$$

$$Overall\ Accuracy = \frac{Total\ Number\ of\ Correctly\ Classified\ Pixels\ (Diagonal}{Total\ Number\ of\ Reference\ Pixels}\ x\ 100$$

To measure the agreement between the predictions of the model and the reality, the Kappa coefficient equation was used (Congalton, 1991). In addition, we could use an error matrix in order to determine if the results provided by an error matrix are more accurate than the results from random sampling (Jensen and Cowen, 1999). In order to calculate the Kappa coefficient values, the following equations were used Eq. 5 (Tilahun & Teferie, 2015; Congalton, 1991).

$$kappa\ Coefficient\ (T) = \frac{(TS\ x\ TCS) - \sum(Column\ Total\ x\ Row\ Total)}{TS^2 - \sum(Column\ Total\ x\ Row\ Total)} x100$$

Where,

TS = total number of samples

TCS = total number of corrected samples

Table 5.3: Accuracy Assessment for the year 2000

LULC Classes	A.J	A.L	B	C.J	D.F	M.D.F	O.F	S.L	S.T	W.B	Total (User)
A.J	14	0	0	0	0	0	1	0	0	0	15
A.L	0	14	0	0	0	1	0	0	0	0	15
B	1	0	18	1	0	0	0	0	0	0	20
C.J	1	0	0	16	0	0	0	1	0	0	18
D.F	0	1	0	1	18	0	0	0	0	0	20
M.D.F	0	0	0	0	0	15	0	0	0	0	15
O.F	0	1	0	1	0	1	15	0	0	0	18
S.L	0	0	0	0	0	0	0	10	0	0	10
S.T	0	1	0	0	0	0	0	0	9	0	10
W.B	0	0	0	0	0	0	0	0	0	9	9
Total (Producer)	16	17	18	19	18	17	16	11	9	9	150

Source: USGS Earth Explorer

Where, A.J = Abandoned Jhum; A.L = Agriculture Land; B = Bamboo; C.J = Current Jhum;

D.F = Dense Forest; M.D.F = Medium Dense Forest; O.F = Open Forest; S.L = Scrubland;

S.T = Settlement; W.B = Waterbody

$$\textit{Overall Accuracy} = \frac{\textit{Number of Total Correct Points (Value)}}{\textit{The Number of Points (Value)}} \times 100$$

$$= \frac{138}{150} x100$$

$$= 92\%$$

Table 5.4: Accuracy Assessment for the year 2010

LULC Classes	A.J	A.L	B	C.J	D.F	M.D.F	O.F	S.L	S.T	W.B	Total (User)
A.J	18	0	0	0	0	0	1	1	0	0	20
A.L	0	9	0	0	0	0	1	0	0	0	10
B	0	0	13	1	0	0	1	0	0	0	15
C.J	1	0	0	22	0	0	0	0	0	0	23
D.F	0	1	0	0	14	0	0	0	0	0	15
M.D.F	0	1	0	0	0	17	0	0	0	0	18
O.F	0	1	0	0	0	0	18	1	0	0	20
S.L	0	0	0	0	0	0	1	10	0	0	11
S.T	0	0	0	0	0	0	0	0	9	0	9
W.B	0	0	0	0	0	0	0	0	0	9	9
Total (Producer)	19	12	13	23	14	17	22	12	9	9	150

Source: USGS Earth Explorer

Where, A.J = Abandoned Jhum; A.L = Agriculture Land; B = Bamboo; C.J = Current Jhum;

D.F = Dense Forest; M.D.F = Medium Dense Forest; O.F = Open Forest; S.L = Scrubland;

S.T = Settlement; W.B = Waterbody

$$\textit{Overall Accuracy} = \frac{\textit{Number of Total Correct Points (Value)}}{\textit{The Number of Points (Value)}} \times 100$$

$$= \frac{139}{150} x100$$

$$= 92.7\%$$

Table 5.5: Accuracy Assessment for the year 2018

LULC Classes	A.J	A.L	B	C.J	D.F	M.D.F	O.F	S.L	S.T	W.B	Total (User)
A.J	17	0	0	0	0	0	1	0	0	0	18
A.L	0	14	0	0	1	1	0	0	0	0	16
B	0	1	17	0	0	0	1	0	0	0	19
C.J	1	0	0	14	0	0	0	0	0	0	15
D.F	0	1	0	0	18	1	0	0	0	0	20
M.D.F	0	1	0	0	0	15	0	0	1	0	17
O.F	0	0	0	0	1	0	15	0	0	0	16
S.L	0	0	0	0	0	0	0	10	0	0	10
S.T	0	0	0	0	0	0	0	0	9	0	9
W.B	0	0	0	1	0	0	0	0	0	9	10
Total (Producer)	18	17	17	15	20	17	17	10	10	9	150

Source: USGS Earth Explorer

Where, A.J = Abandoned Jhum; A.L = Agriculture Land; B = Bamboo; C.J = Current Jhum;

D.F = Dense Forest; M.D.F = Medium Dense Forest; O.F = Open Forest; S.L = Scrubland;

S.T = Settlement; W.B = Waterbody

$$\text{Overall Accuracy} = \frac{\text{Number of Total Correct Points (Value)}}{\text{The Number of Points (Value)}} \times 100$$

$$= \frac{138}{150} x100$$

$$= 92\%$$

$$Users\ Accuracy = \frac{Number\ of\ Correctly\ Classified\ Pixels\ in\ each\ Category}{Total\ number\ of\ CLassified\ Pixels\ in\ that\ Category\ (The\ Row\ Total)} x100$$

Table 5.6: Users Accuracy Assessment

LULC Classes	2000 (%)	2010 (%)	2018 (%)
Abandoned Jhum	93.3	90	94.4
Agricultural Land	93.3	90	87.5
Bamboo	90	86.7	89.5
Current Jhum	88.9	95.7	93.3
Dense Forerst	90	93.3	90
Medium Dense Forest	100	94.4	88.2
Open Forest	83	90	93.8
Scrubland	100	90.9	100
Settlement	90	100	100
Waterbody	100	100	90

Source: USGS Earth Explorer

$$Producers\ Accuracy = \frac{Number\ of\ Correctly\ Classified\ Pixels\ in\ each\ Category}{Total\ number\ of\ Refrence\ Pixels\ in\ that\ Category\ (The\ Column\ Total)} x100$$

Table 5.7: Producers Accuracy Assessment

LULC Classes	2000 (%)	2010 (%)	2018 (%)
Abandoned Jhum	87.5	94.7	94.4
Agricultural Land	82.4	75	82.4
Bamboo	100	100	100
Current Jhum	84.2	95.7	93.3
Dense Forerst	100	100	90
Medium Dense Forest	88.2	100	88.2
Open Forest	93.8	81.8	88.2
Scrubland	90.9	83.3	100
Settlement	100	100	90
Waterbody	100	100	100

Source: USGS Earth Explorer

$$Kappa\ Coefficient\ (T) = \frac{(TS\ x\ TCS) - \sum(Column\ Total\ x\ Row\ Total)}{TS^2 - \sum(Column\ Total\ x\ Row\ Total)} x100$$

Table 5.8: Overall Accuracy and Kappa Coefficient (in %)

Year	Overall Accuracy (%)	Kappa Coefficient (%)
2000	92	91.1
2010	92.7	91.8
2018	92	91.1

Source: USGS Earth Explorer

Table 5.3, 5.4 and 5.5 shows the accuracy assessment for the year 2000, 2010 and 2018 of Serchhip district. The mean overall accuracy was 92.2% accuracy level. Generally, a value of greater than 70% is considered acceptable for accuracy (Congalton, 1991). Table 5.6 and 5.7 shows the users accuracy and producer accuracy assessment for the year 2000, 2010 and 2018. Table 5.8 shows the Kappa Coefficient value and the mean value was 91.3%

5.4 Conclusions

The study of monitoring Land Use and Land Cover (LULC) changes in Serchhip district from 2000 to 2018 constitutes a crucial endeavor, given the paramount importance of land as a natural resource for human survival and sustainable development. Employing Thematic Mapper (TM) 4-5 C1 level-1 and Landsat 8 OLI/TIRS C1 level-1 satellite imagery, along with ArcGIS software, allowed for comprehensive quantification and calculation of changes in land cover over the specified period. Accurate assessment and evaluation were conducted each year to ensure reliability and validity of the findings. To measure the agreement between observed and predicted LULC classes, the Kappa coefficient was employed. This provided an indication of the change detection process' accuracy.

The study demonstrated a positive trend in forest cover expansion, excluding bamboo forests, which declined in area. Notably, bamboo forests occupied the largest extent among all LULC classes, indicating their importance in the study area. Additionally, an increase in scrubland was observed, necessitating careful consideration in planning and implementation to address this changing scenario effectively. This study offers valuable insights into evolving LULC patterns in the Serchhip district. Such information is essential for policymakers, land managers, and environmentalists alike, facilitating informed decision-making processes aimed at preserving and conserving this invaluable natural resource. By understanding and addressing these LULC changes, stakeholders can implement sustainable land management strategies to ensure the long-term health and resilience of the ecosystem and, ultimately, safeguard the well-being of present and future generations.

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Chapter 6

Factors Affecting Land Use and Land Cover Change

6.1 Introduction

A variety of factors influence land use and land cover changes, acting not in isolation but in complex interplay with the environment at different spatial and temporal scales. It is unprecedented to witness the speed, magnitude, and range of human alteration of the Earth's surface (Lambin, 2001; Prakasam, 2010). A thorough understanding of the factors that affect land use and land cover change is essential for researchers, policy makers, and land managers in order to make appropriate decisions (Olsonm, *et al.,* 2004; Prakash, *et al.,* 2007). By analyzing the driving forces, it is possible to determine the process by which LULC is changing and to identify regional ecological changes in the environment (Hu, *et al.*, 2019). Many factors influence the LULC over time and space, including society, economics, and the natural environment (Quintero-Gallego, *et al.,* 2018; Alijani, *et al.*, 2020). It is possible to categorize LULC changes into qualitative and quantitative categories (Belay, 2019). A qualitative analysis can only provide a general perspective on LULC development trends and driving factors. As a result, it is difficult to estimate the extent to which each factor influences changes in LULC. For clarifying the relationship between driving factors and LULC changes, quantitative methods include correlation analysis, multiple linear regressions, principal component analysis, and logistic regression modeling (Li, *et al.,* 2020; Berihun, *et al.*, 2019). This method, however, is subjective and ignores the spatial relationship between driving factors and LULC changes, making it difficult to determine the underlying mechanism of these changes. The geographical detector is a statistical method for detecting spatial differentiation and identifying the factors that contribute to it (Wang, *et al.,* 2010) doing so without making too many assumptions, and overcoming the limitations of traditional linear statistical methods, such as correlation and regression (Phiri, *et al.,* 2019). As a result, geographical detectors are widely used to analyze the factors that drive vegetation change (Peng, *et al.,* 2019; Sati, 2015).

The factors that affect the change in land use and land cover can vary from one location to another. The majority of the population in North-east India is employed in the primary sector (Marchang, 2019; Sati and Lalrinpuia, 2016) which results in a large degree of deforestation. According to the survey conducted, of the total 10 villages (Bawktlang, Vanchengte, Lungchhuan, Lungpho, N. Mualcheng, Neihloh, Sailulak, Sialhau, Sialsir, Piler), every household had jhum cultivations on its agricultural land. Therefore, land use and land cover changes can be attributed to the many factors.

