ENVIRONMENTAL IMPACT ASSESSMENT OF CHAMPHAI – ZOKHAWTHAR ROAD CONSTRUCTION IN MIZORAM

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LALVENTLUANGA

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ENVIRONMENTAL IMPACT ASSESSMENT OF CHAMPHAI – ZOKHAWTHAR ROAD CONSTRUCTION IN MIZORAM

BY

LALVENTLUANGA

Department of Environmental Science

DR. JOHN ZOTHANZAMA

Submitted

In partial fulfillment of the requirement of the Degree of Doctor of Philosophy in Environmental Science of Mizoram University, Aizawl

MIZORAM UNIVERSITY

DEPARTMENT OF ENVIRONMENTAL SCIENCE

Post Box No.: 190 , Phone No: 0389-2330532 Fax : 0389 – 2330385 E-mail : febesmzu@yahoo.co.in

No.MZU/ES/16-3(Ph.D-Regn)/2010 Dated Aizawl, the , 2020

TO WHOM IT MAY CONCERN

This is to certify that the thesis entitled "**Environmental Impact Assessment of Champhai – Zokhawthar Road Construction in Mizoram**" submitted by Mr. Lalventluanga, bearing Mizoram University Ph.D Registration No. MZU/Ph.D/905 of 13.04.2016 in fulfillment of the award of the Degree of Doctor of Philosophy in the Department of Environmental Science, Mizoram University is the embodiment of his original research work done in the field and laboratory, under my supervision and guidance during 2016-2020.

It is also certified that the scholar has been admitted in the department through an entrance followed by an interview as per clause 9 (i) & (ii) of the UGC regulation 2009.

(Prof. H. Lalramnghinglova)
Joint Supervisor

(Dr. John Zothanzama)
Supervisor

MIZORAM UNIVERSITY
DEPARTMENT OF ENVIRONMENTAL SCIENCE
Post Box No.: 190 , Phone No: 0389-2330532 Fax : 0389 – 2330385 E-mail : febesmzu@yahoo.co.in

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This is to certify that the Mr. Lalventluanga, a Ph.D Scholar, Registration No. MZU/Ph.D/905 of 13.04.2016 has worked on the thesis entitled "**Environmental Impact Assessment of Champhai – Zokhawthar Road Construction in Mizoram**" has fulfilled all criteria prescribed by the UGC (Minimum standard and procedure governing Ph.D Regulation). He has fulfilled the mandatory Publication (Publication enclosed). It is also certified that the scholar has been admitted in the Department through entrance followed by an interview as per Clause 9(i) & (ii) of the UGC Regulation 2009.

(Prof. B.P. MISHRA)
HEAD

DECLARATION

Mizoram University
May, 2020

I Lalventluanga, 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 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.

This is being submitted to the Mizoram University for the degree of Doctor of Philosophy in Environmental Science.

(LALVENTLUANGA)

(PROF.B.P.MISHRA) (DR. JOHN ZOTHANZAMA)

Head Supervisor

(PROF. H.LALRAMNGHINGLOVA)

Joint Supervisor

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CONTENTS

List of Figures

CHAPTER – 1

INTRODUCTION

1.1 Concept and Definitions of Environmental Impact Assessment

The environment, in its entirety, has sustained all forms of life on earth. With the onset of human civilization, man has greatly changed and molded his environment according to his needs and benefit. The human society evolved drastically leading to advancements in his overall living conditions. The Industrial Revolution and further onto technological advancements showed man's power and capability while at the same time making him the apex predator and destroyer of the environment. With each stages of transformation made to his environment, the apex predator have adversely affected his natural environment. Increase in human population, greed for global power and lack of ecological concern brought man unto his greatest loss – his life-sustaining environment. Mukherjee (2012) quotes "the environmental degradation is viewed above all as a moral problem, its origins lying in the wider acceptance of ideology of materialism and consumerism, which draws human away from nature even as it encourages wasteful lifestyles."

As the saying goes "Better late than never", human society realized the environmental degradation inflicted onto our surroundings and the rapid depletion of our natural resources. Such concerns lead to global awareness and the need to take initiatives for the protection and conservation of the environment. Environmental Impact Assessment, as one of the later developed tool, has now become an important process for keeping track of programmes and projects that may cause damage to the environment. EIA has been defined in many ways but the core motive of EIA is to predict, identify and mitigate impacts that may occur during implementation of developmental projects and programmes. There has been much light brought to the definitions and properties of EIA. Some important definitions of Environmental Impact Assessment include –

(1) Canter (1996) defined EIA as the systematic identification and evaluation of the potential impacts (effects) of proposed projects plans, programmes or legislative actions relative to the physical, chemical, biological, cultural and socioeconomic components of the total environment.

(2) The United Nations Environment Programme (Anon., 1987) defines EIA as an examination, analysis and assessment of planned activities with a view to ensuring environmentally sound and sustainable development.

(3) The International Association for Impact Assessment (Anon., 1999) defines environmental impact assessment as the process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made.

1.2 Brief historical perspective of EIA

To this day, awareness about our environment and our responsibilities towards its conservation is understood and acknowledged by many people of the world to a wide extent. Countries of the world come together to take worldwide actions, organizations and activists apprise the people through media, rallies, concerts, street preaching and other forms of communication. However, for a long time, society was unable to comprehend that advancement and developments took a toll on the environment. The understanding of the connections between human life and other elements of nature, and the power man possesses to destroy the very system that sustains his life, has shown to be limited simply due to the fact that we have unknowingly and unintentionally destroyed our Earth system while at the same time promising a better future for the next generation.

As the industrial revolution gained popularity and was taking the world by storm, before the First World War rapid industrialization and urbanization in particularly in western countries was causing rapid loss of our natural resources. This continued to the period after the Second World War, and then realization of the effect on natural system and concerns for pollution, quality of life and environmental stress began (Ogola, 2007). However, it was only in the early 1960’s that the concern for our environment received a more public and global impetus. The world then witnessed the emergence of environmentalism with the publication of Rachael Carson's "Silent Spring" in 1962, which brought social awareness about our environmental issues (Singh, 2007). The book explored the indiscriminate use of pesticides and its adverse effects on the environment. In the United States of America, concerns about the environment and the current status of its degradation spread like wildfire and by the latter half of 1960's reached high proportions and grew as very intense movements.

As a result of this, the need to develop a tool to conserve and protect the environment arose. Activists and pressure groups did their part of awakening the general public to their most current issue and concern. The USA then decided to respond to these issues and established the National Environmental Policy Act (NEPA) in 1970 to consider its goal in terms of environmental protection (Glasson *et al.*, 2012). NEPA ushered in a new era of environmental awareness by requiring federal agencies to include environmental protection in all their plans and activities. Although there were complications and errors in implementing the act and its EIA requirement, NEPA opened a way to challenge inadequate statements in the courts and provided a means toward realization of the intent of the law (Caldwell, 1988). The USA thus became the first country to enact legislation on EIA. Since then, EIA has been one of the successful environmental policy innovations of the 20th century (Bartlett, 1988). EIA is now considered as one of the oldest and most mature tools in environmental management. It also initialized work with ecological management, life cycle assessment and product and technology assessment (Thompson and Ross, 2001).

1.3 Development of international agreements and policies for EIA

For the further development and improvement of EIA as an international and widespread legal policy, there have been a few international treaties and conferences that have significantly played a key role in its development globally.

1.3.1 United Nations Conference on Human Environment (The Stockholm Declaration), 1972

Starting with the 1972 Stockholm Declaration of the United Nations Conference on Human Environment, the desire to limit damage to the environment became greatly acknowledged in international agreements. Although, the Declaration does not explicitly refer to EIA, it identified the need for a management tool and principle that would guide the nations of the world in the preservation and protection of the environment (Anon., 2005a). The Stockholm Declaration included 26 principles wherein principles 14 and 15 acknowledged the importance of planning as a tool to reconcile any conflict between environment and development, and avoid adverse effects of human settlements and urbanization on the environment. Most importantly, it was acknowledged that international cooperation is vital for achieving the goal of environmental protection because environmental problems know no political boundaries (Anon., 2018a). The Stockholm Declaration had an immense impact in the structure and development of EIA and with the acceptance of the concept of sustainable development; it laid the foundation for the consideration of environmental assessment in later international agreements.

1.3.2 Convention on Environmental Impact Assessment in a Trans-boundary Context (Espoo, 1991).

The Convention on Environmental Impact Assessment in a Trans-boundary Context is the first multi-lateral EIA treaty adopted in 1991 and came into force in 10^{th} September 1997 (Ogola, 2007). It aims at making proposed activities subject to standardized process of transboundary EIA rather than substantially regulating proposed activities. It lays down a general obligation of states to notify and consult each other on all major projects under consideration that are likely to have a significant adverse environmental impact across borders. This implies that the nation or contracting party/parties under whose jurisdiction a proposed activity is envisaged to take place (party of origin), and the nation or contracting party/parties likely to be affected by the transboundary impact of a proposed activity must notify and consult each under proper set of rules, stages and time frames (Koyano, 2008).

1.3.3 The United Nations Conference on Environment and Development (Rio Declaration), 1992

The Rio Declaration on Environment and Development laid down several principles that have direct and indirect implications to environmental assessment. Principle 17 of Rio Declaration states that "Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority". It clarifies that EIA is to be used as a national decision making instrument in assessing whether proposed activities are likely to have significant adverse impact on the environment (Anon., 2005a). The United Nations Conference on Environment and Development (Rio Summit) also gave birth to Agenda 21, which is a non-binding action plan with regards to sustainable development (Ogola, 2007). The following chapters of Agenda 21 provide development of EIA and propose that Governments:

- Promote the development of appropriate methodologies for making integrated energy, environment and economic policy decisions for sustainable development, inter alia, through environmental impact assessment [Chapter 9.12(b)].
- Develop, improve and apply environmental impact assessment to foster sustainable industrial development (Chapter 9.18).
- Introduce appropriate EIA procedures for proposed projects likely to have significant impacts upon biological diversity, providing for suitable information to be made widely available and for public participation where appropriate, and encourage the assessment of impacts of relevant policies and programs on biological diversity [Chapter15.5(k)].

1.3.4 The World Summit on Sustainable Development (Johannesburg), 2002

The Johannesburg Summit was held on 26th August of 2002 and was the second Earth Summit following the Rio Summit in 1992. It is also referred to as Rio +10 as it is a follow up to the 1992 Rio Summit. The Summit led to the implementation measures regarding environmental assessment, including: (Anon., 2005a)

- Paragraph 19: Encourage relevant authorities at all levels to take sustainable development considerations into account in decision-making, including on national and local development planning, investment in infrastructure, business development and public procurement. This would include actions at all level to: (e) Use environmental assessment procedures;
- Paragraph 97: Continue to enhance the mutual supportiveness of trade, environment and development with a view to achieving sustainable development through actions at all levels to: (d) Encourage the voluntary use of environmental impact assessments as an important national tool to better identify trade, environment and development interlinkages. Further encourage countries and international organizations with experience in this field to provide technical assistance to developing countries for these purposes.

1.4 Evolution and worldwide adoption of EIA

Since its implementation as legislation, the popularity of EIA as a tool to check environmental effects of developmental projects has spread to many countries of the world. Depending upon the status of a country, implementation and use of EIA differed, especially between developed and developing nations. The form and structure of EIA also varies globally due to different economic, social, political, environmental circumstances (George, 2000). There is a growing opinion among nations that EIA is slowing down the growth of a nation and inhibits development decisions – this mindset can be attributed to the limited influence EIA has on nations. Therefore, today, EIA is practiced mainly as a decision aiding tool rather than decision making tool (Anon., 2018b). For better implementation and understanding of EIA, research work and strong training for EIA practitioners and guidance on its practice is greatly needed.

The Evolution of the EIA process through the years from its initiation to the early decades of the 21st Century is shown in Table 1.1.

Table 1.1. Evolution of EIA

Time Periods	Development of EIA
Pre – 1970 *Initial Development*	• Projects review based on technical/engineering and economic analysis. • Limited consideration given to environmental consequences.
Early/Mid – 1970s *Methodological development*	• EIA introduced (NEPA, 1970) • Basic principles; guidelines; procedures; including public participation • Standard methodologies for impact analysis developed (e.g., matrix, checklists, networks) • Several other countries adopted NEPA-based approach (e.g., Canada, Australia, New Zealand) • Major public inquiries (rather than court litigation) help shape their process development
Late 1970s to early 1980s *Increasing scope (Social dimensions included*)	• Use of EIA by developing countries (e.g., Brazil, Philippines, China, Indonesia • SIA (Strategic Environmental Assessment) and risk analysis included in EIA processes • Greater emphasis on ecological modeling, prediction and evaluation methods • Programme ElSs prepared in US • Environmental inquiries in several countries encompass policy review aspects • Informational (non-hearing) provisions for public involvement • Coordination of EIA with land use planning processes (e.g., New South Wales, Victoria)
Mid 1980s to end of decade *Process strengthening and policy integration*	• EC Directive on EIA establishes basic principles and procedural requirements for all member states • Increasing efforts to address cumulative effects • Development of follow-up mechanisms (e.g., compliances and effects monitoring)

	• Ecosystem and landscape level approaches applied (e.g., to assess wetland losses) • World Bank and other international lending and aid agencies establish EIA requirements • Increasing number of developing countries carry out EIAs (e.g., Asia)
1990s *Towards sustainability*	• Requirement to consider transponder effects under Espoo Convention • EIA identified as implementing mechanism for UN conventions on climate change and biological diversity • SEA system established by increasing number of countries • Mediation incorporate into EIA requirements (still limited) • Sustainability principles and global issues receive increased attention (some EIA guidance but still limited) • Increasing use of GIS and other information technologies • Application of EIA to international development activities more widespread • Greater corporate use of EIA, including screening investment and loan decisions and undertaking site and property assessment to establish liabilities • Rapid growth in EIA training, networking and cooperation activities • Enactment of EIA legislation by many developing countries
2000s	• Strategic Environmental Assessment (SEA) evolved and further developed from EIA to overcome the problems associated with it • New approaches are given to EIA and SEA such as Analytical Strategic Environmental Assessment (ANSEA) and Environmental Impact Description (EID) • Principles of sustainability are now fully incorporated into any step or stage involved in the EIA system

Sources: Sadler (1996); Modak and Biswas (1999); Sankoh (1996); Dalkmann, *et al.* (2004); Alshuwaikhat (2005).

As already mentioned, United States of America was the first country to make EIA mandatory through the implementation of National Environmental Protection Act (NEPA) of 1969 -1970 (Glasson *et al.,* 2012). In the coming period, many countries passed legislation to control such environmental degradation (Modak and Biswas, 1999). It can be acknowledged that the people's concern for human life and the physical environment increased the pace of EIA implementation for protection of human life and the physical environment with the occurrence of fatal accidents such as the Ixtoc 'blow out', the sinking of Amoco Cadiz, Bhopal and Chernobyl accidents (Htun, 1990). In November of 2011, a search was carried on a database known as "ECOLEX" which is an environmental law information service jointly operated by United Nations Environment Programme (UNEP), Food and Agriculture Organization (FAO) and International Union for Conservation of Nature and Natural Resources (IUCN) to determine text references in legislation and treaties relating to 'environmental impact assessment' across all countries. According to the ECOLEX, 191 of the 193 member nations of the United Nations either have national legislation or have signed some form of international legal instrument that refers to the use of EIA. Democratic People's Republic of Korea and South Sudan are the only countries without such content in their legislation (Morgan, 2012).

1.4.1 North America

After EIA implementation in the USA, Canada formed an environmental assessment review process in 1973 which later developed in 1984 (Wathern, 1988). However in 1917, the Mexican Constitution had already granted a legislation of environmental protection and conservation of their natural resources.

1.4.2 Europe

EIA developed in Central and Eastern Europe from late 1970s to early 1980s. EIA as a management tool was first issued in the Polish law of water in 1974. In Croatia the regulation of EIA was introduced in 1984 (Sattar, 2007). The EIA legislation enforced in Poland, the Czech Republic, Estonia, Latvia, Ukraine and Romania is said to originate due to common influence of the environmental legislation of the former USSR. Sadler (1996), states that France and Netherlands were also among the first industrialized nations in Europe to adopt EIA legislation. Later in 1985, the European Community (EC), now the European Union (EU) issued a directive making environmental assessments mandatory for certain categories of projects (Wood, 1995).

1.4.3 South America

South America being blessed with natural resources, rainforests, coastal and water resources; their conservation has always been an important sector in the region. In 1972, the first environmental assessment was carried out in Brazil for assessing the significant impacts of a hydroelectric power plant in response of a request to the World Bank (Brito and Verocai, 1999). Brazil and Venezuela are among the first countries to have a developed EIA system. The under developed countries of the region like Belize, Bolivia and the Costa Rica has also enabled the EIA legislation, while some countries are at preparing levels and some are following the EIA requirements due to pressure of funding agencies (George, 2000).

1.4.4 Australia

Australia enacted its environment protection act called "Impact of Proposals" in 1974, which was14 years before the enforcement of European commission's directive on EIA. The scope of EIA procedures in Australia and New Zealand were reformed by the Australian and New Zealand Environment and Conservation Council (ANZECC) in 1991 (Wood, 1995).

1.4.5 Asia

Thailand and Philippines were the first to enact EIA legislation in 1970s even earlier than many European countries. Japan has also introduced formal EIA legislation, while Malaysia and Indonesia have developed sectoral guidelines. India and Pakistan are also the first to establish EIA among the South Asian countries (Biswas and Agarwala, 1992). In Middle East countries Oman, Tunisia and Turkey have also established the EIA system. However, Singapore, Vietnam and Cambodia have no mandatory EIA legislation. Although there is great concern and awareness for the need of EIA, due to political, social, religious and economic differences, many of the countries still haven't enacted EIA in legislation. Briffett (1999) stated that many countries simply follow the requirements of EIA to receive loans from the multinational finance agencies.

1.4.6 Africa

South Africa is considered the first country in the African continent to take initiative towards environmental protection when a committee was formed to develop a plan for ensuring integration of an environmental procedure in 1982. Later the country developed a form of EIA called "Integrated Environmental Management (IEM)" (Kakonge, 1999). Many institutions in Ghana and Tanzania have also developed their own EIA procedures. The African Ministerial Conference on the Environment (AMCEN) and the regional preparatory conference of the United Nations on the Environment and Development (UNCED) held in Cairo in 1985 and in 1991 with its specific recommendations for the use of EIA in the African states lead to the further development of EIA in the continent. Egypt and Nigeria later developed EIA procedures (*Ibid.*, 1999).

Many countries of the world have further enacted EIA in their legislation and are shown in Table 1.2 with their legislation year.