6.2 Major Factors of Land Use Land Cover Change

6.2.1 Mounting Population

A change in population size, distribution, and demographic characteristics is usually considered to be the most important factor that affects land use distribution and change (Turner and Meyer 1994). According to the interviewees of each household surveyed (1141 households), population growth is one of the factors contributing to the change in land use and land cover. According to the 2011 census, the population growth rate between 2001 and 2011 was approximately 20.56%. The increase in population will increase the demand for resources and have a detrimental effect on the existing natural resources. Increasing population has already strained the existing land resources by increasing the demand for food, wood for fuel and construction material, and other necessities. An increase in demand for food has resulted in an expansion of croplands that have encroached on uncultivated lands, including areas of forest cover. As a result, deforestation and soil degradation have occurred. In addition, in the absence of alternative sources of energy, there is an increase in the demand for fuel wood, which has resulted in the destruction of forests. Moreover, they have led to the increased use of crop residues and animal dung as fuel rather than as soil fertilizer to replenish soil fertility (Wubie, *et al.*, 2016). Comparing the two latest census data (2001 and 2011) we can see that there was an increasing population in the study villages (Table 6.1). In table 6.1 we can see that there is an increasing population almost all of the villages except Bawktlang and Piler village in which they have a negative growth rate. The average change percentage among the study villages were 3.73%.

Table 6.1: Population status of Serchhip district during 2001 to 2011

Village	2001	2011	Changes (2001-2011)	Change (%)
Bawktlang	530	319	-211	24.85
Vanchengte	88	130	42	19.27
Lungchhuan	611	710	99	7.49
Lungpho	814	1015	201	10.99
N.Mualcheng	1228	1423	195	7.36
Neihloh	301	345	44	6.81
Sailulak	748	850	102	6.38
Sialhau	555	630	75	6.33
Sialsir	311	333	22	3.42
Piler	359	319	-40	5.90
Total	5545	6074		

Source: Census of India, 2001 & 2011

6.2.2 Decreasing Area under Shifting Cultivation

Land use land cover change was influenced by cropping patterns. Shifting cultivation has been an important farming practice in Mizoram for centuries (Sati, 2022). This form of agriculture has been practiced exclusively for ages and continues to be widely practiced today. The majority of people living in the study area practice shifting cultivation; however, there has been a decrease in shifting cultivation areas during the study period. As shown in Table 6.2, the amount of jhum land decreased. In 2000, the current jhum land area was 146.73 km^2, in 2010, it was 69.38 km^2, and in 2018, it was 44.44 km^2. A decline in abandoned jhum land can also be seen in Table 4.2, where it was 144.54 km2 in 2000 and 59.12 km2 in 2018. As shown in Figures 6.1, 6.2, and 6.3, there was a decline in both abandoned and current jhum in Serchhip District in 2000, 2010 and 2018 respectively. Current Jhum land was higher in the northern part of the district in 2000, and it is still visible throughout the entire district. The current jhum land can be seen in the north and north-western parts of Serchhip district, and it was sparsely distributed throughout the study area in 2018. Similarly, the abandoned jhum land has been affected. In 2000, abandoned jhum land was more prevalent in the south-eastern parts of Serchhip district, but in 2010 the pattern changed and it was more prevalent in the south-western parts, and in 2018 it had a more even distribution throughout the study area. Therefore, the decline of abandoned and current jhum land will alter the land cover and also result in the change of land use in the study area. In addition to the remoteness of the Jhumlands both from settlements and markets, the low yields from agriculture, the shift from agriculture to service industries, and the high levels of climate variability are all contributing factors to this decline (Sati, 2022).

Table 6.2: Current and Abandoned Jhum cover change 2000-2018 (area in km^2)

LULC Classes	2000	2010	2018	Change (%)

				2000-18
Current Jhum	146.73	69.38	44.44	-69.71
Abandoned Jhum	144.54	126.39	59.12	-59.10

Source: USGS Earthexplorer

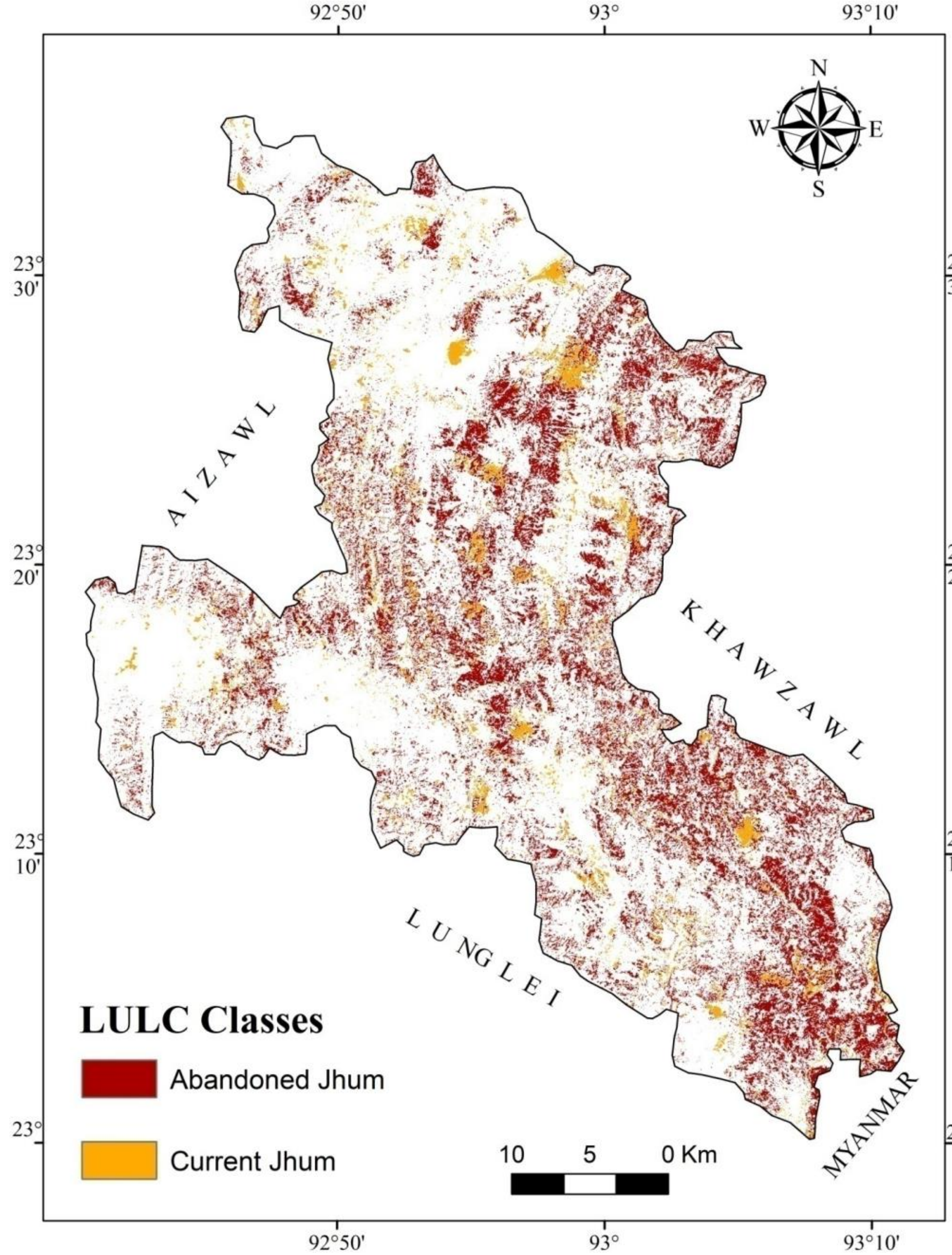

Fig. 6.1: Abandoned and Current Jhum of Serchhip District in 2000; Source: USGS, developed by the author

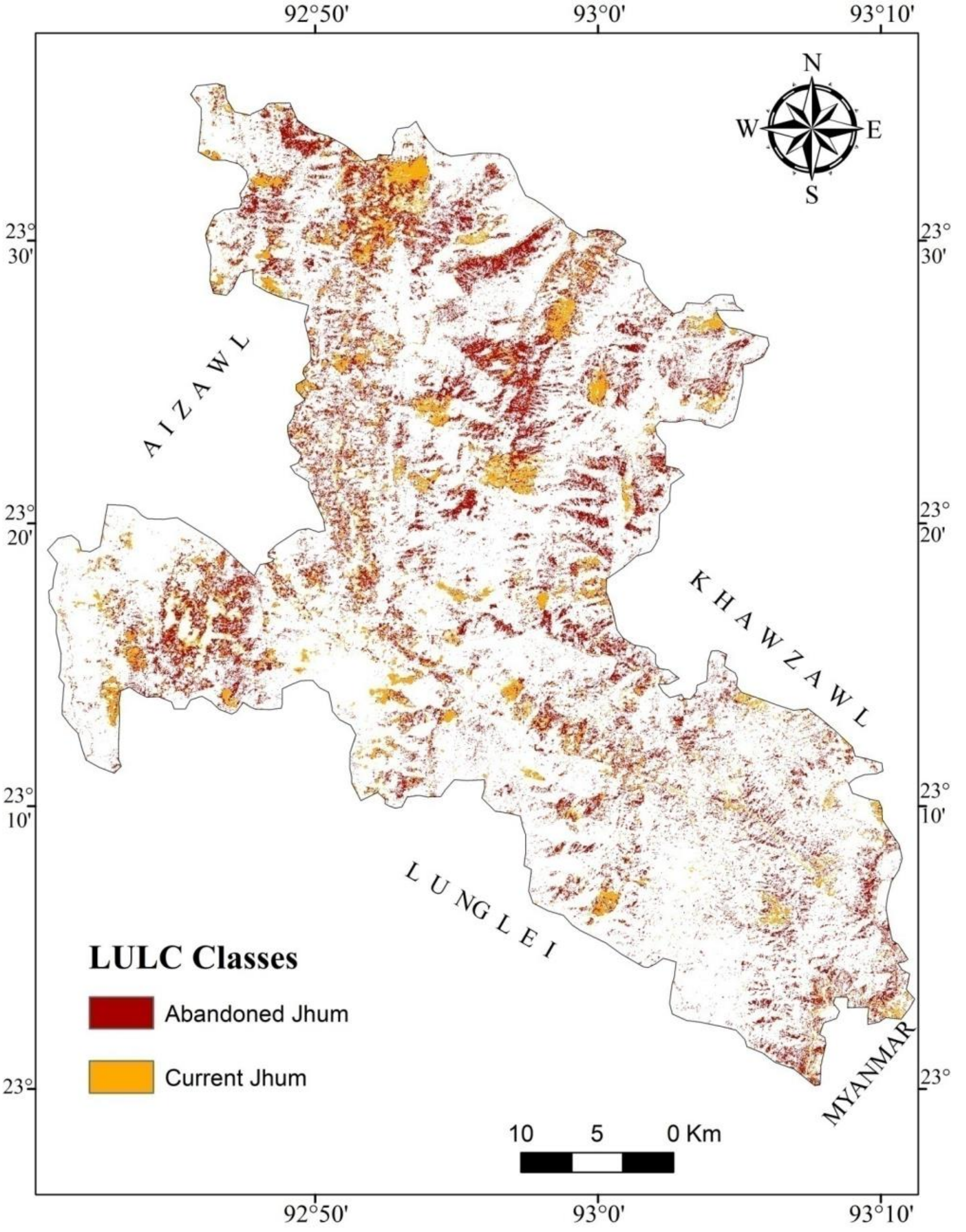

Fig. 6.2: Abandoned and Current Jhum of Serchhip District in 2010;
Source: USGS, developed by the author