Table 1.2. Project Level EIA Legislation Year (1969 – 1995)

COUNTRY	LEGISLATION YEAR	COUNTRY	LEGISLATION YEAR
United States of America	1969	Greece	1986
Japan	1972	Gambia	1987
Canada	1973	Sweden	1987
New Zealand	1974	Portugal	1987
Australia	1974	Italy	1988
Colombia	1974	Turkey	1988
Germany	1975	United Kingdom	1988
Brazil	1976	Ireland	1988
France	1976	Norway	1989
Korea, South	1977	Poland	1989
Philippines	1978	Denmark	1989

Papua New Guinea	1978	Luxembourg	1990
Taiwan	1979	Finland	1990
China	1979	Antarctica	1991
Sri Lanka	1980	Czech Republic	1991
Kuwait	1980	Slovakia	1991
Israel	1982	Estonia	1992
Indonesia	1982	Lithuania	1992
South Africa	1982	Nigeria	1992
Mexico	1982	Argentina	1993
Pakistan	1983	Albania	1993
Switzerland	1983	Hungary	1993
Thailand	1984	Bolivia	1994
Belgium	1985	Chile	1994
Russia	1985	Austria	1994
Malaysia	1985	Armenia	1995
Spain	1986	Iceland	1995
Netherlands	1986	Uganda	1995
India	1986		

Source: Singh (2007)

1.5 General EIA Process

Canter (1996) described environmental assessment serves to provide a public document that with sufficient evidence and analysis of environmental impacts; determining whether a concise report is required or not. EIA is a decision-making aid to prevent projects with strongly negative environmental impacts from going forward and are also meant to help in developmental decisions by mandating a consideration of alternatives (including alternative project locations, scales, processes, layouts, operating conditions, or in some cases, the option of desisting from implementing a project) and ways to prevent, mitigate, and control potential negative environmental and social impacts (Li, 2008). Public involvement and expert consultation have also now become an important step in EIA process and is incorporated as law in most countries.

The general process of EIA involves the following steps:

1. **Screening:** It is the first stage in EIA and is carried out to determine whether EIA is required or not for new projects or expansion of existing projects or modernization of projects and if it requires EIA, then the level of assessment required. Screening is performed to ensure that proposals that will have a significant impact on the environment will have to undergo an EIA and decisions taken during this stage of the EIA process is of fundamental importance to the process. Screening is very important in cases when there are no legal requirements. Donor agencies may have internal screening procedures in order to avoid development projects with adverse environmental impact. Screening in the planning process gives the proponent knowledge on possible locations at an early stage, which may lead to design changes to improve the environmental performance. The document of the screening outcome is called Initial Environment Examination/Evaluation (IEE).
2. **Scoping:** This stage helps identify, at an early stage, the key issues and significant environmental impacts of proposed project that require further investigation. The term scoping is used to describe the process of deciding what should be included in an EIA. It identifies the main public concern about a proposal and organizes the scientific work for the assessment. A scoping process involves two important parts: impact identification and public involvement.
3. **Impact identification and analysis:** This stage identifies and predicts likely environmental and social impact of the proposed project and evaluates the significance. It ensures that all potentially significant environmental impacts (adverse and beneficial) are identified; definitive statements about the nature and magnitude of the impacts are produced and taken into account in the process. The relative significance of the predicted impacts is assessed to allow concentration on key adverse impacts.
4. **Mitigation:** This stage involves the introduction of measures to avoid, reduce, remedy or compensate for any significant adverse impacts. It recommends the actions to reduce and avoid the potential adverse environmental consequences of development activities.

5. **Public consultation and participation:** This stage aims to involve the public in decision making to assure the quality, comprehensiveness and effectiveness of the EIA. The views of public, who are most likely to be affected by the impacts, are adequately taken into consideration in the decision-making process.
6. **Reporting:** This stage in EIA is a vital step in the process where the result of EIA is presented in a form of a report to the decision-making body and other interested parties.
7. **Review:** This involves a systematic appraisal of the EIA report through examining the adequacy and effectiveness of the report and provides information necessary for the decision-making.
8. **Decision-making:** At this stage, decisions on whether the project is rejected, approved or deferred are made by the relevant authority.
9. **Post-decision monitoring:** This stage starts once the project is commissioned. It involves the effective monitoring and management of the project. It checks whether the impacts of the project do not exceed the legal standards and implementation of the mitigation measures are in the manner as described in the EIA report.

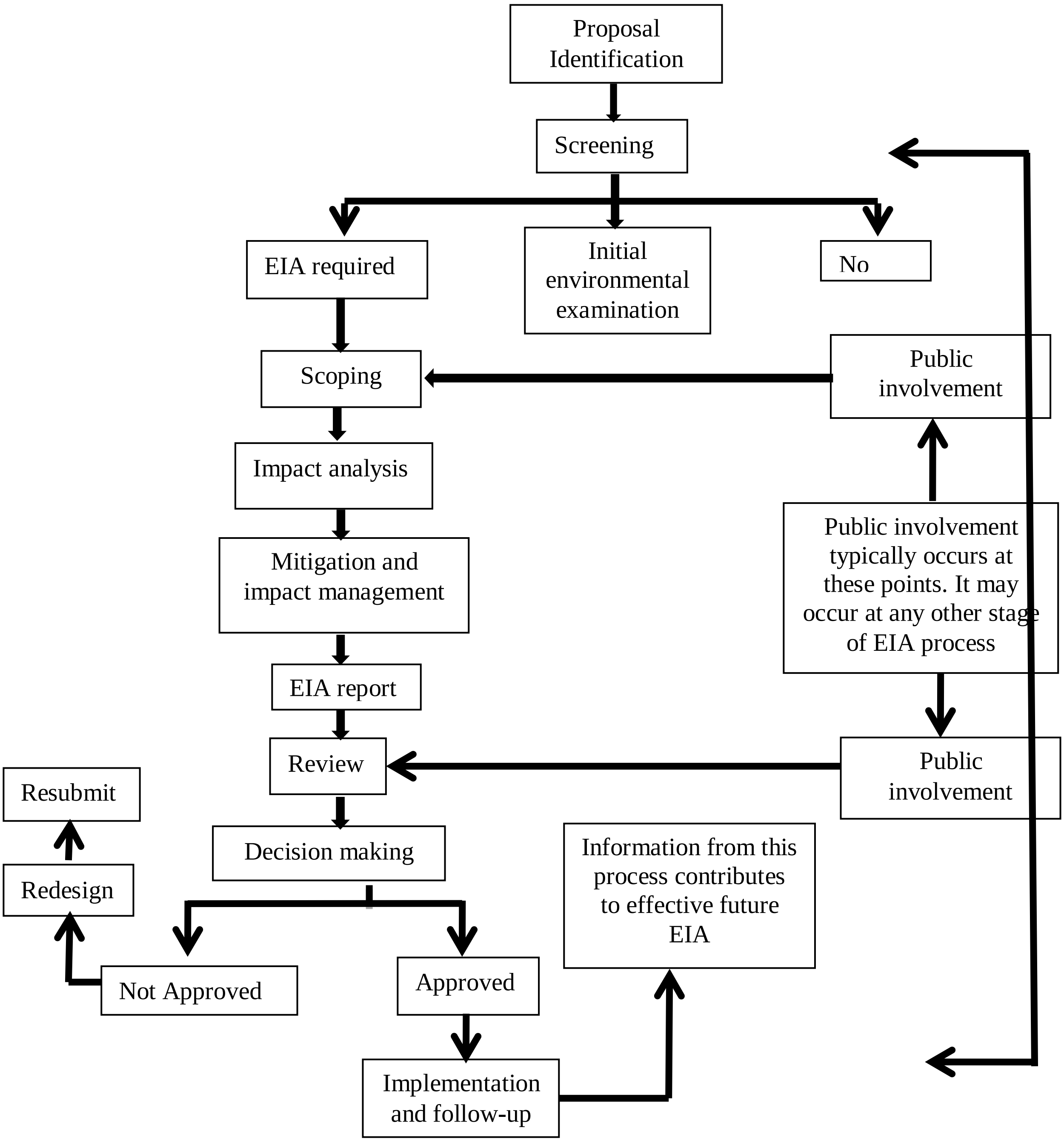

Figure 1.1. Generalized EIA Process Flowchart (**Source:** UNEP, 2002).

1.6 EIA in India

The foundation of environmental impact assessment (EIA) in India was laid in 1976-77 when the Planning Commission asked the then Department of Science and Technology (DST) to examine the river-valley projects from environmental angle. This was subsequently extended to cover those projects, which required approval of the Public Investment Board (Tathagat and Dod, 2015). Initially the newly introduced EIA mechanism had limited scope, lacked legislative support and was exclusively applicable to the river valley projects for which clearances were to be given by then Ministry of Environment & Forests (Mukherjee, 2012). The Government of India later enacted the Environment (Protection) Act on 23rd May1986 wherein decisions were taken to make environmental impact assessment statutory. On 27 January 1994, the MoEF, Government of India, under the Environmental (Protection) Act 1986, enacted an EIA notification and formally introduced Environmental Impact Assessment with a strong supporting legislative, administrative and procedural set-up (Chalotra and Dharmendra, 2016). The EIA notification 1994 was framed for developmental projects seeking environmental clearance in India and has been subsequently amended. The Government of India under Environment (Protection) Act 1986 has also issued a number of other notifications, which are related to environmental impact assessment (Ranshur *et al.*, 2009).

Mukherjee (2012) stated that the legal regime of EIA in India is developed through three important phases namely, phase I consisting of the pre-1994 era, phase II consisting of 1994-2006 era and phase III consisting of post 2006 era respectively. The existing scope of the EIA policy in India in brief includes EIA as a study of the probable changes in the various biophysical and socio-economic attributes of the environment, which result from any proposed project. Thus the sole objective of the assessment before any decision is taken, must be based on the future impact of the consequences of the decision for the quality of the total human environment**.** Among the other environmental policy initiatives, the EIA notification is considered to be an important milestone towards achieving environmental good governance in India.

The EIA Notification, 1994 (Anon., 1994) in its stand to promote sustainable industrialization process, imposed restrictions and legalities on setting up, modernizing or expanding any project (new or already existing) or proposal without getting an environmental clearance from the government. The Ministry of Environment and Forests on 14th September, 2006 introduced and notified EIA legislation prior to the EIA Notification, 1994. The major difference in the New EIA Notification, 2006 (Anon., 2006) from the earlier version of 1994 is its attempt to decentralize power to the State Governments. As per the new notification, significant number of projects will go to the state govt. for getting clearance depending on its size/capacity/area (Tathagat and Dod, 2015). For this, the notification has made a provision to form a state level authority and expert panels, the State Level Environmental Impact Assessment Authority (SEIAA) and the State Level Environment Appraisal Committees at the State level (SEAC) as an attempt to reduce the burden on the Central Government and consequently reduce delays in project appraisals.

1.7 EIA process in India

The process of EIA in India is governed by guidelines and stipulations of the EIA Notification 2006 and its further amendments (Anon., 2006).

Therefore as per the EIA Notification, 2006, the following projects or activities require obtaining prior environmental clearance from the concerned regulatory authority:

- All new projects/activities listed in Schedule;
- Expansion and/or modernization of existing projects /activities; and
- Change in product mix.

All projects and activities are broadly categorized into two categories based on the spatial extent of potential impacts on human health, natural and man-made resources.

- **Category A:** All projects or activities included as Category 'A' in the Schedule, including expansion and modernization of existing projects or activities and change in product mix. All Category 'A' projects require prior environmental clearance from the Central Government in the Ministry of Environment, Forests & Climate Change (MoEF&CC) on the recommendations of an Expert Appraisal Committee (EAC) to be constituted by the Central Government for the purposes of this notification.

- **Category B:** All projects or activities included as Category 'B' in the Schedule, including expansion and modernization of existing projects or activities as specified in the Notification as
    - Expansion and modernization of existing projects or activities listed in the Schedule to this notification with addition of capacity beyond the limits specified for the concerned sector, that is, projects or activities which cross the threshold limits given in the Schedule, after expansion or modernization;
    - Any change in product - mix in an existing manufacturing unit included in Schedule beyond the specified range.

Category 'B' projects will be treated as Category 'A', if located in whole or in part within 10 km from the boundary of:

- Protected Areas notified under the Wild Life (Protection) Act, 1972 (Anon. 1972),
- Critically Polluted areas as notified by the Central Pollution Control Board (CPCB) from time to time,
- Notified Eco-sensitive areas,
- Inter-State boundaries and International boundaries.

Category 'B' projects undergo screening at the state level for categorization into either B1 or B2. Categorization is done on the basis of the information provided by the applicant in the application form (Form 1 or Form 1A in case of construction projects).

Any individual/company seeking prior environmental clearance in all cases has to fill and submit the prescribed Form 1 and Supplementary Form 1A (if applicable) as given in Appendix I & II of the EIA Notification 2006. This has to be done after the identification of prospective site(s) for the project and/or activities to which the application relates, before commencing any construction activity, or preparation of land, at the site by the applicant. Along with the application, the applicant also has to furnish a copy of the pre-feasibility project report. In case of construction projects or activities (given in item 8 of the EIA Notification, 2006

Schedule) in addition to Form 1 and the Supplementary Form 1A, a copy of the conceptual plan has to be provided, instead of the pre-feasibility report.

If a project falls in Category 'B', the project goes to state government for clearance which further categorizes it as either B1 or B2 project. B2 projects do not require preparation of EIA reports. For obvious reasons, the EC process for new projects is different (and more detailed) than for existing projects. The environmental clearance process for new projects comprises a maximum of four stages. These four stages in sequential order are:

1.7.1 Screening

Screening is primarily done to differentiate between projects belonging to Category 'B' which are to be cleared by the State Level Environmental Impact Assessment Authority (SEIAA). Applications seeking prior environmental clearance made in Form 1 are scrutinized by the concerned State level Expert Appraisal Committee (SEAC) for determining whether or not the project or activity requires further environmental studies for preparation of an Environmental Impact Assessment (EIA) for its appraisal prior to the grant of environmental clearance depending up on the nature and location specificity of the project. Those projects requiring an Environmental Impact Assessment report are termed Category 'B1' and remaining projects are termed Category 'B2' and do not require an Environment Impact Assessment report.

1.7.2 Scoping

Scoping refers to the process by which the Expert Appraisal Committee (EAC) in the case of Category 'A' projects or activities, and State level Expert Appraisal Committee (SEAC) in the case of Category 'B1' projects or activities determine detailed and comprehensive Terms of References (ToRs) addressing all the relevant environmental concerns for the preparation of the EIA report. It is that step which determines the various aspects that need to be studied in the EIA report. The EAC or SEAC concerned determines the Terms of Reference (ToR) on the basis of the information furnished in the prescribed application Form1/Form 1A by the applicant, a site visit by a sub-group of EAC or SEAC concerned only if considered necessary by the EAC or SEAC concerned.

The ToR has to be conveyed to the applicant within sixty days of the receipt of Form 1. If the ToR are not finalized and conveyed to the applicant within sixty days of the receipt of Form 1, the ToR suggested by the applicant shall be deemed as the final ToR approved for the EIA studies.

The EIA study conducted shall provide a baseline data describing the existing environmental status of the identified study area. The Ministry of Environment and Forests has published guidelines for different sectors, which outline the significant issues to be addressed in the EIA studies (Ranshur *et al.*, 2009). Quantifiable impacts are to be assessed on the basis of magnitude, prevalence, frequency and duration and non-quantifiable impacts (such as aesthetic or recreational value), significance is commonly determined through the socio-economic criteria. After areas susceptible to significant impact are identified, the baseline status of these should be monitored and then the likely changes in these areas on account of the construction and operation of the proposed project should be predicted.

The following impacts of the project should be assessed:

- Air
    - changes in ambient levels and ground level concentrations due to total emissions from point, line and area sources
    - effects on soils, materials, vegetation, and human health
- Noise
    - changes in ambient levels due to noise generated from equipment and movement of vehicles
    - effect on fauna and human health
- Water
    - availability to competing users
    - changes in quality
    - sediment transport
    - ingress of saline water

- Land
    - changes in land use and drainage pattern
    - changes in land quality including effects of waste disposal
    - changes in shoreline/riverbank and their stability
- Biological
    - deforestation/tree-cutting and shrinkage of animal habitat.
    - impact on fauna and flora (including aquatic species if any) due to contaminants/pollutants
    - impact on rare and endangered species, endemic species, and migratory path/route of animals.
    - impact on breeding and nesting grounds
- Socio-Economic
    - impact on the local community including demographic changes.
    - impact on economic status
    - impact on human health.
    - impact of increased traffic

1.7.3 Terms of reference (ToR)

Terms of Reference is a document produced during Scoping process which contains guidelines and information addressing key environmental issues to be incorporated in the EIA report. It should identify relevant natural resources, the eco-system and the population likely to be affected by the proposed project. Therefore, ToR improves the quality of the reports by incorporating relevant project specific data.

1.7.4 Assessment of alternatives

For the impacts identified and predicted, possible alternatives or mitigation measures should be identified. Alternatives should cover both project location and process technologies.

1.7.5 Environmental Impact Assessment and Environmental Management Plan (EMP)

Once alternatives have been reviewed, Environmental Management Plan (EMP) should be produced to guide the proponent towards environmental improvements. The EMP is a crucial input to monitoring the clearance conditions and therefore details of monitoring should be included in the EMP.

Based on the ToR and EIA study, an EIA report is prepared which should provide clear information to the decision-maker on the different environmental scenarios without the project, with the project and with project alternatives.

1.7.6 Public Consultation

Public Consultation refers to the process by which the concerns of local affected persons and others who have plausible stake in the environmental impacts of the project or activity are ascertained. This stage of the EIA process is to consist of two aspects.

1. A public hearing process in which only local affected people can participate and
2. A process for obtaining written comments from others who are concerned citizens.

All Category 'A' and Category 'B1' projects or activities are to undergo Public Hearing. The procedure for conducting the public hearing has been well crafted in the EIA Notification, 2006. The public hearing has to be completed within a period of 45 days from date of receipt of the request letter from the Applicant. If the State Pollution Control Board (SPCB) or the Union Territory Pollution Control Committee (UTPCC) fails to hold the public hearing within the stipulated 45 days, the Central Government in Ministry of Environment and Forests (MoEF) for Category 'A' project or activity and the State Government or Union Territory Administration for Category 'B' project or activity at the request of the SEIAA, will have to engage any other agency or authority to complete the process, as per the procedure laid down in the EIA Notification, 2006.

1.7.7 Decision making

Decision making process involves consultation between the project proponent (assisted by a consultant) and the impact assessment authority (assisted by an expert group if necessary). Based on the EIA report, EMP and documents of the public hearing, decision is taken.

1.7.8 Environmental Clearance

After decision is made, the impact assessment authority may grant, reject or ask for reconsideration by appraisal committee. The decision made shall be conveyed to the project proponent and be made public documents.

1.7.9 Validity of Environmental Clearance:

As per EIA Notification 2006, the validity time period of clearance granted for various projects are:

- Maximum 30 years for mining projects
- 10 years for River valley projects
- 5 years for all other projects

The validity can be extended to another 5 years by submitting an application in Form - 1 while within the validity period.