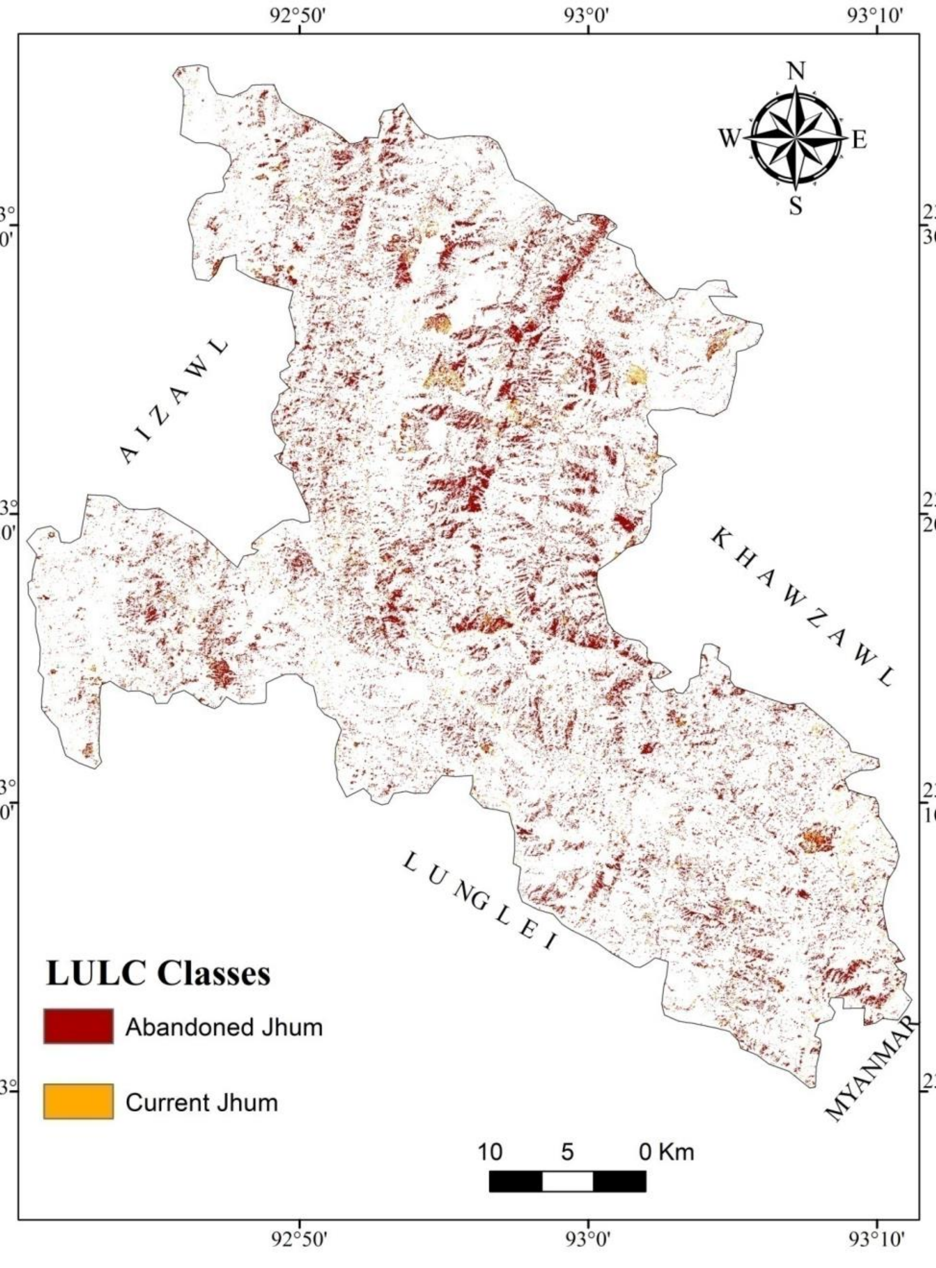

Fig. 6.3: Abandoned and Current Jhum of Serchhip District in 2018;

Source: USGS, developed by the author

6.2.3 Increasing Area under Permanent Agriculture

New policy which was introduced by the Government of Mizoram paved the way for the development of permanent agriculture in the whole Mizoram. Many families in the study area are shifting towards permanent agriculture especially after New Land Use Policy (NLUP) was introduced. A new land use policy (NLUP) was established in 1985 by the State Government with the objective of increasing the area under permanent agricultural cultivation. Even though the policy was not too effective, there was an increasing of permanent agricultural land in Serchhip district especially near mat river valley. During 2000, there was around 23.04 km^2 which was increased to 45.34 km^2 and from that it was again increased to 48.93 km^2 in 2018 (Figure 6.4). Most of the farmers are taking a side on the permanent agriculture rather than shifting cultivation, however, shifting cultivation is still the main cropping pattern in the study. Every year there is an increasing of permanent agriculture and this type of land use land cover change will still be in progress. Therefore, changing the cropping pattern from shifting cultivation to permanent agriculture is one of the main factors for the land use land cover change in Serchhip District. Figure 6.5 shows the orange plantation in the sudy area. Figure 6.6, 6.7 and 6.8 depicted the distribution of permanent agriculture land for the year 2000, 2010 and 2018 respectively. In all of the three-time series, permanent agriculture was found along the Mat river basin (Sati, 2020) which is also the occurrence of Wet Rice Cultivation (WRC) in this area.

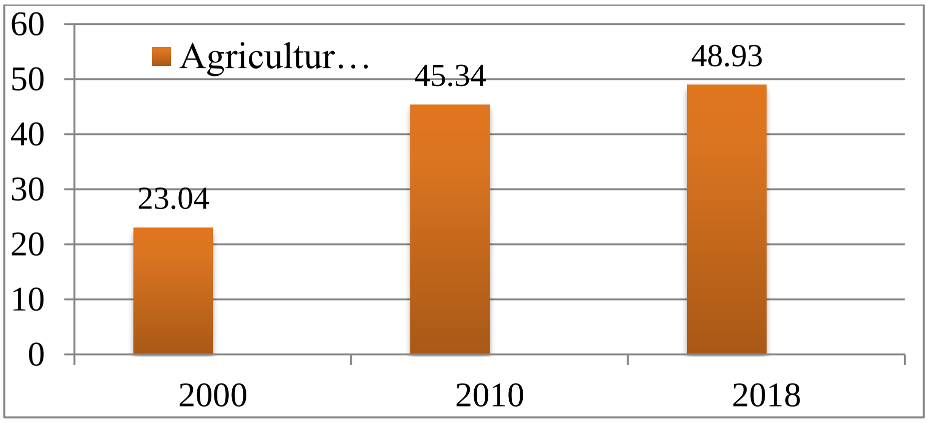

Fig 6.4: Agriculture land area during 2000 to 2018 of Serchhip District; Source: By author

Fig 6.5: Orange plantation near Sialsir village; Source: By author

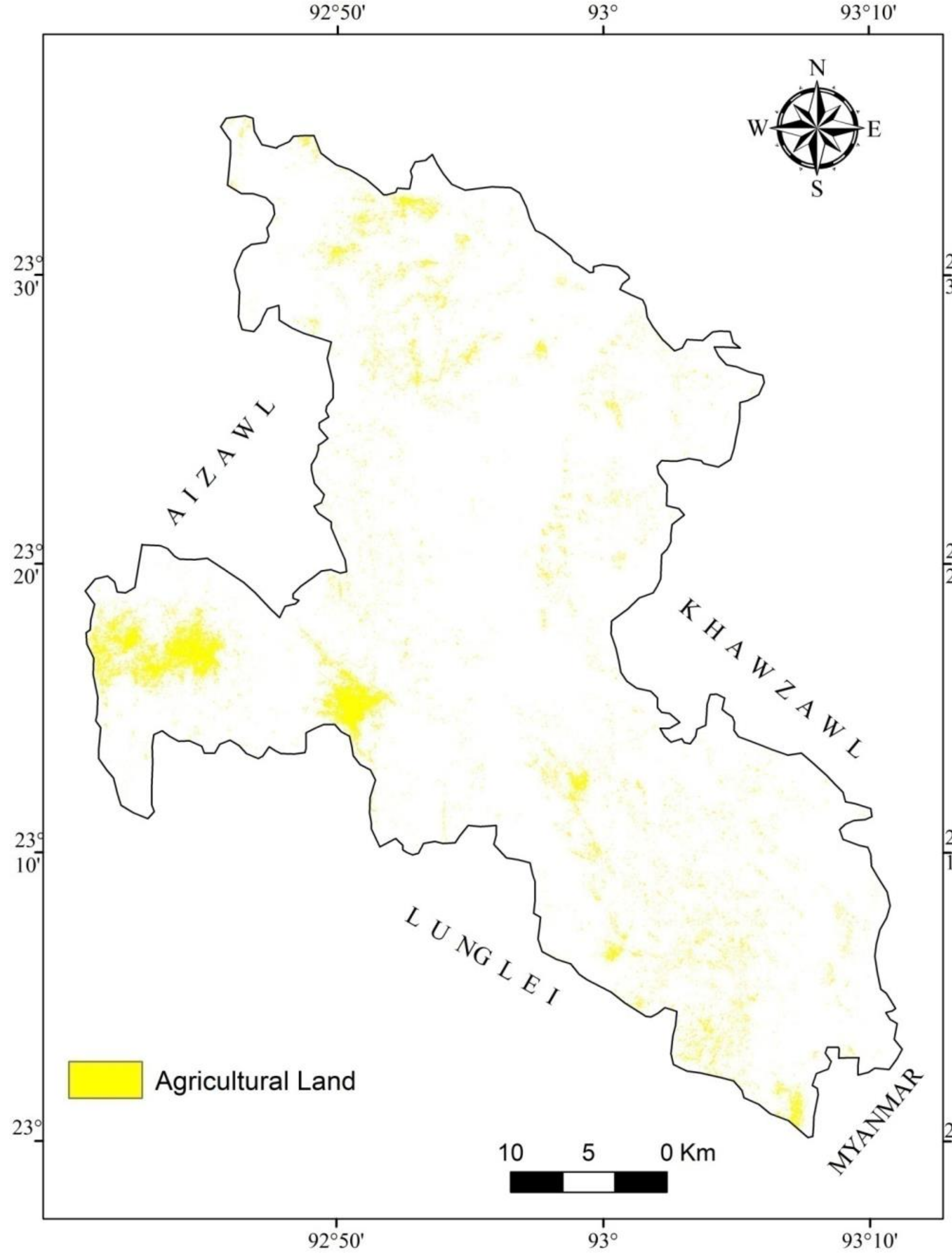

Fig. 6.6: Permanent Agriculture land map of Serchhip District (2000);