1.7.10 Post Environmental Clearance (EC) monitoring

The EIA Notification makes it mandatory for the project management to submit half-yearly compliance reports in respect of the stipulated prior environmental clearance terms and conditions. This has to be done in both hard and soft copies and has to be submitted to the regulatory authority concerned, on the 1st of June and 1st of December of each calendar year. All such compliance reports submitted by the project management shall be public documents. Copies of the same shall be given to any person on application to the concerned regulatory authority. The latest such compliance report shall also be displayed on the web site of the concerned regulatory authority.

1.8 Roads and its ecological effects

Roads are an integral part of the transport system and from ancient times, served as an indicator of a society's level of development. They have facilitated the movement of people and goods with a single mode and with varied means (Anon., 2001). It plays a significant role in the socio-economic development of a nation/community and therefore, is a reflection of a nation's development. The overall performance and social functioning of a community is largely influenced by developed and maintained road networks. Roads enhance mobility, exposure from isolation and therefore poverty (Seiler, 2001).

According to the Ministry of Road Transport and Highways and the Economic Survey of India 2017-2018, India has a total of 56,03,293 km of road length including both surfaced and un-surfaced roads granting India the title of second largest road network size in the world. This road network comprises of national highways, state highways, expressways, major district roads, other district roads and village roads. Improvement in the road sectors will have a great impact on the economy of the country. Better roads will enable the transportation of goods and people at a faster pace thus reducing logistic cost for industries and quality travel for passengers. With the country's unemployment rate estimated at 18.6 million or 3.5 per cent (Anon., 2018c), the road sector will provide a much-needed boost for employment in the country.

According to the Economic Survey of Mizoram 2017 – 2018, the total length of all types of roads in Mizoram is 7632.604 kilometers having a road density of about 36.196 kilometers per hundred square kilometers which is much below the national average of 166 kilometers per hundred square kilometers. Out of the total road network, National Highways covers 1465 kilometers, BRO Roads covers 896 kilometers and State Roads covers 4662 kilometers. As stated earlier, roads being the vital means of communication and transport in the state, socio-economic upgrade of the state are greatly dependent on its roads.

1.8.1 Ecological effects

Road construction can have both negative and positive impacts. The most common positive impact of development of the road infrastructure is the socio-economic advancement and improvement of the people. The quality of life is greatly attributed to the development in road infrastructure. Roads support the automobile industry, lead to faster transportation of goods and people, provides a linkage network - producers to markets, workers to jobs, students to school, the sick to hospitals (Berg, 2015) and most importantly generates employment for millions of people around the world. As stated earlier, these positive and socio-economic benefits of road infrastructure is common and the masses are well aware, however the negative impacts mainly to the environment are neglected and underestimated (Newman *et al.*, 2012). Awareness on these negative impacts needs to be focused on with proper and effective mitigation measures before decision-making is done in any road construction project. Negative impacts of road construction include damage to sensitive ecosystems, loss of productive agricultural lands, resettlement of large numbers of people, permanent disruption of local economic activities, demographic change, accelerated urbanization, and introduction of disease (Tsunokawa and Hoban, 1997). It also causes immense noise pollution which is harmful to both human beings and animals; it increases the air pollution due to generation of dusts, smoke, particulate matter and other harmful gases from the equipments used; it causes water pollution due to siltation in nearby water sources and also causes soil erosion making the area susceptible to landslides and rockslides.

The effects that roads have on the environment can be broadly discussed under the following topics:

i) Roadkills

Roadkill are animals, domestic or wild, that are hit, struck and killed by vehicles on roads or highways. Roadkill is a common threat and has significant impact on wildlife populations. For many decades, road killed animals have been of concern to biologists. Road kill or road mortality of animals is claimed to be the leading source of mortality in wildlife populations and an estimated 1 million vertebrates die on roads every day in the United States (Forman and Alexander, 1998).

In India, road kills have also been a major threat to decline in wildlife population. Although deaths of animals by vehicles hit the news now and again, a vast majority of such roadkills probably remain buried without any trace of record. Pariwakam (2018) of the Wildlife Conservation Trust claims that roads and railway lines have caused the death of at least 16 tigers and over 150 elephants across India over a span of 8-10 years. In addition, he also mentions that mortalities of other endangered species of mammals such as leopard, sloth bears, wild dogs, wolves, jackals, hyena, Indian fox, honey badgers, otters, langur monkeys as well as herbivores such as Indian gaur, spotted deer, barking deer, nilgai and sambar go unrecorded.

ii) Habitat Fragmentation and Isolation of Populations

Habitat fragmentation in its simplicity is breaking up of large areas or landscapes into smaller patches of land causing local and population level changes in flora and fauna. Didham (2010) defines habitat fragmentation as the process by which habitat loss results in the division of large, continuous habitats into smaller, more isolated habitat fragments. With increase in human population, urban sprawl increases wherein human require more space for living, agriculture, livestock, roads etc. which leads to more habitat destruction and fragmentation. Wide range of animals as well as flora that are dependent on large areas of favorable habitat to survive are greatly affected by fragmentation as the landscape in which they thrive is reduced in size and barriers are created (Bender *et al.*, 1998). Fragmentation reduces the amount of habitat available to wildlife in the landscape and thereby diminishes population sizes and the number of species that can live in the landscape (Seiler, 2001).

iii) Pollution

Pollution caused by road infrastructure occurs during the construction phase, operation phase and maintenance phase. These sources of pollution can be attributed to many factors – from use of heavy machinery during construction phase to heavy traffic during its operation and maintenance phase. The common physical and chemical effects of roads to the environment include air pollution, water pollution, noise pollution, soil pollution, effect on biodiversity, alteration in landscapes etc.

The most common effect of road construction is noise pollution especially during the construction phase wherein construction equipment and heavy machineries are operated daily for long durations of time; also heavy traffic during operation phase is a common disturbance in highways. Animals are found to respond to noise pollution by altering activity patterns with increase in heart rate and production of stress hormones. In human beings, exposure to high noise levels which is associated with road construction work can adversely affect human health causing stress, sleep disturbance, high blood pressure and even hearing loss (Gray, 2018).

Air pollution is another cause of roads as it greatly increases the level of pollutants in the area. Land clearing, operation of machines, demolitions etc. are common activities in construction sites and generate high levels of dust which can disperse over long distances polluting nearby areas **(***Ibid.*, 2018). Vehicles emit a variety of pollutants – carbon dioxide, carbon monoxide, oxides of nitrogen, oxides of sulphur, particulate matter, hydrocarbons and heavy metals, all of which have serious effects on flora, fauna and people. Stunted growths in plants near highways, photosynthetic and catalytic complexities, and even abrupt increase in species composition have been recorded (Spellerberg and Morrison, 1998). Emission of dust and other particulate matter have a serious toll in people as it penetrates into the lungs and causes respiratory illness, asthma, bronchitis and even cancer.

Another common effect of road construction is water pollution. Water run-off can alter hydrology, increase sediment load, increase level of nutrients and result in accumulation of pollutants in the water bodies. These water bodies may be a source of drinking water for people and animals in the area. Sedimentation of soil onto rivers during construction phase has resulted in decline in fish populations (Eaglin and Hubert, 1993). Land clearing causes soil erosion which leads to silt-bearing run-off and sedimentation onto water-bodies which increases the turbidity, restricts sunlight penetration and destroys aquatic life. Other pollutants generated from construction sites like oil, diesel, cement and toxic chemicals can also penetrate through the ground polluting groundwater (Gray, 2018). Groundwater is an important source of drinking water in communities and treatment of contaminated groundwater is very problematic.

1.9 Scope and objectives of the study

1.9.1 Scope

The present study deals with the road construction project from Champhai to Zokhawthar area located in the eastern region of Mizoram. Zokhawthar village is the border area between Mizoram and Myanmar. The up-gradation of the Champhai - Zokhawthar road is a development project under the Mizoram State Roads Project – II (MSRP - II) funded by the World Bank. The MSRP – II was initiated as a commitment by the Government of India as means of infrastructure development and trade promotion in the North Eastern part of the country. The developmental project of Champhai – Zokhawthar road is an environmental category "A" developmental project as per World Bank Policy as well as Government of India (GOI), Ministry of Environment, Forest & Climate Change (MoEF&CC) and EIA Notification 2006.

The environmental components including air quality, water quality, noise quality and biodiversity are assessed and monitored in this study. The EIA and EMP report issued by STUP Consultants Ltd., 2014 (Anon., 2014e) is used as a comparative study material for detecting the level of degradation as well as providing baseline data of the environment. Therefore, comparing the end results of the present study with its baseline data reveals the impact road construction has on the environment. Although studies on assessment of air, water, noise or biodiversity have been carried out separately and literatures are readily available, there are no available literatures or data on comparative study and representation of full environmental impact assessment in road construction projects in the state of Mizoram. Studies on impact and degradation caused by road construction activities on the environment provide valuable information and awareness regarding developmental projects. As countries, communities and societies move towards socio-economic advancements; Mizoram Government is also striving towards a better future, initiated developmental projects for its economic growth and has made immense progress over the years. However, Mizoram renowned for its luscious green vegetation and pleasant climate needs to understand the effects of such developmental projects on the environment and must uphold sustainability on its road to socio-economic development.

1.9.2 Objectives

1. To determine the air quality in areas between Champhai and Zokhawthar.
2. To analyze the water quality of water bodies in and around the Champhai – Zokhawthar area.
3. To measure and record the level of noise pollution at different sites along the construction area.
4. To assess the biodiversity effected by the Champhai – Zokhawthar Road Construction.

CHAPTER – 2

REVIEW OF LITERATURE

2.1 An overview

The Environmental Impact Assessment (EIA) commenced in the 1960s, with enactment of the National Environment Policy Act (NEPA) in the United States of America as part of increasing environmental awareness. Since then EIAs have been used increasingly around the world.

The Organisation for Economic Co-operation and Development, an organization with a mission to promote economic and social well-being of people, has simply defined EIA in its entirety as an analytical process that systematically examines the possible environmental consequences of the implementation of projects, programmes and policies (Anon., 1997). N.C. Aery in his book, "Manual of Environmental Analysis" defines it in a more elaborate way as "a systematic, well-documented and multidisciplinary procedure, where we identify, describe and assess the direct and indirect effects of a project or an activity on different environmental factors such as soil, water, air, climate, landscape, cultural heritage, flora, fauna, human beings; and also interactions among the factors" (Aery, 2010). Both definitions shows the true intention of EIA wherein all grounds of environment, society and economy need to be addressed and understood while studying the possible impacts of projects and other developmental actions. Htun (2012) stated that EIA primarily focused on identifying effects and impacts on the physical and natural components of the environment, and that assessing impacts on social, cultural and anthropological components were mandatory for ensuring sustainability. With increasing rate of development by governments of the world, sustainable development in relation to food and agriculture, forestry, industrialisation, urbanisation, and energy has become an important objective that governments should take into concern. Supriya's (2015) statement that EIA is "a trade-off between development and environment" acknowledges the fact that a community's goal towards development brings about rapid industrialization which is also accompanied by massive environmental and social burdens. Therefore, the shortcomings and loopholes in EIA processes must be mended through legislations so as to make EIA more effective and meaningful. EIA as a tool should be applied to identify policy and institutional constraints that are impeding sustainable development.

Many countries of the world have implemented EIA as legislature and aids in decision making by limiting the consequences caused by developmental projects. However, EIA can be considered ineffective and hostile for two reasons – unavailability of proper guideline for EIA procedures suitable for the environmental and socio-economic situation of the nation, and implementation of EIA as legislature in the planning processes of developmental projects. These drawbacks in EIA should be immediately taken into consideration by the concerned authorities so as to ensure sustainable development. In Friends of the Oldman River Society v. Canada 1992, EIA was described in terms of the proper scope of federal jurisdiction with respect to environment matters - "Environmental Impact Assessment is, in its simplest form, a planning tool that is now generally regarded as an integral component of sound decision-making." Likewise the United Nations Environment Programme - Division of Technology, Industry and Economics (UNEP-DTIE) states that EIA aims to predict environmental impacts at an early stage in project planning and design, find ways and means to reduce adverse impacts, shape projects to suit the local environment and present the predictions and options to decision makers (Abaza *et al.*, 2004). Implementation of EIA as legislature and incorporating it in the planning stage of projects is the next step towards EIA improvement and development.

In India, EIA has evolved over the years with its inception in the late 1970's. Dara *et al.* (2017) gave a brief yet complete view of the evolution of EIA in India along with the procedures, administrative set-up and practice followed generally in India. There have been a number of notifications and legislatures passed in the gradual development of EIA and its steady evolution towards a sound legal framework in India. Yadav (2018) also addressed the EIA procedures and practice in India along with its shortcomings and deficiencies. He mentions that EIA is addressing environmental issues of developmental projects especially power projects and regards EIA as the most important tool in achieving sustainable development. In his research work titled, "Environmental Impact assessment: A critique on Indian law and practices", he revealed that implementation of environment impact assessment in India has many defects and requires renovation in order to achieve better environment protection and sustainable development as enshrined in Agenda 21, Rio declaration and different environmental legislation in India. The outcomes/suggestion that was stated in his research work is highly important in environmental protection and economic development.

Venu (1999) in his study titled, "Environmental Impact Assessment: Some Considerations on Evaluation of Flora: An Overview" had already reviewed the main procedure of EIA process carried out in the country. According to his work, he stated that many consultancies or other environmental monitoring firms operate with inadequate literatures and expertise which leads to faulty assessments. Lack of literatures and scanty information leads to vague impact predictions and ultimately fails to formulate suitable mitigation proposals. He suggested that environmental impact assessment groups, resource surveys and experts in the field should immerse themselves in the process through development of organized database, improved scoping process and extended investigation of environmental components related to proposed projects. These will ultimately increase the effectiveness of the process and increase the objectivity of the exercise. Therefore, EIA process is extremely necessary in providing an anticipatory and preventive mechanism for environmental management and protection in any development.

Road construction and related activities have major environmental damage and impacted communities undesirably. In the handbook prepared by World Bank titled "Roads and the Environment", Tsunokawa and Hoban (1997) mentioned that the major environmental impacts of road projects include damage to sensitive ecosystems, loss of productive agricultural lands, resettlement of large numbers of people, permanent disruption of local economic activities, demographic change, accelerated urbanization, and introduction of disease. The impact of roads on the environment is long-term and four-tiered - construction, maintenance, operational and rehabilitation phases. These impacts as mentioned before cause widespread environmental degradation and disruption which in many cases be permanent. Road construction and development is also a source of damage to the human environment, covering a wide range of fields, particularly human settlements, activities, residences and workplaces, health and safety (Anon., 2001). With increase in population, there is also increase in traffic demands which ultimately results in raw materials consumption, air pollution and noise pollution. Hoang *et al.* (2005) mentions that in order to apprehend the extent of impact of road construction and maintenance processes, the energy and materials consumption as well as emissions towards environment must be taken into account.

As environmental impacts from road development are common and mostly inevitable, comprehensive environmental assessment studies and management plans should be carried out by environmentalists, professionals and specialists so that impacts can be reduced, minimized and mitigated. Substantial time and effort should be spent on identifying potential impacts and options for minimizing them, consultation with various groups who have an interest in the project, and to develop and implement mitigation plans.

2.2 EIA of road constructions at the global level

In the report titled "Assessment of EIA process on roads in Ireland" Healy *et al.* (2007) assessed the Environmental Impact Assessment process of eleven researchers in their own fields. Each researcher produced an individual report, examining individual EIA process for selected road proposals. The intention in the process was to critically analyze the operation of the process with an eye to making effective recommendations for improving it. In general it was found that the Environmental Impact Assessments studied failed to meet the requirements of the directive and to follow the EPA Guidelines and Advice Notes, both in establishing all relevant baseline data and information and in making systematic predictions of likely impacts. Well-established methodologies which exist in a discipline were not followed. This failure had a number of consequences such as: the unreliability of the material gained thereby for the purpose of the EIA; the fact that this information cannot be usefully added to the general store of knowledge consisting of data collected at other places and times by recognized methods; and the veracity of the conclusions are harder to verify. Furthermore, data collected and used in the analysis was not made available. This frustrates members of the public seeking to test the methods and analysis used in the EIA.

These problems are recurrent factors in preparing an EIA report and is not limited to specific countries but to all nations in general. The project proponents and other such authorities taking up the projects must mean well in preparing the report, following the guidelines and assessing the possible impacts.

A study on EIA in road sector in Tanzania, Denmark was conducted (Brogaard, 2008). The study examined the effects of government initiatives to regulate the impact of the two forces: roads and population pressure, which contribute to deterioration of the environment in Tanzania. The objective of the study was to draw attention to the limitations of the project-level environmental impact assessment (EIA) with regard to contributing to sustainable development within the planning process. The concluding results showed that the rules, laws and regulations are poorly implemented due to the ineffective decentralization of environmental responsibility and the powerlessness of the EIA tool in securing coerciveness to the recommended legislative mitigation measures. Results also indicated that implementation of criteria for reaching EIA goals is challenged by poorly institutionalized conceptions of these criteria throughout the EIA system.

Based on a collective interpretation of these challenges it was concluded that the success of the government's recommendations of widening the scope of EIA to include environmental assessment of all new policy, plans and programmes (Strategic Environmental Assessment) will be highly dependent on changing the mind-sets and motivation of top personnel at ministerial level, as well as promoting awareness at regional and local level.

Projects funded by the World Bank and Asian Development Bank (ABD) such as the Lifeline Roads Improvement Project under the Government of Armenia (Anon., 2009) and the North-South Fast Track Road Project under the Government of Nepal (Anon., 2015a) are rehabilitation of roads with the prime objective for development. Lifeline Roads Improvement project is categorized as category B project and preparation of a detailed EIA report was mandatory. It aimed at rehabilitation of approximately 100 km of rural roads located in the 7 different regions of the country. The North-South Fast Track Road Project is Category A under ADB Environmental Assessment Guidelines 2003 and also requires clearing of 5 ha of forest for the construction work. From the EIA and EMP reports prepared, potential impacts of the project mentioned in the report included - degradation of landscapes and soil erosion; pollution by construction run-offs like oil, asphalt, chemicals etc leading to water pollution; impacts on the biodiversity of the project region; damages to the plant cover and the habitat for wild life in the cutting and filling areas close to the road; noise and vibration disturbances during construction and temporary air pollution (dust) related to the transportation of construction materials and truck traffic; disposal of excavated materials and construction wastes.

Rehabilitation of the Akure-Ilesha Road, Nigeria (Anon., 2012a) and the construction of South Sudan rural roads (Anon., 2013a) were classified as category B which required EIA and EMP reports. The environmental and social impact study of the South Sudan rural roads project was a study of 11 roads sections that lay mainly in the Greater Equatoria region of South Sudan, whereas Nigeria project was intended to rehabilitate the already existing Akure-Ilesha road. From analysis of the reports prepared, no severe unprecedented and or cumulative negative impacts were identified; however the following significant adverse impacts were identified:

- Air Quality and Noise

  The land clearing and construction-related atmospheric emission (CO, HC and NOx emissions), dust and noise impacts will occur though these will be short-lived.
- Water Quality

  Surface runoff from disturbed soil and in-river construction activities will impact surface water quality during construction. Such impacts will be temporary and limited to small areas downstream, but can affect a large portion of an adjacent fish pond. The effluent will eventually be discharged to the water bodies.