Source: USGS, developed by the author

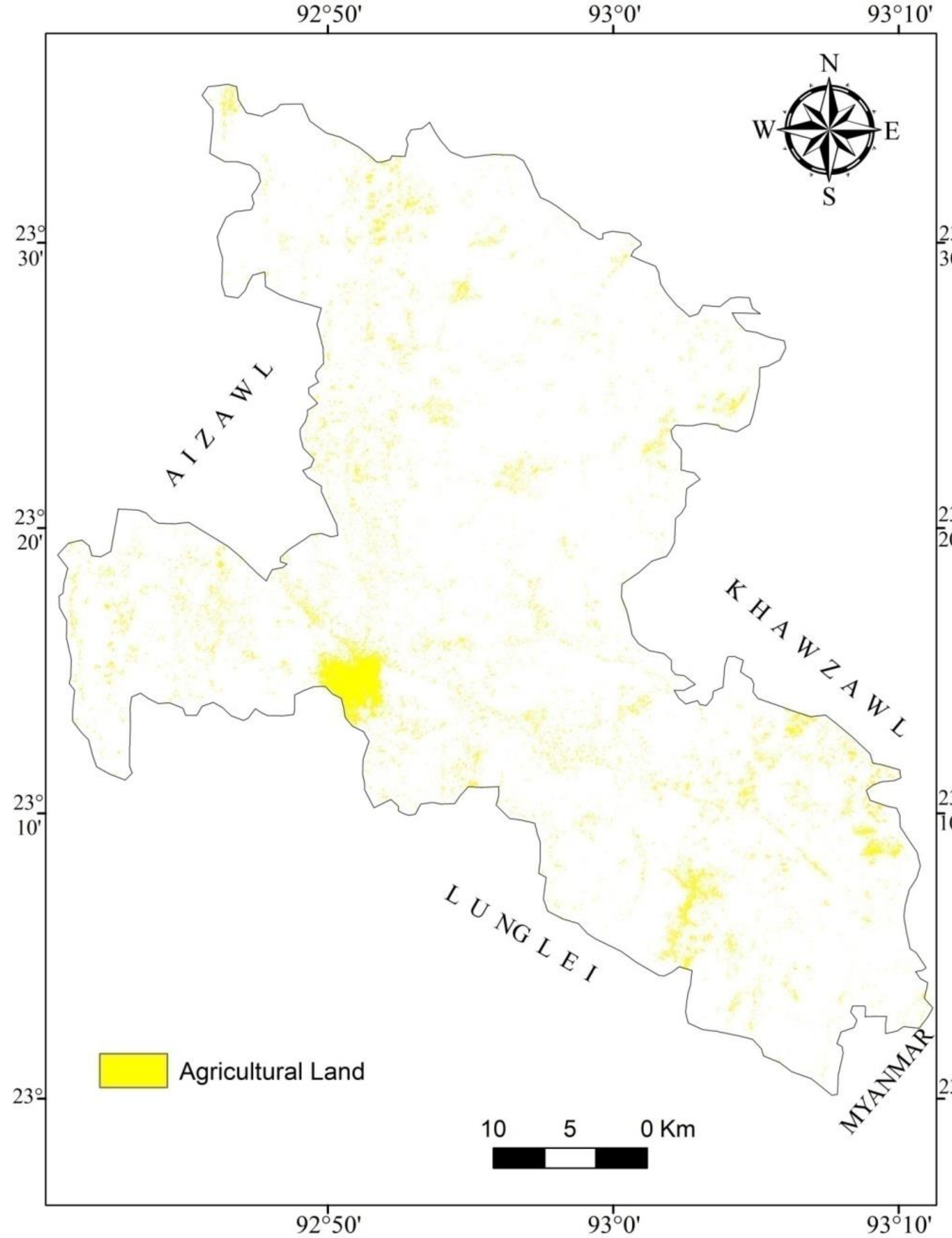

Fig. 6.7: Permanent Agriculture map of Serchhip District (2010);

Source: USGS, developed by the author

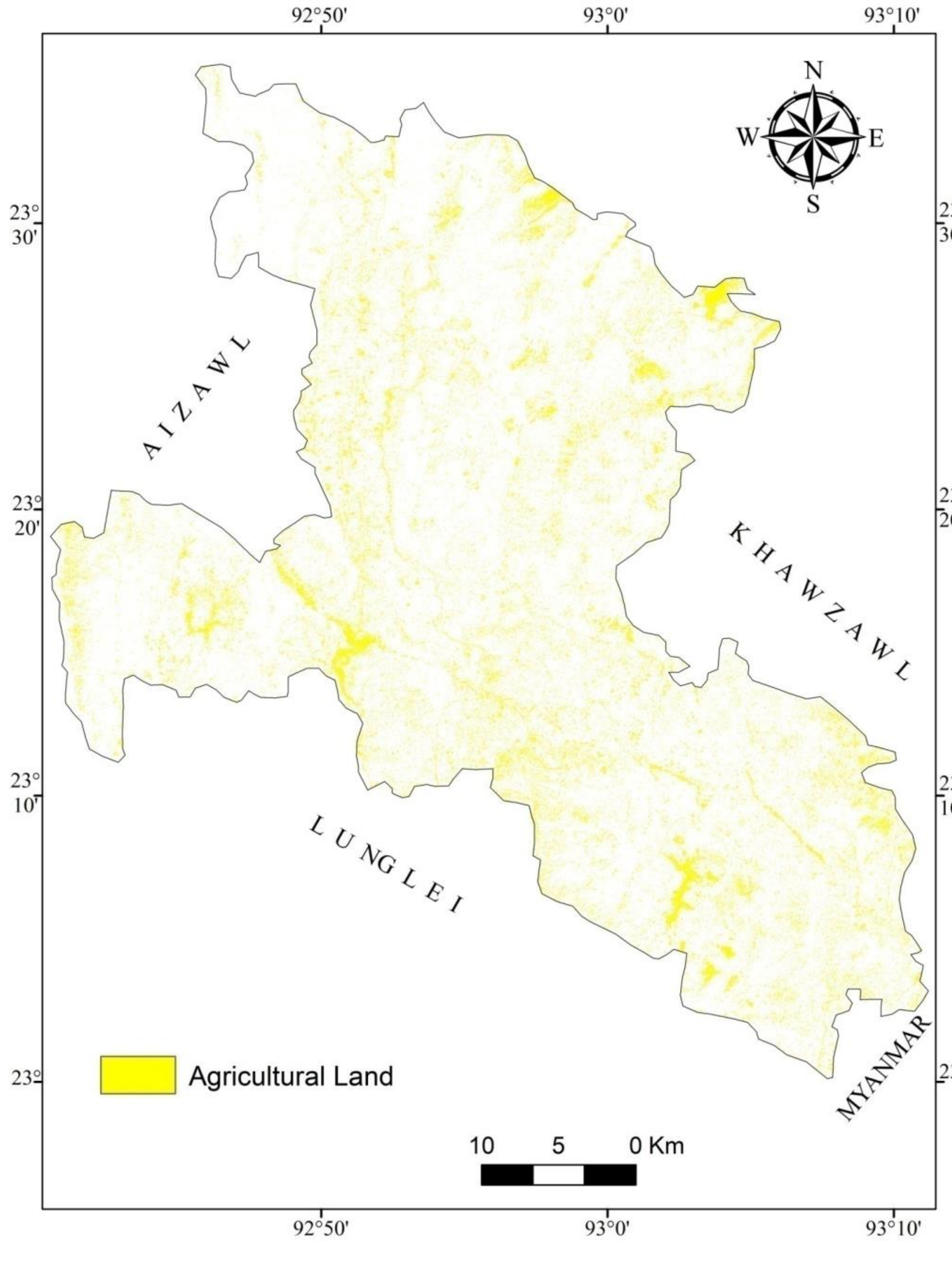

Fig. 6.8: Permanent Agriculture map of Serchhip District (2018);
Source: USGS, developed by the author

6.2.4 Increasing Forest Area

In Mizoram, forests constitute 19,283 km^2 of total forest and tree cover, representing 91.47% of the total geographical area (FSI, 2015). As a whole, Mizoram contributes about 2.43% to the total cover of trees and forests in the country. According to the India State of Forest Report, 2015, there is 0.017 km^2 of forest and tree cover per capita. Figure 6.7 represents the variation forest cover of Serchhip district during 2000, 2010 and 2018 in which during 2000 the dense forest cover was 228.94 km^2, medium dense forest was 221.43 km^2 and open forest was 247.5 km^2. In 2010, the dense forest cover was decreases to 185.94 km^2, medium dense forest was 223.39 km^2 and open forest was 217.95 km^2. In 2018, the dense forest cover was again decreases to 164.48 km^2, medium dense forest was 206.09 km^2 and open forest was 2224.2 km^2. The changed percent of forest cover area during 2000 to 2018 was that the dense forests cover area was increased with 8.11%, medium dense forest cover area was increased with 17.22% and open forest cover area was increased with 36.31%.

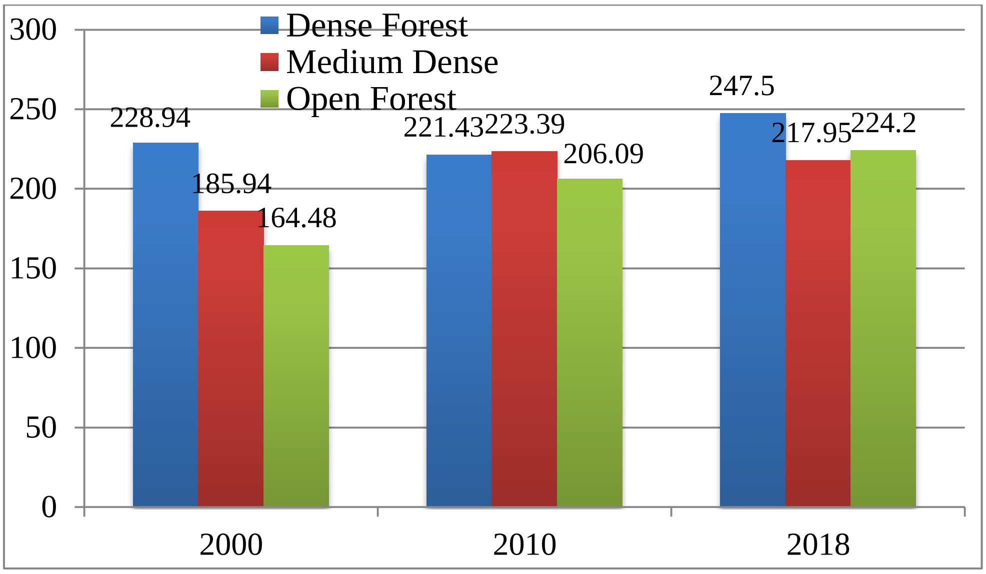

Fig. 6.9: Forest Cover of Serchhip District (2015); Source: By author

6.3 Conclusions

Land use Land cover changes had a different factor, it was broadly divided into two which were qualitative and quantitative categories (Belay, 2019). However, there are many factors influencing the changing of land use land cover, the factors can be different from place to place. In this study, we are having an in-depth study on the anthropogenic activities which results in the land use land cover change in Serchhip district. Four main factors which are population pressure, decreasing area of shifting cultivation, increasing area of permanent agriculture and increasing of forest cover area. The results show that all of the factors are linking with each other, the increasing of population results in the land cover change as majority of the people are farmers who are depending on the forest resources. There was a decreasing area of shifting cultivation in the study area which is the somehow the result of the Government policies. Both abandoned and current jhum land was declining during the study period (2000-2018). The decreasing of shifting cultivation results in the increasing of permanent agriculture, many farmers are shifting towards a more reliable cropping pattern which is permanent agriculture. The increasing of permanent agriculture was due to Government policy and is one of the factors for land use land cover change. Forest cover was divided into dense forest, medium dense forest and open forest. Increasing of forest cover area was surprisingly happen in the study area, this is mainly due to the decreasing of shifting cultivation and this result in the increasing forest cover area especially open forest.

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Chapter-7

Conclusions

The present study examined the land use and land cover change in Serchhip district, Mizoram. Land is define as "a delineable area of Earth's terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface, including those of the near-surface climate, the soil and terrain forms, the surface hydrology (including shallow lakes, rivers, marshes, and swamps), the near-surface sedimentary layers and associated ground water reserve, the plant and animal populations, the human settlement pattern and physical results of past and present human activity (terracing, water storage or drainage structures, roads, buildings, etc.)" (FAO, 1995). Land cover is defining as "the biophysical state of Earth's surface and immediate subsurface" (Turner, *et al.*, 1995). This term refers to the types of vegetation that cover the land surface as well as other aspects of the physical environment such as soils, biodiversity, surfaces, and groundwater, and even human structures like buildings or pavement. According to FAO, land use is defined as the purpose or function for which land is used by a population. "Land use" and "land cover" are not synonymous terms. Land cover refers to the physical, chemical, or biological classification of the terrestrial surface, such as grassland, forest, or concrete, while land use pertains to the activities associated with that cover, such as cattle rearing, recreation, or urbanization (Meyer and Turner, 1994).

Different literature was reviewed which are related to land use and land cover change of a different study areas. Different authors had a different opinion on the land use and land cover change. The methodology utilized was also different from time to time. Many researchers were largely depending on the satellite image whereas other senior researchers were depending on the primary survey. Most of the researchers are concentrating on anthropogenic activities. Other researchers like Meyer demonstrated that land use and land cover change was caused by natural phenomena like weather, flooding, fire, climate fluctuations, and ecosystem changes can also influence land cover. Comparison between two or more temporal images of a study areas are taken out and this type of study was also taken out in this paper. The inter-linkages between climate change and land use and land cover change was also highlighted. Understanding the land use and land cover change is important for the sustainable development. Internationally, many research paper were taken out on the land use and land cover change, whereas, in the study area i.e, Serchhip district, a very limited research were taken out. Some research paper regarding the land use and land cover change in the whole Mizoram were taken out in which a small portion of Serchhip district was highlighted. Study of land use and land cover change will be an important topic as there is a nonstop changing of land use and land cover. Therefore, a research should be taken related to land use and land cover change especially in different parts of the district in Mizoram. The study was based on the satellite image interpretations and a related techniques and it was also based on primary data conducted during 2022 covering 1141 household from 10 village councils representing approximately 47 per cent of the total household.

Serchhip District in India is divided into three physiographic categories based on elevation: High, Moderate, and Low structural hills. The low structural hills cover the largest area (45.08% of the total district area), while the high structural hills cover the smallest area (11.94%). The altitude ranges from 500 to 1880 meters above mean sea level (MSL). For conservation, development, and agriculture strategies, this diversity plays a major role in considering ecological characteristics, land use practices, and agricultural suitability. It is characterized by a diverse drainage system, with five main systems flowing through the region. The Tlawng and Tuichang Rivers are significant water bodies within the district, providing essential water resources and shaping the landscape. It is located in the Sub-Tropical Monsoon region and experiences a tropical humid climate with four distinct seasons: summer, rainy season, autumn, and winter. The temperature ranges between 10° C to 28° C from winter to summer. The winter season is typically cold and dry, with temperatures between 11° and 13° C. It receives heavy rainfall during the summer monsoon season from May to October and cyclonic rain in March, April, and November. This is due to its proximity to the Bay of Bengal. The district's annual rainfall is approximately 1688.80 mm. There is a humid temperate sub-alpine zone and the humid mild tropical zone. The former covers large areas in the west, northeast, and southwest. The latter is predominant in the eastern part, with a smaller portion in the north of the district. It has distinct geological features, with soils consisting of ferruginous sandstone, shale, and alluvial and colluvial materials. The district exhibits a variety of rock formations, including the Bokabil, Bhuban, and Barail formations. A fault zone located near Serchhip Town being an important geological event. Has a significant forest cover, with approximately 81.75 percent of its total area covered by trees. The forests include tropical wet evergreen and semi-evergreen forests, montane sub-tropical forests, and temperate forests, providing diverse biodiversity and ecological benefits to the region.

It has 40 villages and 3 notified towns, with an urban population of 32,019 and a rural population of 32,918, totaling 64,937 people. The district has a high literacy rate of 98.91%, ranking first among Mizoram districts and out of the 640 districts in India. Serchhip District's agricultural landscape is characterized by dominant crops like rice during the Kharif season, cabbage, orange, and banana during Rabi, and other crops like maize, soybeans, and cowpeas. Small-scale irrigation facilities are limited, leading to Jhum cultivation's continued popularity among the inhabitants. The primary occupation in the study area is agriculture, which provides income for a large portion of the population. Small towns in the district show a notable contribution from the tertiary sector, with public establishments and private enterprises playing a significant role in the local economy. Animal husbandry is a significant economic activity alongside agriculture, especially due to the high demand for meat and eggs. Poultry and pig farming are prevalent in households, and cattle and buffalo are also increasing in importance.

This study conducted household surveys in ten villages in Serchhip district, Mizoram. It collected empirical data on various socio-economic factors, including family size, education, occupation, income, and agriculture. A total of 467 households were randomly sampled. Structured questionnaires were used to collect information about cultivation areas, production, and yield of principal crops grown in shifting cultivation systems. The study also analyzed changes in land use and land cover in the study area, comparing data from 2000 to 2018. Descriptive statistics and bar diagrams were utilized for data analysis, and the per capita income from each main crop of shifting cultivation was examined in detail. It covered ten villages in

Serchhip district, representing about 9.35% of the total population. Out of the 1141 households in these villages, 472 households were surveyed. Data on family size and education levels were collected from the surveyed population of 2539 individuals. The majority of the surveyed population in Serchhip district (96.88%) were engaged in primary activities, including shifting cultivation and livestock farming, while a smaller percentage were employed in the secondary and tertiary sectors (2.95% and 0.17% respectively). The study examined crop data, focusing on paddy, chili, tobacco, ginger, and oranges under shifting cultivation. Paddy was the most prominent crop with increasing area and yield from 2000 to 2018. It was followed by ginger and oranges, while other crops showed varying trends in production and yield.

The study conducted a comprehensive analysis of land use and land cover changes in the Serchhip district from 2000 to 2018 using satellite imagery and GIS technology. It aimed to quantify and evaluate land cover changes over the specified period. The findings revealed a positive trend in forest cover expansion, except for a decline in bamboo forests. The study also identified an increase in scrubland, which requires careful planning and management strategies to address effectively. The results provide valuable insights for policymakers, land managers, and environmentalists to make informed decisions and implement sustainable land management practices. This will preserve the region's ecosystem and ensure the well-being of the local population and future generations.

The research identifies four main factors: population pressure, decreasing shifting cultivation, increasing permanent agriculture, and expanding forest cover. Population growth is linked to land cover changes as the majority of people in the area rely on forest resources for their livelihoods. The reduction in shifting cultivation can be attributed to government policies, leading to a shift towards more reliable permanent agriculture practices. Interestingly, the study reveals an unexpected increase in forest cover area, primarily in open forests. This is related to the declining use of shifting cultivation practices. Understanding these factors is essential for informed decision-making and sustainable land management in the region.

Recommendations

In Mizoram, shifting cultivation area decreased from 580 km^2 to 400 km^2 during the 1970s and 1980s. As well, the number of Jhumia families has declined from 50,000 to 40,000 despite an increase in the rural population from 0.33 million to 0.48 million (WAD, 1985). Approximately 1.5% of the total area is affected by shifting cultivation in Mizoram each year, resulting in a loss of forest resources of about Rs. 1 billion (Sati, 2014). The area under shifting cultivation has further diminished in recent years, and the fallow period has been reduced from 20-30 years to 3-5 years as a result of an increase in population (Patro and Panda 1994). In spite of the fact that shifting cultivation is one of the main sources of livelihood, it has adverse effects on the economy. The plots of Jhum are fragmented and small. They are located on rugged, precipitous slopes and are far from villages, which results in a relatively low production and yield of crops. Due to the increase in population and reduction in the fallow period, shifting cultivation has become an uneconomical activity (HARS, 2000). There has been a decrease in food shortages for more than five months as a result of decline in food production. As a result, the Jhumias have become increasingly dependent on forest products in order to maintain their livelihoods (DANIDA, 2000; Sutter 2000). In a similar manner, shifting cultivation has seen a decline in income (Showqi, *et al.*, 2014). It is therefore necessary to develop alternative suitable land use systems (Meyer, *et al.*, 1996). Due to the burning of large areas of forest, shifting cultivation is not suitable for faunal and floral resources. Poor land utilization systems are thought to be responsible for the loss of faunal and floral species. In general, it is considered to be the primary cause of deforestation (FAO, 1986).

The Mizoram Government adopted the New Land Use Policy in 1985. The main objective of the program was to convert shifting cultivation practices into permanent cultivation practices. The state government has reported that each Jhumia will receive approximately 7 acres of land (total of one hundred thousand Jhumias). The scheme has already provided benefits to a number of farmers. In response, crop production and the area of land devoted to permanent farming have increased. However, this policy did not take shape and as a result, many farmers have continued to practice shifting cultivation (Singh, 1992). Mizoram has tremendous potential for growing multiple crops in Mizoram due to its agro-ecological conditions. However, due to poverty, the poor would not be able to utilize the rich agro-biodiversity of the state. In addition, the farmers are not able to afford the investment necessary to convert their jhum lands into terraced fields. Many farmers face acute difficulties in earning a living as a result of the insufficient assistance they receive from the state government. When some policy-based approaches are framed and implemented, shifting cultivation can be sustainable and economically viable. Firstly, Jhum lands should be assigned to the farmers on an ongoing basis, so that they can prepare farmlands for permanent and sustainable agricultural practice. A priority should be given to cultivating cash crops. Intensive rice farming is possible in irrigated floodplains and river valleys through the use of system rice intensification techniques. Cash crops such as fruits, vegetables, and spices can replace traditional crops, which are economically unviable. Cabbage and ginger are two case crops in Mizoram that have significant potential. To facilitate the commercialization of these crops, the State Government can provide market facilities. In several Asian countries, shifting cultivation has been largely replaced by commercial agriculture in recent decades (Turkelboom *et al*., 1996). Market facilities can be provided for the export of ginger and cabbage to the regional market. A longer tenure of ownership of Jhum plots may be granted to farmers, thereby encouraging permanent agriculture and modern agricultural practices. Shifting cultivation should be discouraged, as it is environmentally unsound and economically unprofitable (Sati & Vangchhia, 2018).

In Mizoram, forest resources are used for a variety of purposes. The majority of people in this region are engaged in agricultural practices due to their economic backwardness. The local population therefore relies heavily on the forest resources as a source of timber and non-timber forest products (Sati, 2014). Mizoram's population is heavily reliant on forest products and services for its livelihood. The dependence on forest resources leads to challenges for forest resource management, particularly in and around forest protected areas. Mizoram's people rely heavily on bamboos and bamboo products for food, and a large portion of their population is dependent upon them. In the Mizo community, bamboo shoots are a popular food item. Bamboo is also used to construct houses in both rural and urban areas. Natural bamboo resources are abundant in the state of Mizoram. It is estimated that approximately

57% of Mizoram's geographical area is covered by bamboo forests, which are found at heights ranging from 400 metres to 1500 metres. Bamboo forests are widespread as dominant secondary vegetation along river banks and abandoned jhumland (Sati, 2014).

Mizoram practices forest resource management in a variety of ways. A community forest is conserved by the local people based on the principles of providing opportunities for extraction of goods in order to meet legitimate human needs and ensuring the sustainability of forest resources in the future (Sati, *et al.,* 2014). The management practice varies greatly, as it has developed under different biophysical and cultural conditions (Rinawma, 2003). Although scientific research on forest management practices in traditional and tribal societies lags behind, a few studies have examined the scientific basis for the use of sacred groves, home gardens, and agro-forestry here (Meyer and Turner, 1996). In Mizoram, forest resources are managed by two institutions - the state forest department and the community. The state forest department is directly responsible for approximately 66% of the forest lands. Forestry departments are structured from the state level down to the village level, where they meet the various needs of the people and are also responsible for implementing the rules related to forest conservation. State forests have been divided into reserved forests and protected forests, and 10 national parks and wild life sanctuaries have been established since 1994. All of these initiatives were taken in order to preserve Mizoram's economically viable forest resourcesThere has been a slight increase in forest land from the last three decades due to various efforts taken by the state government to conserve the forests (Uttam, *et al.,* 2018), there was an increasing of forest cover in the study area.

Land ownership to the farming community for cultivation can have significant implications for agricultural practices and rural development. By granting ownership rights, farmers have security and control over their land. This can lead to increased investment in farms and improved productivity. It may also incentivize sustainable land management practices, as farmers have a long-term interest in maintaining land fertility and health. Furthermore, land ownership can empower farmers economically and socially, allowing them to access credit and other financial resources to expand their agricultural activities and invest in modern farming technologies. This, in turn, can contribute to rural development and poverty reduction.