- Ecology

  Contamination of surface and groundwater will arise from chemical effluents, solid waste and domestic sewage discharge and discarded lubricants, fuel and oils. Discharge of effluents has potentials for water pollution with attendant effect on water quality and aquatic life.

2.2.1 Assessment of the environment

Anair (2006) in his study titled "Digging up trouble: The Health Risk of Construction Pollution in California" assessed and analyzed air pollution caused by construction equipments in California, United States of America. The assessment methods stipulated by U.S. Environmental Protection Agency (EPA) and California Air Resources Board (CARB) were adopted to quantify the impact of air pollution in the state and the results indicated that emissions from construction equipments caused more than 1100 premature deaths per year, more than 1000 hospital admissions for cardiovascular and respiratory illness, 2500 cases of acute bronchitis, tens of thousands of asthma attacks and other lower respiratory symptoms. The study concluded that although construction equipments are critical to building roads and highways, the resulting annual health costs due to pollution caused by such equipments amounted to more than nine billion dollars (including hundreds of thousands of lost work days and school absences) which is also economically detrimental to the state as compared to the 8 billion dollars cost for building the road infrastructure in the state in the previous year. The use of such machineries is inevitable especially in case of developmental projects however practical protective and preventive measures can be taken so that the impact on human health can be limited.

In a study of assessment of air quality in the city Eskişehir, Turkey (Ozden *et al.*, 2008), sulphur dioxide (SO_2), particulate matter (PM), nitrogen dioxide (NO_2), ozone (O_3), and non-methane volatile organic carbons (NMVOCs) were assessed and compared with data from local emission inventory studies which provided relative source contributions of the selected pollutants to the region. The contributions of these typical pollution parameters, selected for characterizing such an urban atmosphere, were compared with the data established for other cities in the nation and world countries. Based on the comparisons, ambient air standards, among all the pollutants studied, only the annual average SO_2 concentration was found to exceed one specific limit value (EU limit for protection of the ecosystem). A part of the data (VOC/NO_x ratio), for determining the effects of photochemical interactions, also indicated that VOC-limited regime was prevailing throughout the city.

Physicochemical studies were conducted to assess water resources in Abeokuta North Local Government Area, Ogun State, Nigeria (Olopade, 2013) in relation to their potential for aquaculture uses. Water samples were collected from both surface and groundwater sources and analyzed for pH, colour, turbidity, conductivity, total hardness, chloride, BOD, carbonate, iron, lead and copper. The results revealed a fluctuating behavior of different parameters throughout the study correlations between the physiochemical studied, the result revealed that physicochemical variables were significantly influenced by site but there were no significant difference in the values of Pb and Fe in all the station.

Abewickrema *et al.* (2013) conducted a study to assess the water quality impacts from road construction and rehabilitation projects in surface water bodies in Sri Lanka. Samples collected from the water bodies were assessed for six parameters pH, electrical conductivity (EC), total suspended solids (TSS), Escherichia Coli (E. coli), biochemical oxygen demand (BOD) and dissolved oxygen (DO). The results indicate that road construction projects impose a significant threat on the water quality of natural water bodies and that minimizing the soil erosion and the dust accumulation at the construction sites is extremely crucial.

A study was conducted in Nepal and community noise levels were measured (Murthy *et al*., 2007). The noise levels were measured following standard procedure using calibrated sound pressure level meter at many places of Banepa town. A representative sample of the public was also interviewed using a questionnaire. The results indicated that high noise levels were surpassing on many occasions to the prescribed levels. Overall minimum and maximum noise levels for the Main Road are 60.1dB (A) and 110.2 dB (A). Bus parks and Bus stops had minimum and maximum noise levels were 63.9 dB (A) and 110.2dB (A). The noise levels produced by different motor vehicles ranged from 121 to 91.2 dB (A), which were substantial. The perception survey indicated high prevalence of headaches, lack of concentration, sleep.

Caliskan (2013) assessed the environmental impact on forest road construction on mountainous terrains by conducting an investigation of the construction techniques conducted on forest lands in Turkey. The environmental damage caused by use of hydraulic excavators and bulldozers were evaluated. The results showed the percent damage to forests on steep terrains as 21% of trees (excavators) and 33% of trees (bulldozers) during forest. The percent damage on very steep terrain showed 27% of trees (excavators) and 44% of trees (bulldozers) during forest road construction. From the study, it was determined that machineries used for road constructions led to the destruction of trees as well as stability of the land. Also, excavators were found to be less damaging to forest and more effective towards construction of roads rather than bulldozers. In connection to this, Ledec and Posas (2003) had already studied biodiversity in relation to road projects and activities under their work titled “Biodiversity Conservation in Road Projects: Lessons from World Bank Experience in Latin America”. This study revealed that road construction and biodiversity aims are often at odds while at the same time many potentially serious conflicts between road projects and biodiversity conservation can be minimized and hopefully avoided by careful project identifying, taking special care to avoid passing through protected areas and other critical natural habitats, including forested areas. Although road projects are designed and implemented so as to avoid or compensate adequately for any adverse impacts on natural habitats and biodiversity instances occur where natural habitat loss is inevitable. In such cases, appropriate mitigation measures should be properly implemented. The study concluded that if proper guidelines and measures are followed and implemented, not only does it protect biodiversity; they can also help maintain clean water supplies and public health, minimize local flooding, avoid conflicts between construction workers and local populations, reduce vegetation maintenance costs, and minimize damage to the roads themselves from water infiltration, erosion, and landslides.

Nergiz and Durmus (2016) studied the effects of road construction works on bird communities in Van, Turkey. Population of Sand martin (*Riparia riparia*), European bee-eater (*Merops apiaster*) and European roller (*Coracias garrulus*) nesting at roadside in Van, Turkey were observed by conducting point-count surveys along the 85 kilometers long highway in Van between years 2013-2015. The study concluded that total population number of these species and nests decreased during and after the road broadening and construction efforts between years 2013-2015 ($p<0.05$). These three species failed to find alternative nest area affected by habitat destruction caused by road construction works.

2.3 EIA of road constructions at the national level

The preparation of EIA report (road construction, rehabilitation, upgradation) in India follows a common trend. The structure of the Environmental Assessment Report in India consists mainly of - Introduction, Project Description, Methodology, Environmental Regulatory Framework, Current Environmental Conditions, Environmental Impacts and Mitigation Measures, Analysis of Alternatives, Public Consultation and Environmental Management Plan. The methods and methodology applied in assessment of the environment is similar although additional methods and slight difference in methods may occur depending upon the persons/organizations carrying out the assessment. The approach to carry out EIA study is organized basically in four tasks and is based on the field investigations and reconnaissance surveys in the project area, collection, collation and analysis of secondary data and discussions with key stakeholders on the potential impacts of the project. Information on various environmental components are collected through survey oriented screening, collection of data using questionnaire, monitoring of air, water and soil quality and collection of secondary data. The four mentioned tasks include collection of baseline environmental data; review of policies, regulations and institutional arrangements; identification of potential environmental impacts; and preparation of environmental management and monitoring plan. The specific environmental issues considered are physiography and soils, topography, climate, borrow area and quarry sites, water resources, drainage pattern, air, noise, soil quality, biological characteristics social-environment and other sensitive environmental sites.

The World Bank Group has funded a number of projects in India including projects in the road sector. These projects are to be carried out in guidance with the regulation and policies of the World Bank and its related institutions as well as that of India.

Although the methods and methodologies applied for assessing the environment for an EIA report in India may be similar, baseline data reasonably differs depending on the area and the likely impacts generated also changes based on the extent of the project and location of the project.

The Rajasthan Rural Connectivity Project (Anon., 2013b) and Improvement of Bahjoi-Gajraula section Badaun-Bilsi-Bijnaour road (Anon., 2015b) are road developmental projects funded by the International Development Association (IDA) and the World Bank respectively. RRC Project was taken up by the Public Works Department (PWD) of Rajasthan. Both projects required the preparation of an EIA report which was duly submitted. The typical likely impacts from the proposed operation included:

1. Felling of some limited number of roadside trees;

2. Adverse impacts on water resources, including from silt flow during execution of works;

3. Impairment to or worsening of the local/regional drainage;

4. Construction phase impacts, including those related to camp site operation, dust generation, and pollution from plants, machinery, and vehicles and disposal of debris/other construction wastes;

5. Appropriate management of materials (such as aggregates, sand, water, earth)

The Ministry of Road Transport and Highways was entrusted with the up-gradation of Birpur-Bihpur section of NH -106 of existing single/intermediate lanes to 2 lanes with earthen/paved shoulders configuration in the State of Bihar (Anon., 2014a). In accordance with the EIA Notification 2006, 'Birpur – Udakishanganj section of NH-106 project falls in 'Category-"A" and required preparation of EIA and EMP reports. The potential impacts due to project implementation were identified based on the baseline environmental features. The nature, type and magnitude of the potential impacts on land, air and water environment, socio-economic and biological environment were discussed. The impacts were classified in three stages - Planning and Design stage, Construction stage and Operation stage. This classification broadened the scope of the impact assessment and made the report more valuable in terms of environment protection

2.3.1 Assessment of the environment

A study was done to survey ambient air quality monitoring of Surat city, India (Juned and Hemanji, 2014). The parameters selected for the study were RSPM, SPM, NO_2, SO_2, and CO which was measured according to Bureau of Indian Standards (BIS). The sampling of the pollutants was done by using High Volume Sampler (HVS). The Air Quality Index (AQI) calculated was an effective tool to justify ambient air quality for better management of air quality. Looking to the AQI data, at APMC market N/R Railway Station the value of AQI was found to be 140 which is highest and according to EPA guidelines this value is unhealthy for sensitive groups. SPM exceeded at all stations. Except Snehmilan Garden, Nanpura and Ambawadi-Dumas all stations showed NO_2 concentration above the permissible limit.

The Central Pollution Control Board (Anon., 2014b) conducted air and noise quality assessments during Deepawali Festivals in different cities, states and union territory of India – Arunachal Pradesh, Bihar, Chattisgarh, Delhi, Gujarat, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Meghalaya, Mizoram, Punjab, Puducherry, Tamil Nadu, Tripura, Uttar Pradesh, West Bengal and Andaman &

Nicobar Islands. The ambient air quality monitoring was carried out for 24 hours and parameters of Particulate Matter (Size less than 10µm) or PM_{10} and gaseous pollutants (SO_2 and NO_2) were monitored. Noise measurements was carried out by using a Type 1 integrating sound level meter for 6 hours at each location with sampling duration of 1 second. The overall results show that PM_{10} level ranged between 22 and >1000 µg/m^3 on the festival day and the maximum PM_{10} value of >1000 µg/m^3 was reported at Salt Lake, North Kolkata & Kasba, South Kolkata on the festival day. SO_2 level ranged between 04 and 60 µg/m^3 with the maximum value of 60 µg/m^3 reported at Kasba, West Bengal. NO_2 level ranged between 09 and 82 µg/m^3 with maximum NO_2 value of 85 µg/m^3 reported at Pragati Maidan, Delhi. The noise level ranged between 44 and 105 dB(A) with the maximum noise level value of 105 dB(A) reported at Main Market (C), Guna, in Madhya Pradesh. From the study conducted, it was evident that all the parameters measured exceeded the National ambient air quality standards 2009 and the Noise Pollution (Regulation and Control) Rules, 2000 in many cities and states. While the permissible limit of PM_{10}, SO_2 and NO_2 being 100, 80 and 80 µg/m^3 respectively, the values measured sky-rocketed. Noise monitoring being carried out during the festivals was mainly in commercial areas where the permissible limits were 65 dB(A) during daytime and 55 dB(A) at night. The Leq measured greatly exceeded the limits in many areas.

Analysis of water samples from three sewage treatment plants near River Ganga were assessed (Rai *et al.*, 2010). The treatment plants regularly discharged wastewater into the River Ganga. Biological oxygen demand and dissolved oxygen values analyzed showed that they were well above the permissible limits. Heavy metals (Zn, Cu, Cd, Pb, Cr) in disposed effluents were also found to be above permissible limits at all three sites. Likewise, the most probable number index of Escherichia coli in water samples and coliform counts were recorded as being higher in irrigated water samples and vegetables, indicating a serious health hazard posed by intense microbial and faecal pollution.

In a study conducted in the Yamuna River, Delhi an attempt has been made to devise a methodology to integrate the Water Quality Indices (WQI) with Geographic Information System (GIS) for an effective interpretation of the quality status of the river (Katyal *et al.*, 2012). River Yamuna in Delhi was taken as a case study and the physical and chemical analysis was interpreted using WQI. Final elucidation of the water quality was done on a map using GIS. Water samples were collected from Yamuna River and analyzed for physiochemical parameters. Based on the results of the analyses, spatial distribution maps of selected water quality parameters were prepared using ArcInfo software. The overall index of pollution (OIP) based on the individual index values were estimated giving the values in terms of pollution indices.

Ambient noise level monitoring was carried out at various locations of the Chidambaram town, Tamil Nadu (Balashanmugam *et al.*, 2011). The data obtained was used to compute various noise parameters, namely equivalent continuous level (Leq), Noise pollution level (Lnp), Noise climate (NC), Percentile noise levels (L_{10}, L_{50}, L_{90}). The comparison of the data showed that the noise levels at various locations of the Chidambaram town were more than the permissible limits. Vehicular traffic and air horns were found to be the main reasons for these high noise levels. The noise level values for exceeded the standards set by the Central Pollution Control Board, New Delhi.

Analysis of noise level generated in and around Thoothukudi city was conducted by Gayathri *et al*. (2012). The noise levels were observed during different time intervals at different study areas using the Sound Level Meter. The study areas were demarked as Silent Zone, Commercial Zone and Heavy Traffic Zone and the sound level prevailed in these areas were analyzed and it was observed that in all the study areas the observed sound level exceeded from the normal permissible level, i.e., Silent Zone (40-50 dB), Commercial Zone (55-60 dB), Heavy Traffic Zone (80-85 dB) to a greater significant extent.

Puspwan and Pandey (2011) conducted a study on the vegetative analysis of tree species in the forest of Kedarnath Wildlife Sanctuary. Analysis was done through quadrat method where quadrats were randomly placed at each study site. The cbh (circumference at breast height i.e at 1.37m above ground) of all the trees in each quadrat was measured and recoded individually for each species for the calculation of total basal cover (TBC). The data were then quantitatively analyzed for frequency, density, dominance and their relative values were calculated and summed to get Important Value Index (IVI) of individual species. The species diversity was determined by using Shannon- Wiener Information Index, the concentration of dominance (CD) was determined by Simpson's index and the equitability or species per log cycle index was also determined. According to the study a total of eleven tree species were recorded and the IVI values ranged from 9.78 to 84.33, the density values ranged between 0.3 and 1.9 and TBC values between 13.55 $cm^2/100m^2$ and 4080.80 $cm^2/100m^2$. Distribution pattern varied for different species. The recorded values viz. density, Shannon-Wiener Index (H), Concentration of Dominance (CD) and Equitability (Eq) were within the reported range for these types of forests.

2.4 EIA of road constructions in Northeast India

The North eastern part of India often referred to as the "seven sisters" of North-East India is a cluster of landlocked states and are among the poorest states in India. Recognizing the need to share prosperity and promote growth in lagging states, the Government of India committed to significant investments in infrastructure development and trade promotion for lagging states, including the landlocked states of the Northeast. In India it is estimated that 63.4% of the roads have been paved and only 28.5% of the roads in Northeastern regions are paved (Anon., 2018d). The severe natural conditions of the Northeastern region with its steep mountains and a prolonged monsoon season have long been an enormous obstacle for developing the road network which ultimately puts a halt on its economic growth. In this context, the Government of India has taken measures for rehabilitation, widening and strengthening of National Highways, State Highways and District Roads which are managed by the State Governments.

Recently, Environmental Impact Assessment report of "Preliminary Design Work for Dhubri-Phulbari Bridge in the State of Assam/Meghalaya on NH-127b" was prepared (*Ibid.*, 2018d). The proposed project is an important connectivity link between the two states wherein the Dhubri bridge will cross the Brahmaputra River and will be a 20-km long, four-lane bridge connecting Dhubri in the Assam State on the north bank and Phulbari in the Meghalaya State on the south bank. The detailed EIA report followed the common trend of EIA report format in India and thoroughly formulated the environmental baseline data for the formulation of predicted impacts and mitigation measures. The common use of hot mix plants in construction activities is predicted to contribute substantially to the deterioration of air quality due to emissions of oxides of sulphur, hydrocarbons and particulate matter. The report mentions that disposal of solid and liquid waste from labor camps, fuel and lubricant spills, or leaks from construction vehicles, pollution from fuel storage and distribution sites and that from hot-mix plants is likely to affect water quality. Mixing, casting and material movement will primarily be the noise generating activities and is expected to uniformly distribute over the entire construction period with noise levels ranging between 80 - 95 dB (A). All these impacts generated are likely to occur during construction period and proper implementation of mitigation measures is absolutely mandatory.

The project of 2 lane with paved shoulder of Jowai town to Assam/Meghalaya section (km 69.2 to km173.200) of NH-44 in the state of Meghalaya is part of National Highways Development Phase III Programme (Anon., 2012b). The project road traverses through five (5) settlements in the district Jaintia Hill of Meghalaya State. The stretch of the project road passes through hilly terrain having a general height of 100 m to 1600 m above MSL through the district of Jaintia Hills, which is a part of eastern side of Meghalaya.

The Assam State Roads Project (ASRP) under the Government of Assam is funded by the World Bank with an amount of US$ 200 Million (Anon., 2011). The project includes improvement of about 800 km State Highways (SH) and Major District Roads (MDR).

The impacts generated from EIA and EMP report from both the projects include:

1. Air - With the implementation of the project, there will be emissions from the traffic as well as emissions from developmental activities in addition to the domestic emissions. This will raise the pollution level.
2. Water - Loss of other water supply sources; depletion of ground water recharge.
3. Soil - Oil spill from the operation of the diesel pumps and diesel storage, during transportation and transfer, parking places, and diesel generator sets; excess production of hot mix and rejected materials.
4. Noise pollution - Increase in noise due to construction activity but would be for short term.
5. Soil erosion – Loss of vegetation/ flora.