However, it's essential to consider the potential challenges and impacts of land ownership policies. This includes ensuring equitable distribution of land among farmers and avoiding land concentration in the hands of a few large landowners. Proper land-use planning and land tenure reforms are crucial to striking a balance between individual ownership rights and community interests. Overall, providing land ownership to the farming community can be a beneficial step towards fostering sustainable agriculture, rural development, and improving farmers' livelihoods.

Intensive Farming System (IFS) is an agricultural production approach that aims to maximize yields and productivity through the intensive use of resources and modern farming practices. It involves high-input agriculture, including chemical fertilizers, pesticides, and improved seeds, along with advanced irrigation and mechanization techniques. The key features of the Intensive Farming System include high crop densities, multiple cropping, and efficient water and nutrient management. This is to achieve higher yields per unit area. This system is often employed in areas with limited land availability and high population density, where food production demand is significant.

While IFS can lead to increased agricultural productivity and economic benefits, it also poses certain challenges and concerns. Over-reliance on chemical inputs can lead to environmental degradation, soil degradation, and water pollution. There may also be potential health risks associated with chemical pesticides and fertilizers. Sustainable intensification of agriculture is a crucial aspect of IFS, wherein modern technologies and practices are combined with environmental conservation and responsible resource management. Proper land-use planning, crop rotation, integrated pest management, and organic farming practices are some of the strategies employed to mitigate intensive farming's negative impacts and promote long-term sustainability. Balancing increased productivity benefits with environmental and social concerns is essential for Intensive Farming Systems. This is essential for food security and sustainable agriculture in the future.

The System of Rice Intensification (SRI) is an innovative agricultural methodology aimed at increasing rice productivity while using fewer resources. It is not a single technology but a set of principles and practices designed to improve rice cultivation. Key features of SRI include transplanting young seedlings (8-15 days old) to promote better root establishment and growth, advocating wider plant spacing to enhance tillering and reduce competition, and practicing intermittent irrigation to reduce water usage by up to 30-50%. Additionally, SRI encourages the incorporation of organic matter and compost into the soil to improve fertility and plant health. It relies on mechanical weed control rather than chemical herbicides, and promotes targeted nutrient management using organic sources. SRI has demonstrated success in various regions, increasing rice yields substantially, conserving water, and reducing production costs. As an eco-friendly and sustainable approach, it holds particular significance in areas facing water scarcity and resource limitations.

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HEAD

DEPARTMENT OF GEOGRAPHY AND RESOURCE MANAGEMENT

ABSTRACT

STUDIES ON LAND USE AND LAND COVER CHANGE IN SERCHHIP DISTRICT, MIZORAM

AN ABSTRACT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

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SCHOOL OF EARTH SCIENCES AND NATURAL RESOURCESMANAGEMENT

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Abstract

Studies on Land Use and Land Cover Change in Serchhip District, Mizoram

By

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Department of Geography and Resource Management

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Submitted

In partial fulfillment of the requirement of the Degree of Doctor of Philosophy in Geography of Mizoram University, Aizawl.

ABSTRACT

Land cover pertains to the observable characteristics of the Earth's surface, encompassing natural elements like forests, pastures, agricultural lands, as well as developed features such as urban areas and towns. On the other hand, land use refers to the utilization of these areas, whether for agricultural, residential, industrial, or other purposes, with the potential for dynamic changes over time. The combination of both land cover and land use changes is known as Land Use and Land Cover Change (LULCC), a significant contributor to global land degradation in recent years. The implications of LULCC are profound, affecting local, regional, and global environmental conditions, the carbon cycle, biodiversity, water resources, agriculture, and food security. Hence, scientists worldwide are deeply concerned about understanding LULC patterns and detecting changes to better address environmental security and sustainability issues. With the escalating rates and intensities of LULCC in the modern era, there is an urgent need for governments and businesses to comprehend the situation at hand and develop effective land management strategies. Accurate and up-to-date information on LULC changes and their dynamics is crucial for improving living conditions and standards in a sustainable manner, especially for impoverished rural populations highly reliant on land resources. By grasping the interplay between human activities and natural processes, policymakers and resource managers can devise intervention strategies and efficient land-use practices. This would enable responsible stewardship of land resources, preserving ecological balance, and mitigating the adverse impacts of LULCC on ecosystems and the environment. Therefore, understanding the intricate relationship between land cover, land use, and the associated changes is imperative for safeguarding environmental stability and ensuring the welfare of present and future generations. Sound knowledge of LULCC dynamics empowers societies to make informed decisions and adopt sustainable practices, ultimately leading to a more resilient and harmonious coexistence with the planet's ecosystems.

The recent enhancement of global Land Use and Land Cover (LULC) mapping and change detection is attributed to the utilization of advanced geographical information systems (GIS) and remote sensing technologies, as demonstrated by esteemed

researchers. Leveraging satellite imagery, particularly the comprehensive Landsat data, has proven instrumental in analyzing LULC changes across various spatiotemporal scales, benefiting from the implementation of sophisticated digital image processing algorithms developed among others, which allow for accurate image classification based on spectral, spatial, and multi-temporal information from diverse sensors.

The distinctive topographical attributes of India, encompassing a wide range of climates, soil types, and socioeconomic conditions, exert a notable influence on the intricate LULC variations observed throughout the nation. Notably, India's burgeoning population, surging from 200 million to 1.2 billion during the 20th century, and rapid economic development from the 1950s onward, have been pivotal factors contributing to shifts in the LULC sector. For instance, the country witnessed a decline in forest area from 100 million to 81 million hectares, while farmland expanded from 100 million to 120 million hectares between 1880 and 1950. Subsequently, carbon emissions related to deforestation and land use changes followed a similar temporal trend from 1880 to 2000.

Despite the significance of LULC patterns, comprehensive statistics and updated mapping of land use and land cover changes in India remain insufficient. The endeavor to address this knowledge gap has been pursued by both federal government bodies and individual states, with agencies such as the Survey of India, the National Atlas and Thematic Mapping Organization, and the National Bureau of Soil Survey and Land Use Planning playing pivotal roles in efficiently disseminating thematic maps and statistical data. Focusing on the northeastern region of India, this area boasts diverse agro-climatic conditions, distinct soil types, and irregular physical features, thus yielding unique LULC changes compared to other regions in the country. Owing to variations in cropping patterns and topographical factors, the land use and land cover changes in the northeastern region are distinctive and complex. Additionally, the prevalence of indigenous communities in this region has influenced land usage practices, with agriculture being a prominent occupation contributing to significant declines in forest cover and escalating deforestation.

Shifting cultivation in Mizoram, India's fifth smallest state with an area of 21,087 square kilometers, the region experiences tropical and sub-tropical climates characterized by dry winters from November to February and monsoon rains from May to September. As a result of its rugged topography dominated by mountains and hills, around 60% of Mizoram's population is engaged in agriculture and its allied activities, with approximately 63% of the total crop area devoted to Jhum Cultivation. Notably, the cropping pattern and primitive agricultural practices play a significant role in driving land use and land cover changes in. A detailed examination of Mizoram's forest cover reveals fluctuating trends. In 2005, the state's forest cover area was estimated to be 18,684 km^2, accounting for 89.24% of its landmass. By 2015, forests covered 18,748 km^2, representing 88.93% of the state's total land area. During this period, the area covered by dense forest, moderately dense forest, and open forest were 138 km^2, 5,858 km^2, and 12,752 km^2, respectively.

Overall, the application of GIS and remote sensing technologies has significantly advanced LULC mapping and change detection on a global scale, enabling a deeper understanding of the complex interplay between human activities and environmental dynamics. The case of India, with its diverse landscape and socioeconomic complexities, presents a compelling example of how these technological advancements can aid in the formulation of effective land management strategies and conservation efforts to promote sustainable development and protect invaluable ecosystems. Similarly, the examination of LULC changes in Mizoram exemplifies the critical role of cropping patterns and agricultural practices in shaping regional landscapes, reinforcing the need for holistic approaches to balance developmental aspirations with environmental preservation. With the continued evolution of GIS and remote sensing technologies, ongoing research in LULC mapping and change detection promises to foster a more comprehensive understanding of the Earth's dynamic land cover and usage patterns, enabling informed decisions and policies to safeguard the planet's ecological integrity for future generations.

The issue of land use and land cover change (LULCC) has garnered global attention as a matter of utmost concern. Recent advancements in technologies, particularly Remote Sensing and Geographic Information Systems (GIS), have facilitated a comprehensive exploration of the complexities surrounding LULCC. The interplay between land use and land cover creates intricate relationships, where changes in one aspect significantly impact the other, underscoring the criticality of studying LULCC across all regions worldwide. In the specific context of Mizoram, a significant proportion of the population heavily relies on agriculture production, predominantly practicing shifting cultivation as the prevailing cropping pattern. However, this traditional practice has resulted in forest degradation and environmental alterations, thus instigating consequential land use and land cover changes in Serchhip district, situated within the boundaries of Mizoram.

The scenario in Mizoram underscores the broader importance of investigating LULCC dynamics, as it epitomizes the delicate equilibrium between human activities and their ecological ramifications. To effectively address these challenges and foster sustainable development, it becomes imperative to adopt prudent land management practices and informed policy measures. By leveraging advanced technologies like Remote Sensing and GIS, researchers and policymakers can vigilantly monitor and respond to LULCC, thereby ensuring the preservation of biodiversity and environmental stability in the region. In embracing these innovative tools, the local communities and the ecosystem can thrive in a mutually beneficial manner, paving the way towards a resilient and sustainable future.

Serchhip District is located in the central part of the state, bounded by the geographical coordinates between 23°35'N and 23°00'N latitude and 92°41'E and 93°10'E longitude. It shares borders with Aizawl district to the north and northwest, Lunglei to the south, Myanmar to the southeast, and Khawzawl district to the east. The district is demarcated by the Tuikum and Mat rivers, serving as its natural boundaries. Encompassing a total land area of 1,421 square kilometers, Serchhip comprises approximately 42 villages and two Rural Development Blocks. According to the Census of India in 2011, Serchhip district is home to a population of 64,937 individuals, consisting of 32,851 males and 32,086 females. The district exhibits an average population density of 46 persons per square kilometer. Impressively, the literacy rate in the district stands at 97.91%, surpassing the state average of 91.58%. Serchhip district falls under the tropical monsoon climate zone in India.