The improvement and upgradation of Imphal-Kanchup-Tamenglong Road Section in the State of Manipur is yet another road connectivity project funded by Asian Development Bank. Its EIA report notes that the project is a 103.052 km long road project in Manipur state mostly located in hilly terrain (Anon., 2015c). The major impacts likely to occur during construction include:

1. Alteration in topography due to felling of trees, hill cuttings, ground clearing; stone quarrying, construction of structures, etc.
2. Natural hydrology of water sources along the road project maybe disrupted due to soil erosion. Temporary pollution of rivers from spillage of chemicals and oil at construction sites and waste from construction camps, discharge of sediment-laden water from construction areas and uncontrolled surface water discharge over the road edge creating large–scale erosion on down-slopes is also very much likely to occur.
3. Air quality during construction may be degraded by generation of dust (PM) and generation of polluting gases including SO_2, NOx and HC from vehicular movements, site clearance, earth filling and material loading and unloading.
4. Noise and vibration will also be unavoidable and is likely to affect people living or working near road projects.
5. The road project passes through about 2.1 km of forest area and may cause adverse impacts on flora and fauna of the area. Removal of the existing

vegetative cover and the uprooting of about 2732 trees may reduce the ecological balance in the areas and enhance soil erosion problem.

2.4.1 Assessment of the environment

Air quality assessment was conducted at a congested street in Agartala city, Tripura in which parameters of PM_{10} and $PM_{2.5}$ along with trace gases of NOx, and SOx were assessed using Dust sampler and Fine particulate sampler (Roy *et al.*, 2018). It was found that PM_{10} and $PM_{2.5}$ levels reached 310.55 $\mu g/m^3$ and 155.29 $\mu g/m^3$ respectively which exceeded the permissible limit set by CPCB for 24 hour monitoring. However, SOx and NOx concentrations were below the permissible limits at 10.83 $\mu g/m^3$ and 11.44 $\mu g/m^3$ respectively. Heavy traffic, high number of vehicles and roadside deforestation were attributable to the high concentrations of parameters measured.

According to the report by Greenpeace (Sharma *et al.*, 2018), the monthly average PM_{10} data for the year 2016 was obtained from Guwahati and other cities/towns in Assam. It was found that 12 cities except Bongaigaon had higher concentrations of PM_{10} than the annual average levels prescribed by CPCB and all of them were approximately three times more polluted as compared to the WHO annual standard. Nagaon recorded the highest annual average PM_{10} levels in the state with values of 142 $\mu g/m^3$ in 2015.

Water quality assessment carried out in Nagaland and Karbi Anglong district of Assam wherein water samples were collected from various random locations – ground water and surface water (Puzari *et al.*, 2015). The samples were analyzed for different parameters like arsenic and fluoride content, pH, alkalinity and total hardness. The following methods were used for analysis - Hardness was determined by titration method using standard EDTA solution and Eriochrome Black T as indicator; titrimetric method was used to determine alkalinity; pH measurement was done using Eutech pH 510; T*hermo* Scientific *iCE 3000* Series Atomic Absorption Spectrophotometer was used to determine arsenic concentration; and Fluoride concentration was determined by using Thermo Scientific Orion Sure – Flow

Fluoride electrodes. The overall results revealed that drinking water quality in Karbi Anglong district (Assam) and Dimapur district needed improvement although no serious health issues were found.

Das *et al.* (2014) studied the seasonal variation of water quality of River Siang in Arunachal Pradesh. Water colour, air temperature, water temperature and pH were measured using of mercury thermometer and pen type pH meter. Dissolved oxygen, free carbon dioxide, conductivity, alkalinity, turbidity, hardness, TDS, TSS, sulphate, iron, chloride, manganese, sodium and zinc were analyzed in the laboratory using standard procedure of American Public Health Association and using Perkin Elmer Atomic Absorption Spectrophotometer (AAS). The results showed that physico-chemical characteristics of the river varied according to seasons and the downstream of the River Siang were more polluted than that of upstream mainly due to sewage and waste disposal nearby towns. However, the study suggested that there was no harmful chemical contamination and if proper measures the river would remain healthy.

A Geographic Information System (GIS) based noise assessment was carried out to study the noise pollution scenario of Guwahati city (Alam, 2011) at various locations, i.e. commercial zones, residential zones and silence zones (educational institutions and hospitals and nursing homes). Sound Level Meter (SLM) was used for assessment of noise levels and noise mapping was done using GIS technique. From the study, it was observed that noise environment of the Guwahati city is deteriorating and unsafe in various locations for human and it exceeded the noise standards suggested by the Central Pollution Control Board (CPCB) and Bureau of Indian Standards (BIS). It was also observed from that, places with high traffic congestion, narrow roads, heavy constructional activities and poor traffic management areas were more vulnerable to high noise levels. Highest noise levels were found ranging between 80-90 dB (A) recorded in commercial locations, 65-75 dB(A) in residential areas, 65-75 dB(A) in silence zone in the city.

A study was conducted in Udaipur, Tripura which evaluated the trend of noise in the Udaipur town areas (Das *et al*., 2014). Equivalent noise levels were monitored in nine different stations in different parts of the town area and it was observed that the noise level is much above the statutory limits of Central Pollution Control Board.

A study was conducted as an attempt to evaluate noise pollution load of Agartala city (Sen *et al*., 2014). The study seek to find a solution for the noise pollution problems of the Agartala City by making certain restriction on the use of sound generating instruments, mass awareness among people and regular enforcement of Noise Pollution (Prevention & Control) Rules 2000.

Vegetation assessment was carried out at Nokrek Biosphere Reserve in Meghalaya (Sangma and Lyngdoh, 2014) to provide baseline information on the biodiversity status of the biosphere. The study revealed that a total of 146 species were present in the biosphere, out of which 68 were trees, 35 shrubs and 44 herb species. Tree density ranged from 1020 to 1320 individuals per hectare and the highest IVI was obtained for *Syzygium syzygoides* and *Duabanga grandiflora* in the buffer region while *Syzygium operculatum* and *Actinodaphne oboata* dominated the core zones.

Tree species assessment was carried out at Hollongapar Gibbon Wildlife Sanctuary, Assam (Sarkar and Devi, 2014). Quantitative analysis of diversity, population structure and regeneration status of tree species were studied and analyzed during 2010–2011. 100 quadrats ($10m^2$) were laid by following random plot sampling method. A total of 75 tree species belonging to 60 genera and 40 families were recorded from the study area. The status of natural regeneration of species was determined based on their population size. Majority of tree species (36%) exhibited “fair regeneration” condition followed by “good regeneration” status (24%). The overall population structure of tree species showed reverse J-shaped population curve and “good regeneration” status.

2.5 EIA of road constructions in Mizoram

Compared to other North-eastern states, Mizoram lacks poorly in connectivity and infrastructure. However, in recent years the government has taken many initiatives to improve the road connectivity in the State and as already stated earlier, according to the Economic Survey of Mizoram 2017 – 2018, the total length of all types of roads in Mizoram is 7632.604 kilometers. Most of the state roads are still in poor conditions, with potholes, ruts, cracks, and landslide prone areas. Poor road quality and inadequate carrying capacity contribute to low riding quality, low travel speeds, and high vehicle operating costs. This translates into costly and slow road travel with negative effects on passenger fares and freight charges.

Among the initiatives taken, the Mizoram State Roads Projects Phase I and II is expected to expand or rehabilitate about 500 km of the State's core road network which amounts to nearly three-fourths of the total network, benefiting an estimated 70 percent of the state's largely poor population that relies on the road network on a daily basis (Anon., 2014c).

Government of Mizoram initiated a project funded by World Bank under the Mizoram State Roads Projects. The Aizawl bypass (Anon., 2003) starts from Zemabawk on NH-54 and followed the eastern route. The designed length of the bypass is about 13.48 km. EIA report was prepared as required by World Bank policies and that of the Indian Government. The predicted impacts generated from assessment included:

1. Destabilization of slopes and soil erosion
2. Loss of productive soil - The most immediate, direct and long-term effect of cutting of the slopes is the elimination of the productive capacity and topsoil.
3. Impact on water resources - The surface water quality in the project area may get contaminated temporarily due to accidental spills of construction material, oil, grease, fuel and paint from the equipment yards and asphalt plant; the water retention capacity of the area being low due to the steep terrain, surface water resources will be tapped for water required during the construction stage.

4. Impacts on air quality - Generation of exhaust gases is likely due to movement of heavy machinery, oil tankers etc. Gases like S02, HC, NOx and other volatile gases will be generated from hot-mix plant operations.
5. Impacts on noise quality - Due to various construction activities, there will be temporary noise impacts in the immediate vicinity of the project corridor.
6. Loss of biodiversity - Construction of the Aizawl By-Pass shall involve substantial hill cutting and removal of topsoil. This activity will cause following major impacts on the surroundings; loss of vegetation cover having shrubs, grasses and other plants.

The Chhumkhum- Chawngte Road (C-C Road) and Champhai-Zokhawthar Road (C-Z Road) are under the MSRP II – RCTP for improvement. The existing C-C Road will be upgraded from village road standard to 2-Lane National Highway Standard (Anon., 2014d) and Champhai–Zokhawthar road to 2-Lane National Highway (Anon., 2014e). Both are categorized as environmental category “A” as per World Bank Policy. For category “A” projects a detailed EIA report need to be prepared along with an Environment Management Plan. From the EIA report thus prepared, the proposed project is expected to have both positive and negative impacts on the surrounding environment. Assessment of the nature, type and magnitude of the potential negative impacts on the various relevant physical, biological and cultural environmental components along the project corridor is done.

The widening and improvement of NH54 (Aizawl – Tuipang) project funded by Japan International Cooperation Agency (JICA) is also an important project aimed at providing better connectivity and increased economic development for Mizoram with neighboring countries. The existing road is about 381 km in length, stretches over five districts in Mizoram and can be considered as one of the most important road in the State as it is the lifeline of many Mizo people who depend on road network for the supply of essential commodities. Although there has not been any research papers published on the monitoring of the impacts of the project, the Environmental Impact Assessment Report (Anon., 2015d) suggests the significant environmental impacts as clearance of roadside trees, temporary deterioration of ambient air quality and nose/vibration levels during construction phase from land clearing, ground shaping, and quarry and camp operations. Such predicted impacts are planned to be mitigated through compensatory afforestation; timing of construction activities to minimize fauna disturbance; control of noise, dust, wastewater, fuel combustion emissions, and construction debris generation through good construction practices; and implementation of road safety measures to separate road users from active construction fronts.

2.5.1 Assessment of the environment

A study of air pollution was carried out in Aizawl city during 2006–07 (Lalrinpuii and Lalramnghinglova, 2008). The objectives of study were to estimate suspended particulate matter (SPM), respirable suspended particulate matter (RSPM), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2). The ambient air quality at four different stations was monitored. SPM in the atmosphere was determined using high volume method. RSPM in the ambient air was determined using the cyclonic flow technique and a respirable dust sampler was used for the estimation of RSPM and SPM. NO_2 in the atmosphere was determined using Jacob and Hochheiser modified (sodium arsenite) method and SO_2 in the air was determined using the modified West and Gaeke method. The findings from the study showed that the concentration of SPM, RSPM, NO_2 and SO_2 varies greatly from one station to another. The study was done based on the National Ambient Air Quality Standards given by the Central Pollution Control Board. It was found that the average concentration of SPM in Bawngkawn was the highest at 131.85μg/m^3 and was lowest at the MZU Campus (38 μg/m^3). Automobile exhaust was found to contain 40–50 μg/l SPM; thus some areas with high vehicle density like Bawngkawn have the highest SPM. The RSPM concentration at all the stations was more or less similar, ranging from 38.06 μg/m^3 (lowest) at Laipuitlang to 58.06 μg/m^3 at Bawngkawn (highest).

The study also showed that the average NO_2 concentration was highest in Bawngkawn (12.89 μg/m^3), followed by Khatla (11.54 μg/m^3), Laipuitlang (7.08 μg/m^3) and MZU Campus (3.04 μg/m^3). The average SO_2 concentration in Aizawl city was below the detection level, i.e. 4 μg/m^3. Bawngkawn had the highest value (1.57 μg/m^3) followed by Khatla (0.94 μg/m^3), Laipuitlang (0.82 μg/m^3) and MZU campus (0.78 μg/m^3). According to the air quality standards given by NAAQS and WHO, the pollutants values obtained are all within the standard level.

Assessment of air quality was conducted at the Tuirial municipal waste dumping site in Aizawl (Zothanzama *et al.,* 2013) wherein the air quality for suspended particulate matter (SPM), respirable suspended particulate matter (RSPM), NO_2 and SO_2 were analyzed for a period of one year during 2011-2012. The findings showed that the SPM and RSPM concentrations were to a great extent above the permissible limit of the National Ambient Air Quality Standard (NAAQS) by the Central Pollution Control Board (CPCB) throughout the study period. The highest SPM mean concentration found was on April 2012 at 789.64 (SD ± 1172.73) μg/ m^3 and highest RSPM on November 2011 at 1345.99 (SD ± 108.29) μg/ m^3. The mean concentration of NO_2 also showed above permissible limits for four months with highest on March 2012 at 43.62 (SD ± 8.19) μg/ m^3. The SO_2 showed highest concentration at 1.95 (SD ± 0.57) μg/m^3 which was within the permissible limit throughout the study period.

A study was conducted to assess water quality of Tlawng river in Aizawl district of Mizoram (Lalchhingpuii *et al*., 2011) for a period of two years, i.e. 2007 – 2009. The data thus generated were compared with WHO (2004) and BIS-10500 standards. It was found that the average DO content ranged from 5.83 to 6.83 mgL^{-1} where the lowest DO level shows below permissible limit; BOD from 0.48 to 0.84 mgL^{-1} which indicates a low organic content in the water; total hardness from 48.75 to 102.71 mgL^{-1} $CaCO_3$; calcium hardness from 29.14 to 56.14 mgL^{-1} $CaCO_3$; magnesium hardness from 19.66 to 46.57 mgL^{-1} $CaCO_3$ and fluoride content from 0.38 to 1.08 mgL^{-1} where some of the water samples shows below permissible limit. The DO content was negatively correlated with other parameters studied.

Analysis of important water quality parameters (pH, DO, and BOD) of Tuirial river in Mizoram was conducted (Lalparmawii and Mishra, 2012). Analysis was done for a period of two years, i.e. from January 2008 to December 2009. The findings revealed that pH of water ranged from 7.19 during winter season to 7.95 at during rainy season; DO content of water ranged from 6.2 mgL^{-1} during rainy season to 8.1 mgL^{-1} at during winter; BOD content of water ranged from 0.2 mgL^{-1} during winter season to 1.2 mgL^{-1} at during rainy season. The results indicated that all values are within the prescribed limit of water quality standard laid down by various scientific agencies.

A study was conducted at Palak Dil, the largest lake in Mizoram, which is located in the southern part of Mizoram near the border of Indo-Burma hotspots region on the assessment of the water quality of the lake and biodiversity of the surrounding area (Lalmuansangi and Lalramnghinglova, 2014). The Palak Dil is a nationally recognized natural lake and the catchment area is approximately18.5 sq.km and the total water body is around 1.5 sq.km only. The water quality, viz. temperature, pH, total dissolved solids, electrical conductivity, acidity, alkalinity, dissolved oxygen, biological oxygen demand, carbon dioxide, total hardness, chloride, nitrate, phosphate and iron were analyzed and it was found that all the parameters are within the standard limits given by various scientific agencies. Study on biodiversity was carried out by field enumeration, collection and identification of the flora and fauna. It was observed that the ecosystem in which birds and animals living there is gradually degrading due to anthropogenic activity and developmental works.

Assessment of noise pollution was conducted in Aizawl city of Mizoram during 2009 to 2011 (Ralte *et al.,* 2013). Different levels of noise were recorded from industrial zones, commercial zones, residential zones and silence zones by using Sound Level Meter 2031/A. Of all the four zones, residential zones and silence zones were found to exceed the standard prescribed by the Noise Pollution (Regulation and Control) Rules, 2000. Among the commercial zones New Market and Zangena Petrol Pump exceed the standard level. All the study sites under industrial zones were within the standard level.

Lalnundanga *et al.* (2015) conducted a study titled “Impact of road construction on the socio-economic condition of the communities in the hilly terrain of Lunglei district, Mizoram, India” wherein the living quality of people in the area were assessed using pre- structured questionnaires during the construction phase and the post construction phase. From the study it was concluded that there was significant improvement in the socio-economic conditions in the area. The efficiency of import and export of goods and services made products easily available and thus reduced the price of goods. With better connectivity sparked outside exposure, which ultimately increased the number of educational institutions and in turn improved the literacy rate in the area. Also, improvements in medical centers were observed which greatly improved the well-being and health of the villagers. However, the negative impacts attributed to road constructions were also highlighted in this study in terms of hydrogeologic degradation in the form of soil erosion, mass movement, sedimentation and altered stream flow. Impacts are also often lined and chained wherein accelerated soil erosion is caused mainly due to removal of vegetation cover which causes loosening of soil, creation of routes for water run-off and mass movement of unstable slopes.

Useful bio-engineering techniques adopted by using local materials such as wood, bamboo and bushes help soil erosion and have shown remarkable results in the road construction between Aizawl and Lunglei. Other records on analysis of spring water quality, noise pollution, traffic emissions in Aizawl City etc. are available in the Centre of Environmental Studies, Department of Environmental Science, Mizoram University, Aizawl.

CHAPTER – 3

MATERIALS AND METHODS

The following materials and methods were adopted for the present study:

3.1 Study area and study site: Mizoram

Mizoram is a hilly region which is located in the eastern border of India between 21 °58' to 24° 35' N latitude and 92° 15' to 93° 29' E longitude. It has a total geographical area of 21,081 sq.km. with a population of 10, 91,014 (Statistical handbook Mizoram, 2018). Mizoram became the 23rd State of the Indian Union in 20th February, 1987. The state has a solid vantage point as well as strategic importance in that it is sandwiched between Myanmar in the east and south (404 kms) and Bangladesh in the west (318 kms).

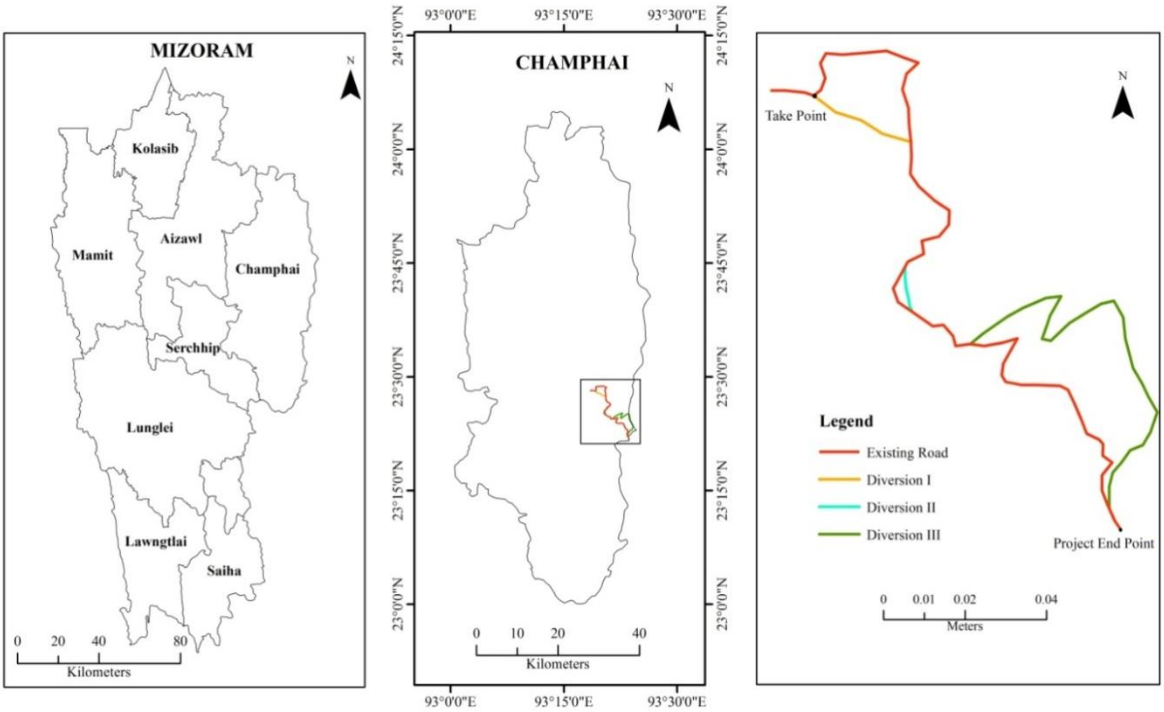

Figure 3.1. Map of study area

A distinct feature of Mizoram is its variegated hilly terrains. The hills are steep and separated by rivers which create deep and beautiful gorges between the hill ranges. Its hilly terrains ranges from an average altitude above 1300 m (MSL), medium hills ranges between 500 m and 1300 m and low hills are usually below 500 m (MSL). Phawngpui Tlang also known as the Blue Mountain reaches nearly 2,200 m (MSL) and is the highest peak in Mizoram.

Mizoram has a pleasant climate and enjoys moderate temperatures throughout the year. Temperature generally ranges from 11ºC to 21ºC during winter season and 20ºC to 30ºC during summer season. The state is a monsoon-influenced region with average rainfall of 254 cm per annum. The total forests cover of Mizoram 18,748 sq.km. The state is divided into eight (8) districts - Aizawl, Champhai, Mamit, Lunglei, Lawngtlai, Saiha, Kolasib and Serchhip. There are three Autonomous District Councils – Lawngtlai Autonomous District Council (LADC) with their headquarters at Lawngtlai; Chakma Autonomous District Council (CADC) with their headquarters at Chawngte (Kamalanagar); and Mara Autonomous District Council with their headquarters at Saiha. These autonomous councils are administered in accordance with the Sixth Schedule of the Constitution of India (Mizoram Census 2011).

3.2 Champhai district

Champhai is the third largest of the 8 (eight) districts in Mizoram in terms of size and population following Aizawl and Lunglei Districts. The district lies in the eastern part of Mizoram between 93.21°E longtitude and 23.26°N latitude. It has 80 km long international boundary with Myanmar in the east and Myanmar border is about 8 km from the district headquarters Champhai. The district is bounded by Manipur state in the north, Serchhip district in the west and Aizawl district in the north-west.

Champhai is the headquarters of Champhai district which is located in the eastern part of the district and it perches at an altitude of 5500 ft above sea level. The district covers 5 (five) Assembly Constituencies viz. Lengteng, Tuichang, Champhai North, Champhai South and East Tuipui. The District comprises of 4 (four) R.D. Blocks viz. Champhai, Ngopa, Khawzawl and Khawbung.

Champhai district is mostly populated by Mizo of diverse ethnic identity. A large population in Champhai District has their origin in the neighboring Myanmar who migrated to Mizoram in search of better livelihood. Champhai has a vast agricultural potential as it has a vast flat land below Champhai town and on the river banks of the major rivers within the district. It has a beautiful landscape with abundant flora and fauna.

Champhai district has pleasant climate throughout the year. The minimum and maximum temperature is 0°C to 20°C during winter and 15°C to 30°C during summer. Other information on Champhai is tabulated below (Table 3.1).

Table 3.1. Information on Champhai district.

Sl.No.	Particulars		Unit	Rural	Urban	Total
1	**Area**		sq.km	-	-	3,185
2	**Households**		No.	15452	10068	25520
3	**Population**					
	a.	Male	No.	39110	24278	63,388
	b	Female	No.	38106	24251	62,357
	c.	Total	No.	77216	48529	125,745
	d.	Growth Rate (2001-2011)	%	16.39	15.54	16.01
	e	Density	per sq.km	25	607	39
	f.	Proportion to Mizoram population	%	-	-	11.46
4	**Literacy rate**		%	95.23	95.08	95.15
5	**Birth rate**		per 1000 population	11.95	21.26	15.53
6	**Death rate**		per 1000 population	4.88	5.79	5.23
7	**Forest cover (sq.km)**					
	a.	Very dense forest	sq.km	-	-	60
	b.	Moderately dense forest	sq.km	-	-	1042
	c.	Open forest	sq.km	-	-	1570

	d.	Total	sq.km	-	-	2672
8	**Roads and communications**					
	a.	Length of National Highway within the District	Km	228	-	228
	b.	Length of State Highway within the District	Km	-	-	-
	c.	Length of District Roads	Km	218.180	17.500	235.680
	d.	Length of Town Roads	Km	-	88.428	88.428
	e.	Length of Village Roads	Km	408.830	-	408.830
9	**Annual average rainfall (2015-2017)**		Mm	158.26	155.11	156.69

Sources: Mizoram District Profile 2017, Mizoram Census 2011.

3.2.1 A brief history and current status of Champhai district.

Champhai is one of the oldest places in Mizoram occupied by Mizo people. From different poems and fables, it can be said that Champhai is more than 100 years old. The first clan to rule or occupy Champhai was the Hmar clan; after their migration, Ralte clan occupied it followed by the Sailo clan. After a few periods of years, the reign of the Sailo clan came to an end and shortly after Champhai was under the rule of the Lushai clan.

Champhai occupies a very important place in the field of administration even during the pre-independent period. The British troops were said to have settled at Champhai in 1897 and the first Circle Inspector (Rahsi) was stationed at Champhai in 1902. The Circle Inspectors were also known as right-hand-men of the British who administered the area and took control over the area. After Indian Independence from the British in 1947, Champhai continued to occupy an important position under the erstwhile Lushai Hills District (later known as Mizo district) which was one of the districts in the state of Assam. The first Political Assistant was posted at Champhai in 1956 who was a representative for the Deputy Commissioner of the Mizo district under Assam state. Champhai was soon upgraded to the status of a civil sub-division in the year 1976 following the upgradation of Mizo district to a Union Territory status in 1972. Till the beginning of 1998, Champhai distict was an administrative sub-division under the undivided Aizawl district with its headquarters at Champhai headed by a Sub-Divisional Officer. However, the status of the sub-division was upgraded to a full-fledged district by the state government and the name given to the district was Aizawl East district. The name was later changed back to Champhai district.

According to the District Census Handbook of Champhai (2011) and Mizoram District Profile (2017), in addition to the Sadar sub-division with its headquaters at Champhai, the district has two more civil sub-divisions namely Khawzawl and Ngopa respectively with their administrative headquarters at Khawzawl and Ngopa respectively. The district also consists of 4 (four) Rural Development Blocks namely Champhai, Khawzawl, Ngopa and Khawbung. There are 105 inhabited villages, 1 inhabited sub-village, 4 notified towns and 105 village councils within Champhai district. Village Councils have been functioning actively in all the notified Towns and Villages.

3.3 Champhai – Zokhawthar road construction

Road construction between Champhai and Zokhawthar is selected as the study area, depicted in Figure 3.2. The road construction and up-gradation of the Champhai - Zokhawthar road is a development project under the Mizoram State Roads Project – II (MSRP - II). The MSRP – II was initiated as a commitment by the Government of India as means of infrastructure development and trade promotion in the North eastern part of the country.

World Bank was requested for financing rehabilitation, widening of State Highways and District Roads in the State of Mizoram which is managed by the Public Works Department of Mizoram Government.

The developmental project of Champhai – Zokhawthar road is an environmental category "A" developmental project as per World Bank Policy as well as Government of India (GOI), Ministry of Environment and Forest (MoEF) and EIA Notification on Environmental Clearances (September 14, 2006) for Environment

Clearance for Category A and B projects. Therefore it requires preparation of a detailed EIA report as well as an Environmental Management Plan (EMP) report.

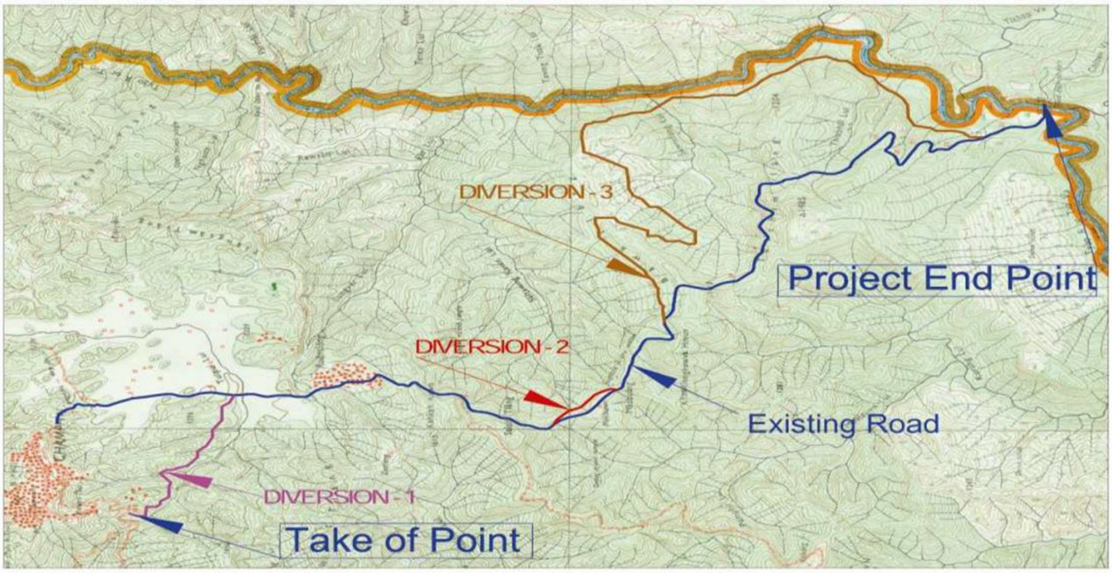

Figure 3.2. Designed map of Champhai - Zokhawthar road construction (**Source:** Anon., 2014e).

3.3.1 Project Proponent

Public Works Department (PWD) of the Government of Mizoram is the proponent of the C-Z Road. The Project Implementation Unit (PIU) within the PWD is the implementing agency for the MRSP II including *Champhai – Zokhawthar* Road.

The improvement and up-gradation work is carried out by *M/S TARMAT LTD.*

3.3.2 Objectives of Champhai –Zokhawthar road development(C-Z road)

The prime objective of this road improvement is to develop an international trade route between India and Myanmar and enhance the economic and commercial development of the Champhai district as well as the entire Mizoram state.

The improvement process involves widening of the *Champhai – Zokhawthar Road* from single lane standard to 2-Lane National Highway Standard, re-alignment and geometric improvement to provide connectivity with the North Eastern belt of Mizoram.

The existing Champhai – Zokhawthar Road (C-Z Road) is 28.0 km long. The designed length of the road is 27.247 km including spur road (short road forming a branch from a longer road) of 2.53 KM length. The Champhai–Zokhawthar Road passes through villages viz; *Khankawn, Zotlang, Ruantlang, Mualkawi, Melbuk & Zokhawthar*. A number of villages like *Ruantlang, New Hruaikawn, Tlangsam*, etc. are located nearby which are heavily depending on this road. This road is an important lifeline for the people in the North- Eastern belt of Mizoram. At several locations, the road alignment passes through or near prime agricultural land, forest plantation, habitation etc.

3.4 Air quality analysis

3.4.1 Instrumentation and sampling parameters

High Volume Air Sampler (HVS) manufactured by Envirotech Instruments Pvt. Ltd. approved by CSIR/NEERI KNOWHOW, was used for ambient air quality analysis. The parameters measured were Suspended Particulate Matter (SPM), Respirable Suspended Particulate Matter (RSPM), Sulphur dioxide (SO_2), and Nitrogen dioxide (NO_2). Handbook of Methods in Environmental Studies: Air, Noise, Soil and Overburden Analysis (Maiti, 2003) and Manual on Environmental Analysis (Aery, 2010) were mainly used for analysis of air quality parameters. Gravimetric methods were used for measuring particulate matters. SPM (>10µm) was determined using the high volume method and the cyclonic flow technique was employed for determination of RSPM (<10 µm). Jacob & Hochheiser modified (sodium arsenite) method was used for determination of NO_2 (Merryman *et al.* 1973) and the modified West and Gaeke method was used for SO_2 (West *et al.* 1956). Pre-weighed Glass Fibre filter paper (Whatman GF/2) and a pre-weighted SPM cup was used for measuring RSPM and SPM. Absorbing media was prepared and placed in the impinger for measurement of SO_2 and NO_2.

The Air Sampler was placed at the selected site at Zokhawthar and ran for 16 hours (6 a.m to 10 p.m). After completion of the sampling, the samples were taken to the Mizoram Pollution Control Board Laboratory at Champhai for further analysis and calculations. Standard spectrophotometric methods were essentially followed for determination of absorbance of the samples. The results generated were then compared with the standards set by Central Pollution Control Board - National Ambient Air Quality Standards (NAAQS) vide Notification dated 11th April 1994 and National Ambient Air Quality Standards (NAAQS) vide Notification dated 18thNovember 2009.

Meteorological data of the sampling site was also assessed. Temperature and humidity was measured using Digital Thermo-Hygrometer (Mextech J411TH) and wind velocity was measured using Digital Anemometer (GM816A).

3.4.2 Analytical methods and equations used for calculation

a) Sulphur dioxide (SO_2) - Modified West & Gaeke Method

Sulphur dioxide from air is absorbed in a solution of potassium tetrachloromercurate (TCM). A dichlorosulphitomercurate complex, which resists oxidation by the oxygen in the air, is formed. The complex thus formed is made to react with para-rosaniline and formaldehyde to form the intensely coloured pararosaniline methylsulphonic acid. The absorbance of the solution is measured by means of a suitable spectrophotometer. 30 ml of absorbing solution is placed in the impinger unit of the sampler and the machine is run for four (4) hours at the flow rate of 1 L/min. After sampling, the sample is then transferred to a sample storage bottle and any water lost by evaporation during sampling is replaced by adding distilled water. In the laboratory, 10 ml of the collected sample is transferred into a 25 ml volumetric flask - 1 ml of 0.6% sulphamic acid, 2 ml of 0.2% formaldehyde solution, and 2 ml pararosaniline solution is added to the sample, is mixed thoroughly and 25 ml with distilled water is again added. A blank solution is prepared in the same manner using 10 ml of unexposed absorbing reagent. After 30 min color development interval, the absorbance is measured and recorded at 540 nm.

The following equation is used for calculation of gaseous pollutants, SO_2 in ambient air.

$$SO_2 \text{ Concentration } \mu g/m^3 = \frac{(A - B) \text{ x } G.F \text{ x } Vs}{Va \text{ x } Vt}$$

Where,

A = Absorbance of exposed sample

B = Absorbance of reagent blank solution

G.F = Graph factor of the concerned pollutant (µg/abs.)

Vs = Total volume of the exposed sample (ml)

Va = volume of air sampled (m^3)

Vt = Volume of aliquot taken for analysis, (ml)

b) Nitrogen dioxide (NO_2) - modified Jacob & Hochheiser Method

Ambient nitrogen dioxide (NO_2) is collected by bubbling air through a solution of 2 sodium hydroxide and sodium arsenite. The concentration of nitrite ion (NO_2) produced during sampling is determined colorimetrically by reacting the nitrite ion with phosphoric acid, sulfanilamide, and N-(1-naphthyl)-ethylenediamine dihydrochloride (NEDA) and measuring the absorbance of the highly coloured azo-dye at 540 nm. 30 ml of absorbing solution is placed in the impinger unit of the sampler and the machine is run for four (4) hours at the flow rate of 1 L/min. After sampling, the sample is then transferred to a sample storage bottle and any water lost by evaporation during sampling is replaced by adding distilled water. In the laboratory, 10 ml of the collected sample is transferred into a 50 ml volumetric flask - 1 ml of hydrogen peroxide solution, 10 ml of sulphanilamide solution, and 1.4 ml of NEDA solution is added to the sample and mixed thoroughly and 50 ml with distilled water is again added. A blank solution is prepared in the same manner using

10 ml of unexposed absorbing reagent. After a 10 min color development interval, the absorbance is measured and recorded at 540 nm.

The following equation is used for calculation of gaseous pollutants, NO_2 in ambient air.

$$NO_2 \text{ Concentration } \mu g/m^3 = \frac{(A - B) \text{ x G.F x Vs}}{\text{Va x Vt x } 0.82}$$

Where,

A = Absorbance of exposed sample

B = Absorbance of reagent blank solution

G.F = Graph factor of the concerned pollutant (µg/abs.)

Vs = Total volume of the exposed sample (ml)

Va = Volume of air sampled (m^3)

Vt = Volume of aliquot taken for analysis, (ml)

0.082 = Sampling efficiency

c) Respirable Suspended Particulate Matter (RSPM <10 µm) – Gravimetric Method (Maiti, 2003 and Aery, 2010)

Air is drawn through a size-selective inlet and through a filter media i.e. glass fibre filter paper of 20.3 X 25.4 cm (8 X 10 in) in size at a maintained flow-rate. Particles with aerodynamic diameter less than the cut-point of the inlet (<10 µm) are collected, by the filter paper. The mass of these particles is determined by the difference in filter weights prior to and after sampling. The concentration of PM in the designated size range (RSPM) is calculated by dividing the weight gain of the filter paper by the volume of air sampled.

The following equation is used for calculation of RSPM in ambient air.

$$RSPM\ (\mu g/m^3) = \frac{W_f - W_i \times 10^6}{V}$$

Where,

W_f = Final weight of filter paper, (g)

W_i = Initial weight of filter paper, (g)
V = air volume sampled (m^3)
10^6 = conversion of g to µg (1g = 106 µg)

d) Suspended Particulate Matter (SPM >10µm) – Gravimetric Method (Maiti, 2003 and Aery, 2010)

Similar to the analysis and collection of RSPM, air is drawn through an inlet and passes through a tubular structure and collected in a pre-weighted filter cup at a maintained flow-rate. Particles with aerodynamic diameter above <10 µm are collected at the filter cup. The mass of these particles is determined by the difference in filter weights prior to and after sampling. The concentration of PM in the designated size range (Non-SPM) is calculated by dividing the weight gain of the filter cup by the volume of air sampled. The total SPM concentration is calculated by adding the concentration of RSPM with the concentration of Non-SPM.