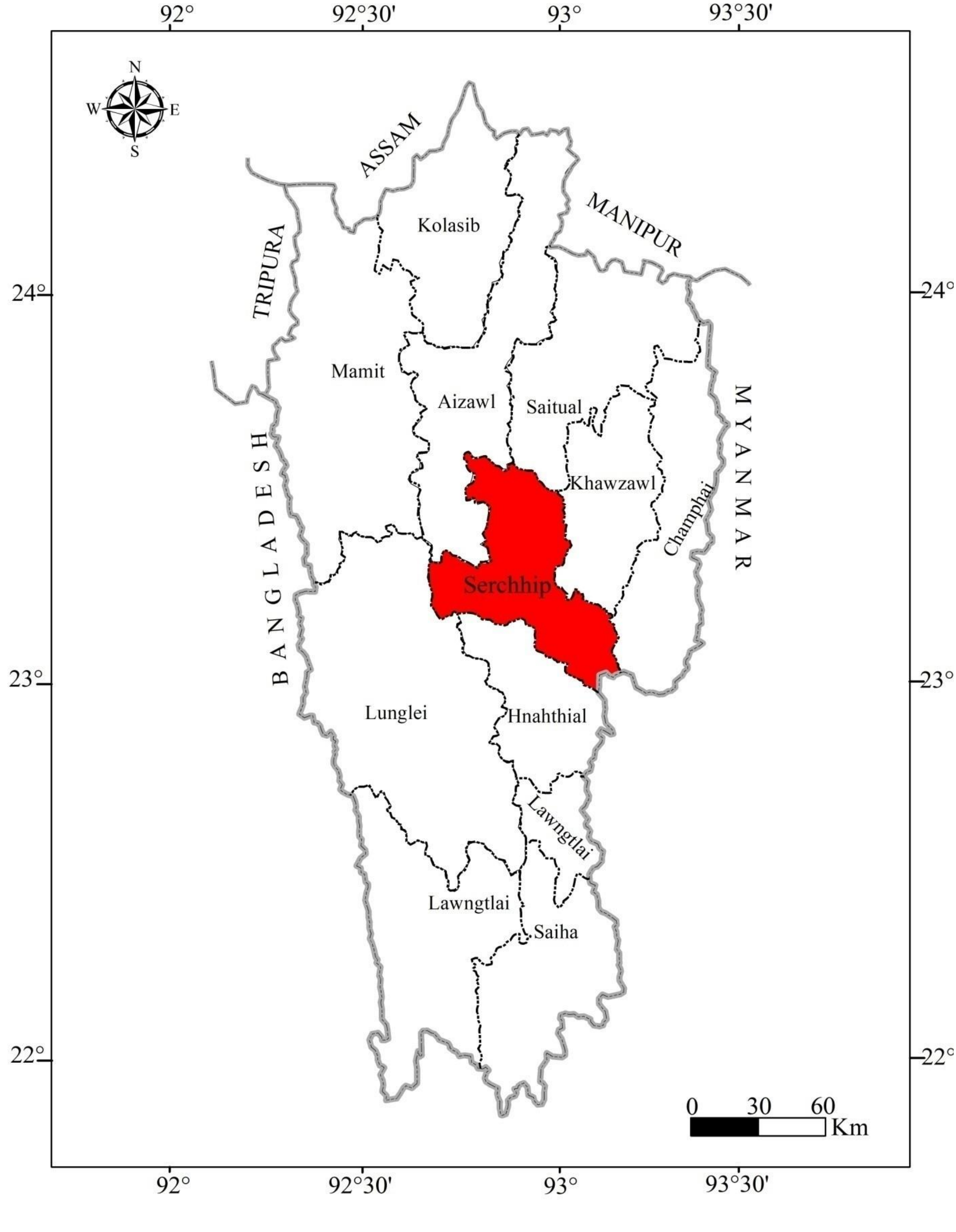

Figure 1: The study area; Source: By author

In this research, a comprehensive approach encompassing both qualitative and quantitative methods were employed. The data compilation process drew upon primary and secondary sources, ensuring a robust and comprehensive dataset. The investigation was centered on ten villages situated within the Serchhip district, consisting of four villages in the Serchhip R.D. Block and six in the E. Lungdar R.D. Block. The selection of these specific villages took into account considerations of accessibility and population size, providing a representative sample for the study.

To gather detailed insights, a thorough survey was conducted, covering a total of 467 households from the selected villages, representing approximately 47% of samples from each village. The researcher conducted interviews with the heads of these households, employing standardized questionnaires designed to elicit valuable information regarding cropping patterns, crop diversity, crop yield, and the awareness of land use and land cover change. Additionally, demographic data pertaining to age, sex, education, income, and employment status were also collected, enhancing the richness of the dataset. As an essential component of the research, the geographic coordinates (latitude, longitude, and elevation) of each community's location were diligently compiled using GPS technology. This geospatial information provided valuable context and reference points for the study.

Table 1: Demographic Features of Study Villages

Village	Total Population	Total Households (2011 Census)	Surveyed households	% of total households	Sex Ratio (Female/thousand Male)	Family Size
Bawktlang	319	64	42	64.1	93.3	4.79
Vanchengte	130	27	20	70.4	78.8	4.65
Lungchhuan	710	138	50	36.2	106.7	5.54
Lungpho	1015	181	51	27.6	100	5.41
N.Mualcheng	1423	267	80	29.6	109.7	5.16
Neihloh	345	62	38	59.7	101.7	6.21
Sailulak	850	170	46	26.5	110.3	5.3
Sialhau	630	111	67	59.5	109.2	5.4
Sialsir	333	57	41	70.2	109.7	5.83

Piler	319	64	37	62.5	85.8	5.68
Total/average	6074	1141	472	47	100.5	5.40

For a comprehensive analysis of land use and land cover dynamics, satellite images from the Landsat Thematic Mapper (TM) 4-5 and OLI/TIRS C1 level-1 sensors, spanning the years 2000, 2010, and 2018, were harnessed from the USGS Landsat archive. These high-quality images were instrumental in the classification of land uses and land coverings, in line with the methods established by Tucker et al. (1985). The integration of satellite imagery and ground-level data enabled a holistic understanding of the changing landscape and its implications for the studied region.

A variety of statistical techniques, such as mean, median, and percentiles, were employed to analyze the data comprehensively. Graphical representations in the form of bar diagrams were utilized to visually present the findings. Additionally, the research drew on various secondary data sources, including government reports, archives, and the latest census data from 2011.

To create Land Use and Land Cover (LULC) maps, the study utilized ArcMap 10.4® and employed a supervised classification technique with a maximum likelihood algorithm. To ensure the accuracy and reliability of the classification process, rigorous assessment methods were implemented, including user accuracy assessment, producer accuracy, overall accuracy, and the Kappa coefficient. These assessment measures were crucial in validating the precision of the generated LULC maps. By employing this wide range of statistical techniques and assessment measures, the research aimed to yield robust and credible insights into the dynamic patterns of land use and land cover changes within the studied area. The combination of primary and secondary data, along with advanced spatial analysis techniques, contributed to the comprehensiveness and accuracy of the research findings.

Serchhip District in India is categorized into three physiographic regions based on elevation: High, Moderate, and Low structural hills. The largest area is covered by the Low structural hills, accounting for 45.08% of the total district area, while the High structural hills cover the smallest area at 11.94%. The variation in elevation between 500 to 1880 meters above sea level (MSL) plays a pivotal role in influencing ecological traits, land use patterns, and agricultural suitability, rendering this diversity essential for conservation, development, and agricultural strategies. Notably, the district boasts a diverse drainage system with five main river systems flowing through the region. Among them, the Tlawng and Tuichang Rivers are significant water bodies that contribute vital resources and significantly shape the landscape. The study area experiences a subtropical monsoon climate, characterized by four distinct seasons - summer, rainy season, autumn, and winter. The annual temperature fluctuates between cold and hot, with winter temperatures ranging from approximately 11 to 13 ºC, accompanied by dry and chilly conditions. During the summer monsoon season from May to October, the region receives heavy rainfall, while cyclonic rains occur in March, April, and November due to its proximity to the Bay of Bengal. The district's annual rainfall averages around 1688.80 mm.

The ecological landscape of Serchhip District exhibits significant forest coverage, with approximately 81.75 percent of the total area occupied by trees. These forests encompass tropical wet evergreen and semi-evergreen forests, montane sub-tropical forests, and temperate forests, providing diverse biodiversity and ecological benefits to the region. The district comprises 40 villages and three notified towns, with a total population of 64,937 individuals, showcasing a high literacy rate of 98.91%, ranking it first among Mizoram districts and in India. Agriculture dominates the economic landscape, with prominent crops such as rice during the Kharif season, cabbage, orange, and banana during Rabi, and other crops like maize, soybeans, and cowpeas. Jhum cultivation remains popular, primarily due to limited small-scale irrigation facilities. Additionally, animal husbandry, especially poultry and pig farming, significantly contributes to the local economy alongside agriculture.

This study conducted comprehensive household surveys in ten villages located in Serchhip district, Mizoram. It diligently gathered empirical data encompassing various crucial topics such as population demographics, education, employment, income, and agriculture, among others. The selection of 467 households for the study was random, ensuring a representative sample.

Structured questionnaires were utilized to systematically collect data on the extent of cultivated areas, crops harvested, and yields of major crops cultivated under intermittent farming practices. Additionally, the research evaluated changes in land use and land cover within the study region by comparing data from the years 2000 and 2018. The study employed descriptive statistics and bar charts to analyze the average earnings derived from the three most significant crops cultivated by nomadic farmers. The crops under focus included paddy, chili, tobacco, ginger, and oranges, cultivated under shifting cultivation systems. Notably, paddy emerged as the primary crop, displaying an increase in both area and yield from 2000 to 2018. Ginger and oranges followed suit, while other crops exhibited varying trends in production and yield. It encompassed ten villages in Serchhip district, representing approximately 9.35% of the total population. Out of the 1141 households in these villages, 472 households were surveyed, providing valuable data on family size and education levels from the surveyed population of 2539 individuals. The majority of the surveyed population in Serchhip district (96.88%) were engaged in primary activities, primarily shifting cultivation and livestock farming, with a smaller percentage employed in the secondary and tertiary sectors (2.95% and 0.17%, respectively).

The research identifies four principal factors contributing to land cover changes in the study area: population pressure, a decline in shifting cultivation, an increase in permanent agriculture, and an expansion of forest cover. The growth of the local population has a direct impact on land cover transformations, as the majority of inhabitants heavily rely on forest resources for their livelihoods. The diminishing practice of shifting cultivation can be attributed to government policies that have prompted a shift towards more reliable and permanent agricultural methods. Interestingly, the study uncovers an unexpected rise in forest cover, particularly in open forest areas, which is associated with the declining popularity of nomadic farming techniques. In order to make well-informed decisions and ensure sustainable land management in the region, it is imperative to comprehend and acknowledge these factors influencing land cover changes. A comprehensive understanding of the intricate relationships between population dynamics, agricultural practices, and forest expansion is critical for effective and sustainable land use planning and resource management.

The altitude within the region ranges from 500 to 1880 meters above Mean Sea Level (MSL), as indicated in Figure 3.4 sourced from the ICAR report of 2015. This range signifies a considerable difference in elevation and underscores the topographical diversity present in the area. Notably, the study area exhibits distinct altitude patterns in different parts. The northern and southern regions, in particular, stand out for their high altitudes, particularly near the Myanmar border. These elevated areas may be characterized by rugged terrains, steep slopes, and potentially cooler climatic conditions. Geographic features can significantly influence local ecosystems, including vegetation types, wildlife habitats, and microclimates.

The district is drained by the Tlawng or Dhaleswari River and the Tuichang River. Serchhip district drainage system was divided into five drainage system that flow through the district, namely Tuipui drainage system, located within Serchhip district. Tuipui drainage system drains only the south-eastern portion of the district. Zawngtah lui, Arsi lui, and lengthuam lui are some of its important tributaries within the district. Zuva lui drainage originates from Lailen mountain near East Lungdar village, which is approximately 1445 meters above mean sea level, and flows southward, parallel to the Tupui river, until it becomes part of Tiau river in the south. A number of smaller tributaries flow into it, the most notable of which are Dilkawn lui, Saisiak lui, Sehung lui, and Mauhak lui. Among the drainage systems in the district, Tuichang I & II is the largest. The river originates from the Darngawn mountain near Khawzawl town at a height of 1449 metres above mean sea level. In the mid-western part of the watershed, Tuikum lui and Tuisang lui are the most important tributaries of Tuichang, while the most important ones in the southern part of the watershed are Varhva lui, Chekawn lui, Tuiphal lui, Maicham lui. Nghalrawh lui, Tuikau lui, Tuiphar lui, Kharzawl lui and Kawlkulh lui are the most important rivers. Mat drainage system originates at a height of 1590 m above mean sea level near Baktawng village in Serchhip district and flows southward until it confluences with Chhimtuipui river in Lunglei district. The river formed a considerable portion of the western boundary of the district with Aizawl district. Within the district, its main tributaries include Hmawngawn lui, Tuicher lui, Lumtui lui, Matvate lui, and Darnam lui. The Tlawng drainage system is one of Mizoram's most important rivers and is the longest river in the state. Flowing northwards, it originates from Zopui mountain, near Lunglei town, at a height of 480 meters above mean sea level. During its course, it passes through five districts of the state, forming district boundary lines in the process. In the south-western part of the district, it formed a boundary between Serchhip and Aizawl districts. Lak lui and Tuihnial lui are important tributaries of Tlawng river before it enters Aizawl district from Serchhip.. The total lengths of perennial streams are 1184.09 km and the total length of non-perennial streams are 5075.66 km. The district does not have any natural ponds or lakes. Parallel and trellis patterns are evident in the major drainage system, a dendritic drainage pattern is predominant, and there is a high degree of dissection.

Located in the Sub-Tropical Monsoon region, the Serchhip District is influenced by the tropical humid climate with moderate winters and pleasant summers. According to the climate classification by the Department of Environment & Forest, Govt. Mizoram, there are four climate seasons: summer from March to May; rainy season from June to August; autumn from September to October; and winter from November to February. The temperature between winter and summer varies between 10^o to 28^o C. There is usually a cold and dry winter. Winter temperatures vary between 11^o and 13^o C in general. Mizoram generally receives rain from monsoons during the six months of the summer season from May to October. Further in March and April and in November it receives cyclonic rain. Owing to its proximity with the Bay of Bengal the rainfall both monsoonal and cyclonic is heavy. The intensity of rainfall has been markedly influenced by climate disturbances in the Bay of Bengal. Approximately 1688.80 millimeters of rainfall are received annually in the District.

In the southern portion of the district, valley fills are alluvial and colluvial patches that are unconsolidated and of limited extent. Geologically, the soils in the district are made up of ferruginous sandstone, shale, alluvial and colluvial materials that get transported by rivers and streams. In general, the soil formations have been classified into colluvial soil which is formed along steep side slopes due to accumulation of material on the slope surface, and alluvial soil, which is found in valley fill areas along the river/ stream courses and terraces, is a deep, thick soil which is susceptible to erosion due to its topography. Rocks are hard, compact, and alternate with soft rock. A few of the geological formations that can be found in Serchhp District include the Bokabil formation, the Bhuban formation, and the Barail group.

Serchhip district forests type are tropical wet evergreen and semi-evergreen forests, montane sub-tropical forests, temperate forests. Forests of tropical evergreen and semi-evergreen species are often found below an altitude of 900 meters and provide a great deal of biodiversity to the State. Generally, these forests are found on steep slopes, along rocky and steady river banks, or in areas not suitable for shifting cultivation. Forests classified as evergreen or semi-evergreen are difficult to differentiate since they occur in areas with similar characteristics. A tropical wet evergreen forest can usually be found in the central and western parts of the study area, whereas semi-evergreen forests can be found in the northern, north-eastern, and central parts of the study area.

According to 2011 census, there are 40 villages and 3 notified towns in the district, two Rural Development Blocks are located within it namely Serchhip and East Lungdar. Serchhip district has a population of 64,937 out of which 32,851 are males and 32,086 are females with an urban population of 32,019 and a rural population of 32,918. In the period 2001-2011, the rate of decadal growth in population was 20.56 %. The density of the population is 46 persons per km^2. Chhingchhip Village, with a population of 3,741 persons, is the most populous village in this district, whereas Tuichang Village, with a population of 27, is the least populous. The total numbers of workers in this area, including both main and marginal workers are 32397. Serchhip has a total literacy rate of 98.91% with 54,470 total literates. This means that 98.76 out of 100 persons over the age of 6 years are literate. Among the 8 districts of Mizoram and out of the 640 districts of India, it is ranked number one in terms of literacy rate. Among males, the literacy rate of Serchhip stands at 27,598 (99.24%), while among females, it stands at 26,872 (98.28%).

There are 21804 cultivators, 1284 agricultural workers, 926 household industry workers, and 8383 other workers among the total population. There are 154.75 km^2. Of gross cropped land in the District with a cropping intensity of 125%. During the Kharif seasons, rice dominates the farmland of the district, occupying 40% of the total area cultivated. Maize represents 9.33% of the total gross crop area. The Kharif season is also a time when soyabeans, pumpkins, and cowpeas are important crops to grow. Mizoram produces an extensive amount of cabbage during Rabi, with Serchhip constituting the largest source of cabbage. There are also other crops that are grown during Rabi, such as brinjal, tomato, carrot, and knol-khol. Among the horticultural crops, orange cultivation is very popular; E. Lungdar Block has produced a large number of oranges that it has become the largest source of oranges in Mizoram. Bananas are also an important crop in the district today.

Agriculture and related activities are the main occupations of the people in the District, which is dominated by the primary sector. Serchhip, the largest town, employs nearly half of its workforce in primary activities. A sectoral distribution of output can also be seen as a reflection of the economic condition of these towns. Market-oriented cropping (market-based gardening) and animal husbandry are the two primary activities in small towns with the highest productivity. More than two-thirds of the total output in these towns is attributed to the tertiary sector, which includes public establishments and private enterprises. The public sector plays an important role in creating employment opportunities. It has been observed that in urban economies, government employees and businessmen often plant crops in neighboring areas of the town during their free time in order to supplement their incomes or to obtain food items from farms for their households. There are a number of government employees and businessmen who own agricultural land. There are a variety of occupations available in these towns such as animal husbandry, subsistence farming, animal rearing, foraging, carpentry, etc. Pig farming (only one or two pigs) and poultry farming (only 10-20 hens) are very popular in small towns. There is a strong influence of the urban economy on the rural economy as a result of the complexity of the urban economy.

Land use and land cover change (LULCC) is the process of changing the earth's surface by human activity. Humans have been altering land for thousands of years to get livelihoods and other necessities, but today's extent, intensity, and rate of LULCC are higher than ever. Globally, these changes are driving unprecedented changes to ecosystems and environmental processes on a local, regional, and global scale. It is thus crucial to analyze LULC changes today in order to prepare forecasts and decision-making on ecological management and future environmental planning based on data available on these changes. The change in land use and land cover is perhaps the most visible form of global environmental change since it impacts our daily lives on a spatial and temporal scale. There is a technical distinction between changes in land use and changes in land cover. A change in land use or land cover means a quantitative change in the area of a given land use or land cover (increase or decrease). In addition to anthropogenic factors, there are also environmental and climate driven factors that play a role in changing land use and land cover. Land use change in various spatial and temporal domains is an example of the material expression of these changes, and it also depicts the dynamics of the environment and the development of the human species in relation to land availability. A number of empirical studies conducted by researchers from a wide variety of disciplines have shown that changes in land use/land cover have become key to a wide range of applications, including agriculture, the environment, ecology, forestry, geology, and hydrology. Aside from changing the physical dimensions of the spatial extent of the land use and land cover classes, land use and land cover changes also influence large numbers of secondary processes that lead to the eventual degradation of earth's ecosystem. The most significant impact of changes in land use and land cover is the reduction of vegetation cover. Consequently, the loss of vegetation cover has many deleterious effects on the environment, including loss of biodiversity, climate change, changes in radiative forcing, pollution of other natural ecosystems with a reduction in their quality, and changes in hydrological regimes.

A variety of factors influence land use and land cover changes, acting not in isolation but in complex interplay with the environment at different spatial and temporal scales. It is unprecedented to witness the speed, magnitude, and range of human alteration of the Earth's surface. A thorough understanding of the factors that affect land use and land cover change is essential for researchers, policy makers, and land managers in order to make appropriate decisions. By analyzing the driving forces, it is possible to determine the process by which LULC is changing and to identify regional ecological changes in the environment. Many factors influence the LULC over time and space, including society, economics, and the natural environment. It is possible to categorize LULC changes into qualitative and quantitative categories. A qualitative analysis can only provide a general perspective on LULC development trends and driving factors. As a result, it is difficult to estimate the extent to which each factor influences changes in LULC. For clarifying the relationship between driving factors and LULC changes, quantitative methods include correlation analysis, multiple linear regressions, principal component analysis, and logistic regression modeling. This method, however, is subjective and ignores the spatial relationship between driving factors and LULC changes, making it difficult to determine the underlying mechanism of these changes. The geographical detector is a statistical method for detecting spatial differentiation and identifying the factors that contribute to it doing so without making too many assumptions, and overcoming the limitations of traditional linear statistical methods, such as correlation and regression. As a result, geographical detectors are widely used to analyze the factors that drive vegetation change.

The factors that affect the change in land use and land cover can vary from one location to another. The majority of the population in North-east India is employed in the primary sector which results in a large degree of deforestation. According to the survey conducted, of the total 10 villages (Bawktlang, Vanchengte, Lungchhuan, Lungpho, N. Mualcheng, Neihloh, Sailulak, Sialhau, Sialsir, Piler), every household had jhum cultivations on its agricultural land. Therefore, land use and land cover changes can be attributed to the many factors.

In Mizoram, shifting cultivation area decreased from 580 km^2 to 400 km^2 during the 1970s and 1980s. As well, the number of Jhumia families has declined from 50,000 to 40,000 despite an increase in the rural population from 0.33 million to 0.48

million. Approximately 1.5% of the total area is affected by shifting cultivation in Mizoram each year, resulting in a loss of forest resources of about Rs. 1 billion. The area under shifting cultivation has further diminished in recent years, and the fallow period has been reduced from 20-30 years to 3-5 years as a result of an increase in population. In spite of the fact that shifting cultivation is one of the main sources of livelihood, it has adverse effects on the economy. The plots of Jhum are fragmented and small. They are located on rugged, precipitous slopes and are far from villages, which results in a relatively low production and yield of crops. Due to the increase in population and reduction in the fallow period, shifting cultivation has become an uneconomical activity. There has been a decrease in food shortages for more than five months as a result of decline in food production. As a result, the Jhumias have become increasingly dependent on forest products in order to maintain their livelihoods. In a similar manner, shifting cultivation has seen a decline in income. It is therefore necessary to develop alternative suitable land use systems. Due to the burning of large areas of forest, shifting cultivation is not suitable for faunal and floral resources. Poor land utilization systems are thought to be responsible for the loss of faunal and floral species. In general, it is considered to be the primary cause of deforestation.

The Mizoram Government adopted the New Land Use Policy in 1985. The main objective of the program was to convert shifting cultivation practices into permanent cultivation practices. The state government has reported that each Jhumia will receive approximately 7 acres of land (total of one hundred thousand Jhumias). The scheme has already provided benefits to a number of farmers. In response, crop production and the area of land devoted to permanent farming have increased. However, this policy did not take shape and as a result, many farmers have continued to practice shifting cultivation. Mizoram has tremendous potential for growing multiple crops in Mizoram due to its agro-ecological conditions. However, due to poverty, the poor would not be able to utilize the rich agro-biodiversity of the state. In addition, the farmers are not able to afford the investment necessary to convert their jhum lands into terraced fields. Many farmers face acute difficulties in earning a living as a result of the insufficient assistance they receive from the state government. When some policy-based approaches are framed and implemented, shifting cultivation can be sustainable and economically viable. Firstly, Jhum lands should be assigned to the farmers on an ongoing basis, so that they can prepare farmlands for permanent and sustainable agricultural practice. A priority should be given to cultivating cash crops. Intensive rice farming is possible in irrigated floodplains and river valleys through the use of system rice intensification techniques. Cash crops such as fruits, vegetables, and spices can replace traditional crops, which are economically unviable. Cabbage and ginger are two case crops in Mizoram that have significant potential. To facilitate the commercialization of these crops, the State Government can provide market facilities. In several Asian countries, shifting cultivation has been largely replaced by commercial agriculture in recent decades. Market facilities can be provided for the export of ginger and cabbage to the regional market. A longer tenure of ownership of Jhum plots may be granted to farmers, thereby encouraging permanent agriculture and modern agricultural practices. Shifting cultivation should be discouraged, as it is environmentally unsound and economically unprofitable.