The following equations are used for calculation of SPM in ambient air.

$$Non\,SPM\ (\mu g/m^3) = \frac{W_f - W_i \times 10^6}{V}$$

W_f = Final weight of filter cup, (g)
W_i = Initial weight of filter cup, (g)
V = air volume sampled, (m^3)
10^6 = conversion of g to µg (1g = 106 µg)

$$Total\,SPM\ \left(\frac{\mu g}{m^3}\right) = RSPMconcentration + Non\,SPM\ Concentration$$

3.5 Water quality analysis

3.5.1 Collection of water samples

Water samples were collected from two sources – Mualkawi rivulet located at latitude 23°25’39.3” and longitude 93°20’08.3” with an elevation of 1292 m and

Tiau river located at latitude 23°21’46.6” and longitude 93°23’18.2” with an elevation of 704m. The containers used for collection of water samples were pre-soaked with 10% HCl and thoroughly rinsed with distilled water. The samples from the two sources were collected seasonally *viz.,* Winter (December to February), Summer/Pre-monsoon (March to May), Monsoon (June to August) and Autumn/Post-monsoon (September - November). Handbook of Methods in Environmental Studies, Water and Wastewater Analysis (Maiti, 2004) and Standard Methods for the Examination of Water and Wastewater (APHA, 2005) were used for analysis of various physico-chemical parameters and were compared with the standards set by World Health Organization (1971), U.S. Public Health Service (1962), Indian Council of Medical Research (1975) and Bureau of Indian Standards (2012). The parameters *viz.*, temperature and pH were tested and measured in the field by using Hannah portable pH meter. Turbidity, total dissolved solids (TDS), electrical conductivity (EC), total alkalinity, total hardness, chloride (Cl) and total iron were tested and measured at Public Health Engineering Department Laboratory, Champhai and Departmental Laboratory, Environmental Science Mizoram University, Aizawl.

Meteorological data of the sampling site was also assessed. Temperature and humidity was measured using Digital Thermo-Hygrometer (Mextech J411TH) and wind velocity was measured using Digital Anemometer (GM816A).

3.5.2 Analytical methods

(i) pH (Maiti, 2004)

The pH of water samples was measured by Hannah Instruments – Waterproof pH tester.

(ii) Temperature (Maiti, 2004)

The temperature of water was measured by Hannah Instruments - Waterproof Temperature Tester and result was expressed in ˚C.

(iii) Turbidity (Maiti, 2004)

The turbidity of water was determined by using Thermo Scientific Eutech TN-100 Waterproof Turbidimeter and result was expressed in NTU.

(iv) Total dissolved solids (TDS) (Maiti, 2004)

TDS of water samples was measured using Eutech Con 700 TDS Meter, and result was expressed in mg/L.

(v) Electrical conductivity (Maiti, 2004)

The electrical conductance of water samples was measured by using a Eutech Con 700 Conductivity Meter and result was expressed in mS/cm.

(vi) Total alkalinity (Maiti, 2004 and APHA, 2005)

The total alkalinity of water samples was measured by using potentiometric titration method. The alkalinity of water is a measure of its capacity to neutralize acids. Alkalinity is a measure of the water ability to absorbed H+ without significant pH change, i.e., alkalinity was a measure of buffering capacity of water. The amount of CO_3 + OH- is determined by titration with acid to pH 8.3, the end point being detected with phenolphthalein. The amount of HCO_3- was determined by further titration with acid to end point pH between 4.2-5.4 with methyl orange or mixed indicator as end point indicator. Standard sulphuric acid (0.02N) was used as a titrant to lower down the pH of sample at 8.3 (phenolphthalein alkalinity) and to pH 3.7 (methyl orange alkalinity).

Total alkalinity was calculated with the following formula, and result was expressed in mgL-1CaCO3.

$$\text{Phenolphthalein alkalinity (P)} = \frac{A\ x\ 1000}{Vol.\ of\ sample\ taken}$$

$$\text{Methyl Orange alkalinity (M.O)} = \frac{B\ x\ 1000}{Vol.\ of\ sample\ taken}$$

Total alkalinity (T) = $\frac{A+B\ X\ 1000}{Vol.\ of\ Sample\ taken}$

(vii) Total hardness (Maiti, 2004 and APHA, 2005)

Total hardness was measured by using Ethylene Diamine Tetra Acetic Acid (EDTA) titration method. Total hardness or permanent hardness of water is generally caused by the presence of chlorides and sulphates of calcium and magnesium. This can be determined accurately by colorimetric method. This method is based on the ability of sodium arsenate to form a unionized complex with magnesium. If Erichrome black T, a dark blue dye, is added to this solution containing Ca++ and Mg++ ions , a pink colorless complex is formed. After adding sodium arsenate solution to this complex, the solution turns blue again. This is because Ca++ and Mg++ from the dye complex is removed and forms a complex with sodium versenate solution. Changes of pink color to blue indicate the end point.

Total hardness (as $CaCO_3$ mg/L) =$\frac{CxDx\ 1000}{Vol.of sample taken}$

Where,

C = ml of EDTA (titrant) required by sample for titration.

D = 1mg $CaCO_3$ equivalent to 1ml EDTA titrant (1mg for 0.01 M EDTA used)

(viii) Chloride (Maiti, 2004 and APHA, 2005)

Chloride (Cl^-) was determined by using Mohr's argentometric titration method in neutral or slightly alkaline solution. It is titrated against Silver Nitrate ($AgNO_3$), using Potassium Chromate as an indicator. When water samples containing chlorides are titrated against silver nitrate solution, chlorides are quantitatively precipitated as white silver chloride. Reddish brown precipitate of silver chromate is formed as the concentration of chloride ions dissipates and silver ion concentration increases, thus indicating the end-point.

$Ag^+ + Cl^- = AgCl$ (white ppt.)

$2Ag + CrO_4 = AgCrO_4$ (Red ppt.)

(ix) Total iron (Maiti, 2004 and APHA, 2005)

Total iron will be measured by using Potassium Thiocyanate method. Iron is brought into solution, reduced to the ferrous state by boiling with acid. For estimation of iron content in water sample, 100 ml of sample was taken in a conical flask, 5 ml of 1 + 1HCl (i.e.50% HCl + 50% distilled water) and 3 drops of Potassium Permanganate ($KMnO_4$) was added to the sample. Then 5 ml of Potassium Thiocyanate (KSCN) was added into the prepared sample if colour appears. For comparison, a blank solution is prepared. The blank solution is then titrated against standard iron solution until colour matches that of the sample colour.

$$\frac{Pipette\ reading\ x\ 0.1\ x\ 1000}{Vol.of\ sample\ taken}$$

3.6 Noise quality analysis

3.6.1 Instrumentation

Lutron SL-4001 was used for measuring sound levels. The operational function of data recording was done by switching on the device at "A" weighting scale and "slow" response (CPCB, 2015). The numerical values displayed on LCD were recorded. Readings were taken for duration of 1 hour. After recording of all the readings, Lmax, Lmin and Leq were calculated (Maiti, 2003) and the results were compared with the level of the standards of Noise Pollution (Regulation and Control) Rules, 2000. Noise sampling was carried out at three sites *i.e.,* Zotlang (Residential area), Tarmat Base Camp (Residential area) and Zokhawthar (Residential area).

Leq is the equivalent continuous sound pressure level and is the preferred method to describe sound levels varying over time, resulting in a single decibel value which takes into account the total sound energy over the period of time. In other words, Leq represents a varying sound source over a given time as a single number. Lmax is described as the highest time-weighted sound level measured over a period of time. Lmin is the lowest time-weighted sound level measured over a period of time.

Meteorological data of the sampling site was also assessed. Temperature and humidity was measured using Digital Thermo-Hygrometer (Mextech J411TH) and wind velocity was measured using Digital Anemometer (GM816A).

3.7 Biodiversity analysis

3.7.1 Flora diversity assessment

a) Nested quadrat method

The forest vegetation along the road project was analyzed for trees, shrubs and herbs. Two 10 m^2 size quadrats at 1 km intervals were laid randomly for identification and study of woody species. In each quadrat diameter at breast height (dbh) were measured and recorded for measurement of basal area. For shrubs and herbs, 5 m^2 quadrats and 1 m^2 quadrats respectively were laid randomly within each 10 m^2 quadrats. Quantitative analysis of the vegetation data was analyzed for frequency, density, abundance (Curtis and MacIntosh, 1950) and their relative values were calculated, summed up to get Importance Value Index (IVI) of individual species (Philips, 1959). Biodiversity indices were also calculated: Species richness was calculated by adopting Whittaker's α diversity; Species diversity was calculated using Shannon-Wiener information index; Species evenness was computed using Pielou's evenness index; and Concentration of Dominance was computed using Simpson's index.

b) Quantitative analysis

Quantitative analysis incorporates analytical tools which are employed to express the characteristics of a community and helps build the structural composition of the study area. These include a number of parameters and characters as frequency, density, abundance, basal area, etc. (Aery, 2010)

i) Frequency:

It is the number of quadrats (as %) in which species occurs. Thus frequency of each species is calculated as follows:

$$Frequency = \frac{No. of\ quadrats\ in\ which\ species\ occurred}{Total\ no. of\ quadrats\ sampled} \times 100$$

ii) Density:

It represents the numerical strength of a species in the community. The number of individuals of the species in any unit is its density. It gives an idea of the degree of competition. It is calculated by the following formula:

$$Density = \frac{Total\ no. of\ individuals\ of\ a\ species\ in\ all\ quadrats}{Total\ no. of quadrats\ sampled} \times 100$$

iii) Abundance:

It is the number of individuals of any species per quadrats of occurrence. It is calculated as follows:

$$Abundance = \frac{Total\ no. of\ individuals\ of\ a\ species\ in\ all\ quadrats}{Total\ no. of\ quadrats\ in\ which\ the\ species\ occurred} \times 100$$

iv) Importance Value Index (IVI):

IVI is used in order to express the dominance and ecological success of any species with a single value. This index utilizes three characters viz., relative frequency, relative density and relative dominance.

$$Relative\ frequency = \frac{No. of quadrats\ of a\ species}{Total\ no. of quadrats\ of occurrence\ of\ all\ species} \times 100$$

$$Relative\ density = \frac{No. of\ individual\ of\ a\ species}{Number\ of\ individual\ of\ all\ species} \times 100$$

$$Relative\ dominance = \frac{Total\ basal\ area\ of\ a\ species}{Total\ basal\ area\ of\ all\ species} \times 100$$

$$Basalcover = \frac{(cbh)}{4n}$$

IVI = Relative frequency + Relative density + Relative dominance

To convert the values of diameter (cm) at breast height (1.5 m above the ground) to basal area (sq.cm) through the following relation:

$$Average\ basal\ area = \pi r^2$$

Where r = average diameter/2

c) *Biodiversity indices*

The following biodiversity indices were computed for the assessment of plant diversity:

i) Species richness, D (Whitaker, 1975)

D = S/logN

Where S = No. of species in a sample

N = Total number of individuals in the sample

ii) Species diversity, H′ (Shannon and Wiener, 1963)

$H' = -\sum Pi \ln Pi$

Where Pi = proportion of each species in the sample.

iii) Evenness index, E (Pielou, 1975)

E = H′/ln S

Where H′ = Shannon's index value

S = Total no. of species

ln = Bits per individual

iv) Index of Dominance, 1-D (Simpson, 1949)

$$D = 1 - \Sigma \frac{ni(ni-1)}{N(N-1)}$$

Where ni = number of individuals in the i^{th} species

N = Total number of individuals

3.7.2 Fauna diversity assessment

a) *Personal interview (Aery, 2010)*

Personal interview was conducted in the adjoining areas and villages between Champhai and Zokhawthar areas for generating information from local residents regarding sightings of animals and birds in the area. Interviews were conducted in an informal manner in a relaxed setting. The interviews were recorded using voice recorder software in smart-phones and important points were noted down.

b) *Field observation (Ibid., 2010)*

Field observation was carried out by walking through forests and along roads for sightings of animals – birds, reptiles and mammals. Species of fauna spotted were identified with the help of local residents and research papers in such fields.

CHAPTER – 4

RESULTS

4.1 Air quality

The concentration of gases and particulate matter are assessed at Zokhawthar site (main construction site during study period) on seasonal basis – Winter season (December, January, February); Summer season (March, April, May); Monsoon season (June, July, August) and Autumn season (September, October, November). The sampling site – Zokhawthar is located at latitude N 23°22'09.1" and longitude E 93°23'06.8" with an elevation of 781m. The meteorological data of sampling sites is shown in Table 4.1.

Table 4.1. Meteorological data of sampling site.

ZOKHAWTHAR			
Sampling period	**Temperature (°C)**	**Relative humidity (%)**	**Wind Velocity (m/s)**
Sept – Nov 2016	22.3	50	1.5
Dec '16 – Feb 2017	16.3	27.5	2.1
Mar – May 2017	21.2	37	2.1
June – Aug 2017	21.0	32.5	2.5
Sept – Nov 2017	22	52.5	1.2
Dec '17 – Feb 2018	15.5	30.2	1.8
Mar – May 2018	20.5	35.5	2.0
June – Aug 2018	18.8	28.0	1.0
Overall mean	**19.7**	**36.7**	**1.8**

Statistical Analysis

ANOVA was employed to assess seasonal variation in Zokhawthar site and it was revealed that there was no significant variation between the seasons during the assessment period (September 2016 to August 2018) – 0.960 (at 5%) (Appendix I). Air quality with mean value is shown in Table 4.2.

Table 4.2. Air quality assessment with overall mean and NAAQ Standards.

Sampling period	**SPM (µg/m^3)**		**RSPM (µg/m^3)**		**NO_2 (µg/m^3)**		**SO_2 (µg/m^3)**	
	Mean	**NAAQS**	**Mean**	**NAAQS**	**Mean**	**NAAQS**	**Mean**	**NAAQS**
Sept – Nov 2016	112.13	200	51.21	100	25.42	80	6.67	80
Dec '16 – Feb 2017	162.12		67.89		31.26		7.71	
Mar – Apr 2017	92.31		28.65		8.94		5.32	
June – Aug 2017	76.18		24.76		11.92		4.66	
Sept – Nov 2017	143.72		71.26		23.78		5.88	
Dec '17 – Feb 2018	133.78		77.61		14.34		6.87	
Mar – May 2018	105.34		31.02		17.45		4.45	
June – Aug 2018	121.04		48.98		15.56		4.67	
Overall mean	118.32		50.17		18.58		5.76	

4.1.1 Suspended particulate matter (SPM)

During the assessment period from Sept 2016 to August 2018, the average SPM concentration ranges from 76.18 to 162.12 µg/m^3 with a total mean concentration of 118.32 µg/m^3. From the results, the lowest concentration was detected in monsoon season (June - August, 2017) and the highest concentration was detected in winter season (December – February, 2017).

The concentrations in all seasons were compared with the permissible limits set by Central Pollution Control Board (2010) - National Ambient Air Quality Standards (NAAQS) vide Notification dated 11th April 1994 and National Ambient Air Quality Standards (NAAQS) vide Notification dated 18th November 2009 (Appendix II) and were well below the limits. Suspended particulate matter (SPM) mainly consists of fumes, smoke and dust which pose health hazards to humans when present in high concentrations. In plants, high SPM concentration can cause damage to leaf structure and also causes corrosion (ENVIS, 2018). Seasonal variation of SPM concentration is given in Figure 4.1.

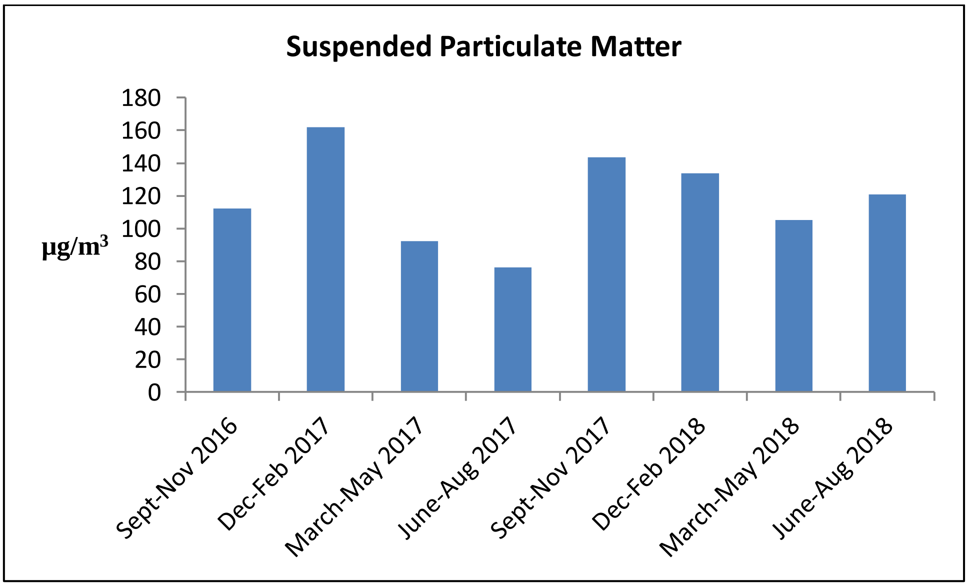

Figure 4.1. Seasonal variation of SPM (µg/m^3) concentration during September 2016 - August 2018.

4.1.2 Respirable suspended particulate matter (RSPM)

During the assessment period from Sept 2016 to August 2018, the average RSPM concentration ranges from 24.75 to 77.61 µg/m^3 with a total mean concentration of 50.17 µg/m^3. From the results, the lowest concentration was detected in monsoon season (June - August, 2017) and the highest concentration was detected in winter season (December – February, 2018).

The concentrations in all seasons were compared with the permissible limits set by Central Pollution Control Board (2010) - National Ambient Air Quality Standards (NAAQS) vide Notification dated 11th April 1994 and National Ambient Air Quality Standards (NAAQS) vide Notification dated 18th November 2009 (Appendix II) and were well below the limits. Respirable Suspended particulate matter (RSPM) is much smaller in size as compared to SPM and consists of substances that have deleterious consequences. The primary sources of RSPM include incomplete combustion, automobile emissions, dust which causes asthma attacks, bronchitis, high blood pressure, heart attack, strokes and premature death (Reddy *et al.*, 2015). Seasonal variation of RSPM concentration is given in Figure 4.2.

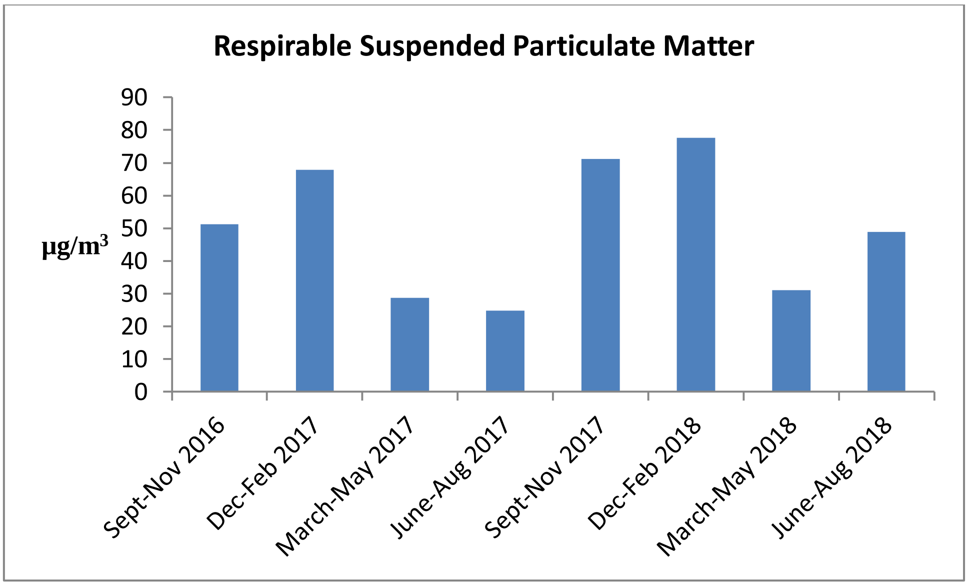

Figure 4.2. Seasonal variation of RSPM (µg/m^3) concentration during September 2016 - August 2018.

4.1.3 Nitrogen dioxide (NO_2)

During the assessment period from Sept 2016 to August 2018, the average NO_2 concentration ranges from 8.94 to 31.26 µg/m^3 with a total mean concentration of 18.58 µg/m^3. From the results, the lowest concentration was detected in summer season (March - May, 2017) and the highest concentration was detected in winter season (December - February, 2017).

The concentrations in all seasons were compared with the permissible limits set by Central Pollution Control Board (2010) - National Ambient Air Quality Standards (NAAQS) vide Notification dated 11th April 1994 and National Ambient Air Quality Standards (NAAQS) vide Notification dated 18th November 2009 (Appendix II) and were well below the limits. Nitrogen dioxide is created when nitrogen and oxygen in the combustion air are heated to a high temperature. It causes corrosion of materials and is toxic to humans at high levels. It is also a precursor in the formation of photochemical smog (Chen *et al.*, 2007). Seasonal variation of NO_2 concentration is given in Figure 4.3.

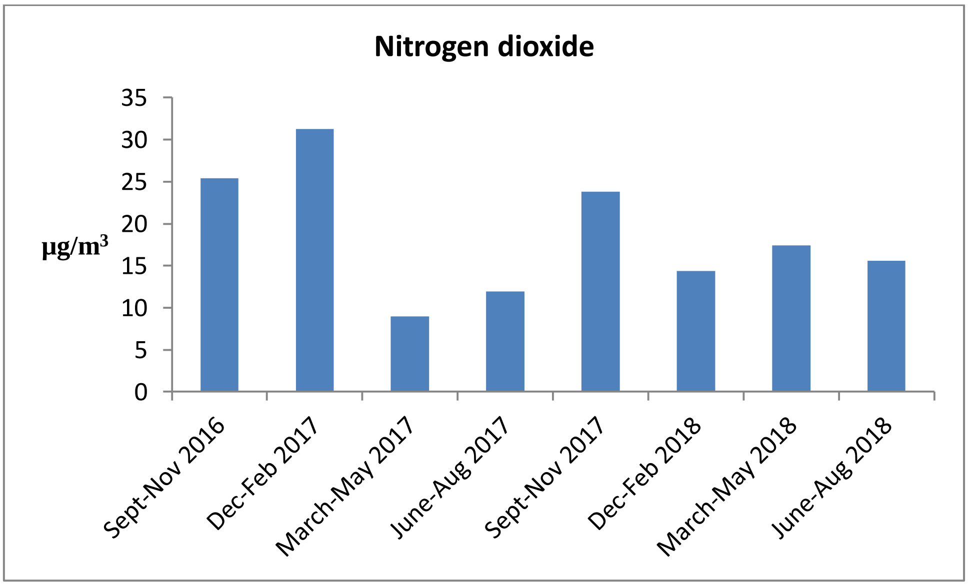

Figure 4.3. Seasonal variation of NO_2 (µg/m^3) concentration during September 2016 - August 2018.

4.1.4 Sulphur dioxide (SO_2)

During the assessment period from Sept 2016 to August 2018, the average SO_2 concentration ranges from 4.45 to 7.71 µg/m^3 with total mean concentration of 5.76 µg/m^3. From the results, the lowest concentration was detected in summer season (March - May, 2018) and the highest concentration was detected in winter season (December - February, 2017).

The concentrations in all seasons were compared with the permissible limits set by Central Pollution Control Board (2010) - National Ambient Air Quality Standards (NAAQS) vide Notification dated 11th April 1994 and National Ambient Air Quality Standards (NAAQS) vide Notification dated 18th November 2009 (Appendix II) and were well below the limits. Sulphur is present in fuels in variable amounts and is discharged to the atmosphere as sulphur dioxide (SO_2) during combustion. High concentrations of SO_2 cause damage to plant tissue and causes complications in human respiratory system such as bronchitis (*Ibid.*, 2007). Seasonal variation of SO_2 concentration is given in Figure 4.4.

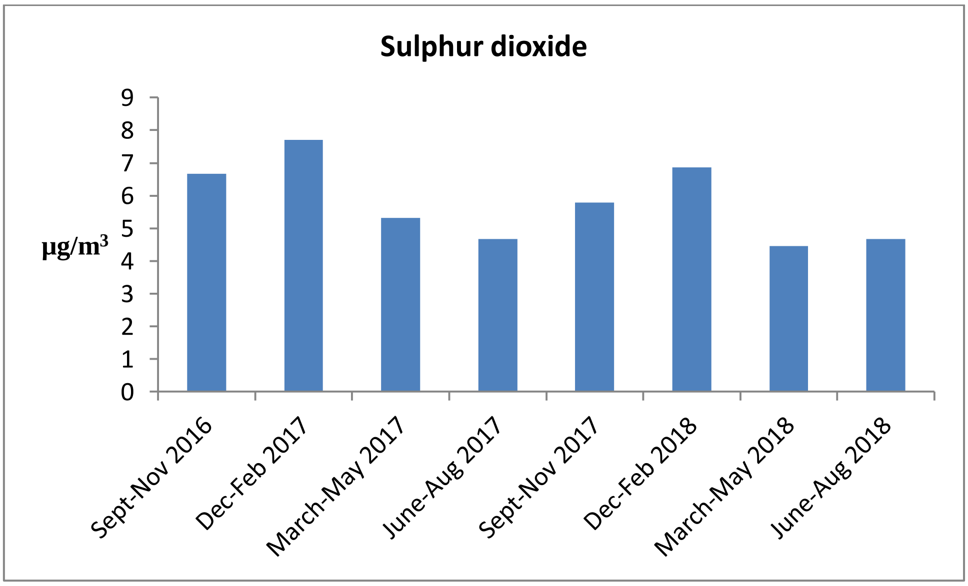

Figure 4.4. Seasonal variation of SO_2 (µg/m^3) concentration during September 2016 - August 2018.

4.1.5 Comparison of air quality with baseline data from pre-construction phase 2014

The results generated from the present study are statistically compared with the baseline data of Pre-Construction Phase – "Environmental Impact Assessment Report of Widening to 2-Lane, Re-Alignment and Geometric Improvement of Champhai-Zokhawthar Road (00.000 Km to 27.247 Km) within Mizoram State Roads Project II dated 16 February 2014 STUP Consultants Pvt."

Statistical Analysis

ANOVA was employed to assess the overall average air quality concentrations of the present study with its baseline data from Pre-Construction Phase 2014 and it was revealed that there was no significant variation between the two phases – 0.758 (at 5%) (Appendix III). The comparisons of air quality between pre-construction and construction phases are depicted in Figure 4.5.

Suspended Particulate Matter (SPM)

The overall average SPM concentration during the study period i.e. 118.32 $\mu g/m^3$ is higher in comparison to concentration during pre-construction phase i.e. 95.5 $\mu g/m^3$. The overall average SPM concentrations in both phases were below the permissible limits as per Central Pollution Control Board (2010) - National Ambient Air Quality Standards (NAAQS) vide Notification dated 11th April 1994 and National Ambient Air Quality Standards (NAAQS) vide Notification dated 18th November 2009 (Appendix II).

Respirable Suspended Particulate Matter (RSPM)

The overall average RSPM concentration during the study period i.e. 50.17 $\mu g/m^3$ is higher in comparison to concentration during pre-construction phase i.e. 35.5 $\mu g/m^3$. The overall average RSPM concentrations in both phases were below the permissible limits as per Central Pollution Control Board (2010) - National Ambient Air Quality Standards (NAAQS) vide Notification dated 11th April 1994 and National Ambient Air Quality Standards (NAAQS) vide Notification dated 18th November 2009 (Appendix II).

Nitrogen dioxide (NO_2)

The overall average NO_2 concentration during the study period i.e. 18.58 µg/m^3 is higher in comparison to concentration during pre-construction phase i.e. 14.5 µg/m^3. The overall average NO_2 concentrations in both phases were below the permissible limits as per Central Pollution Control Board (2010) - National Ambient Air Quality Standards (NAAQS) vide Notification dated 11th April 1994 and National Ambient Air Quality Standards (NAAQS) vide Notification dated 18th November 2009 (Appendix II).

Sulphur dioxide (SO_2)

The overall average SO_2 concentration during the study period pre-construction phase is the same concentration at 5.7 µg/m^3. Therefore, the overall average SO_2 concentrations in both phases were below the permissible limits as per Central Pollution Control Board (2010) - National Ambient Air Quality Standards (NAAQS) vide Notification dated 11th April 1994 and National Ambient Air Quality Standards (NAAQS) vide Notification dated 18th November 2009 (Appendix II).

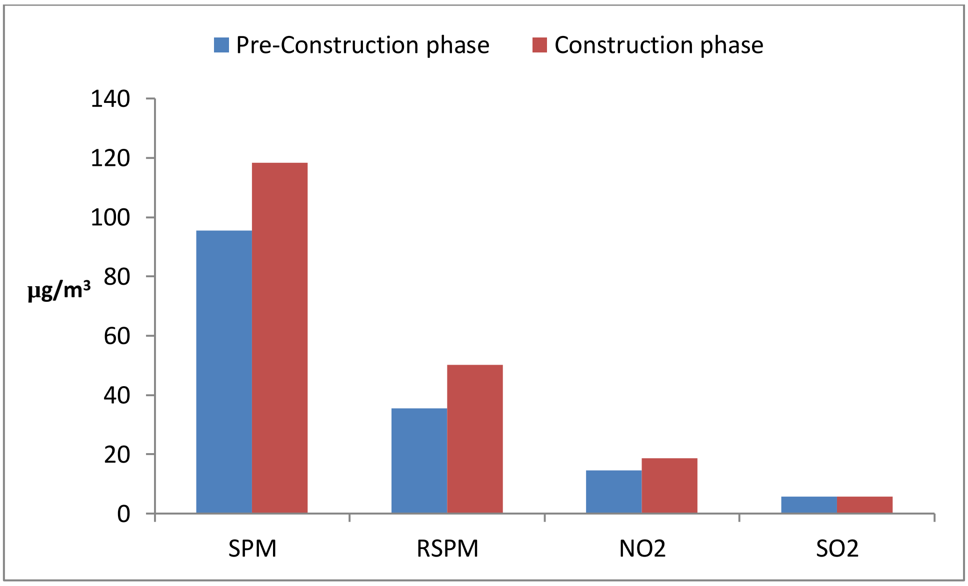

Figure 4.5. Comparison of air quality between pre-construction and construction phases.

4.2 Water quality

The physio-chemical properties of water from Mualkawi rivulet and Tiau river were assessed on seasonal basis – Winter season (December, January, February); Summer season (March, April, May); Monsoon season (June, July, August) and Autumn season (September, October, November). Mualkawi rivulet is located at latitude 23°25’39.3” and longitude 93°20’08.3” with an elevation of 1292m whereas Tiau river is located at latitude 23°21’46.6” and longitude 93°23’18.2” with an elevation of 704m. The meteorological data of sampling sites is shown in Table 4.3.

Table 4.3. Meteorological data of sampling sites.

	Mualkawi rivulet (Mualkawi)			**Tiau River (Zokhawthar)**		
Sampling period	**Temperature (°C)**	**Relative humidity (%)**	**Wind Velocity (m/s)**	**Temperature (°C)**	**Relative humidity (%)**	**Wind Velocity (m/s)**
Jun – Aug 2016	18.6	40	1.6	22.0	50	0.4
Sep – Nov 2016	19.0	36	0.5	19.8	40	1.4
Dec – Feb 2017	16.3	34	1.0	18.0	33	1.3
Mar–May 2017	22.5	35	2.0	24.4	40	2.3
Jun – Aug 2017	20.2	30.5	2.5	19.7	30	2.2
Sep – Nov 2017	20.0	45	1.0	22.5	45	0.8
Dec – Feb 2018	15.7	30	2.4	17.5	30	2.1
Mar–May 2018	21.4	34	2.1	22.0	35	1.6
Overall mean	**19.2**	**35.6**	**1.6**	**20.7**	**38**	**1.5**

Statistical Analysis

For Mualkawi rivulet, ANOVA showed that there was no significant variation between the seasons during the assessment period (June 2016 to May 2018) – 0.512 (at 5%) (Appendix IV). Also for Tiau river, ANOVA was employed to assess seasonal variation and revealed that there was no significant variation between the seasons during the assessment period (June 2016 to May 2018) – 0.969 (at 5%)

(Appendix V). The water quality assessment results for Mualkawi rivulet and Tiau river are shown in Table 4.4 and 4.5 respectively.

Table 4.4. Water quality assessment at Mualkawi rivulet *(The symbol '±' indicates the standard deviation or the amount of variation from the mean value).*

Parameter	**Unit**	**Jun – Aug 2016**	**Sep – Nov 2016**	**Dec – Feb 2017**	**Mar – May 2017**	**Jun – Aug 2017**	**Sep – Nov 2017**	**Dec – Feb 2018**	**Mar – May 2018**
pH	-	6.1 (±0.20)	7.3 (±0.20)	8.2 (±0.0)	6.8 (±0.10)	6.3 (±0.20)	7.7 (±0.11)	8.3 (±0.20)	7.2 (±0.30)
Temperature	°C	19.4 (±0.36)	19.1 (±0.25)	18 (±0.05)	18.9 (±0.20)	19.2 (±0.15)	20.6 (±0.11)	18.2 (±0.21)	19.4 (±0.15)
Turbidity	NTU	14.5 (±0.10)	16.2 (±0.26)	9.5 (±0.15)	17.2 (±0.20)	15.6 (±0.23)	26.3 (±0.05)	12.5 (±0.25)	15.7 (±0.25)
Electrical Conductivity	mS/cm	30.2 (±0.21)	38.6 (±0.50)	44.7 (±0.30)	72.2 (±0.25)	44.5 (±0.10)	34.6 (±0.51)	36.4 (±0.56)	58.9 (±0.43)
TDS	mg/L	16.4 (±0.06)	18.2 (±0.21)	22.3 (±0.31)	36.1 (±0.31)	22.4 (±0.36)	17.3 (±0.36)	21.3 (±0.42)	36.7 (±0.21)
Total hardness	mg/L	16 (±0.57)	10 (±0.0)	16 (±1.0)	50 (±1.15)	16 (±2.0)	8 (±1.73)	17 (±1.0)	39 (±2.08)
Total Alkalinity	mg/L	30 (±0.58)	40 (±1.53)	40 (±2.08)	70 (±3.51)	40 (±2.64)	44 (±0.58)	40 (±1.73)	70 (±2.51)
Total Chloride	mg/L	5.7 (±0.15)	6.2 (±0.21)	5.2 (±0.26)	6.5 (±0.31)	6.8 (±0.31)	7.2 (±0.34)	6.6 (±0.26)	5.4 (±0.26)
Total iron	mg/L	0.13 (±0.0)	0.11 (±0.01)	0.22 (±0.03)	0.1 (±0.02)	0.12 (±0.04)	0.31 (±0.08)	0.17 (±0.02)	0.16 (±0.03)

Table 4.5. Water quality assessment at Tiau river *(The symbol '±' indicates the standard deviation or the amount of variation from the mean value).*

Parameter	**Unit**	**Jun – Aug 2016**	**Sep – Nov 2016**	**Dec – Feb 2017**	**Mar – May 2017**	**Jun – Aug 2017**	**Sep – Nov 2017**	**Dec – Feb 2018**	**Mar – May 2018**
pH	-	6.2 (±0.0)	6.9 (±0.10)	7.9 (±0.06)	7.2 (±0.05)	7.1 (±0.06)	7.6 (±0.15)	7.9 (±0.15)	7.5 (±0.06)

Temperature	°C	22.8 (±0.06)	19.7 (±0.21)	20.4 (±0.12)	21 (±0.20)	20 (±0.17)	21 (±0.15)	20.4 (±0.26)	20.1 (±0.20)
Turbidity	NTU	12 (±0.20)	11.5 (±0.26)	1 (±0.0)	8.3 (±0.30)	12.6 (±0.21)	15.2 (±0.12)	11.9 (±0.15)	10.4 (±0.25)
Electrical Conductivity	mS/cm	96.5 (±0.46)	110.5 (±0.26)	146.6 (±0.67)	160 (±0.66)	138.3 (±0.29)	104 (±0.30)	140 (±0.47)	148.5 (±0.50)
TDS	mg/L	48.2 (±0.32)	61.1 (±0.17)	73.4 (±0.30)	80.1 (±0.17)	68.1 (±0.30)	52.3 (±0.42)	70.7 (±0.40)	74.6 (±0.34)
Total hardness	mg/L	60 (±1.52)	64 (±2.08)	84 (±2.51)	140 (±2.14)	75 (±3.0)	60 (±3.21)	93 (±2.51)	122 (±2.51)
Total Alkalinity	mg/L	50 (±0.0)	100 (±3.0)	100 (±5.29)	110 (±6.51)	100 (±5.0)	100 (±1.15)	100 (±2.51)	110 (±4.58)
Total Chloride	mg/L	6.4 (±0.06)	5.3 (±0.38)	6 (±0.0)	10 (±0.53)	8.3 (±0.36)	5.7 (±0.30)	6.5 (±0.05)	7.5 (±0.17)
Total iron	mg/L	0.32 (±0.01)	0.22 (±0.04)	0.4 (±0.03)	0.3 (±0.03)	0.53 (±0.04)	0.32 (±0.01)	0.46 (±0.05)	0.17 (±0.03)

4.2.1 Temperature

During the assessment period from June 2016 to May 2018, the average temperature of Mualkawi rivulet ranges from 18.0 to 20.6°C with a total mean value of 19.1°C. From the results, the lowest temperature recorded was in winter season (December - February, 2017) and the highest temperature recorded was in autumn season (September – October, 2017). For Tiau river, the temperature ranges from 19.7 to 22.8°C with a total mean value of 20.6°C. The lowest temperature value was recorded in autumn season (September - October, 2016) and highest temperature value was recorded in monsoon season (June - August, 2016).

The samples were compared with the permissible limits for Drinking Water Quality Standards (Appendix VI) and Inland Surface Water Quality Standards (Appendix VII) set by different scientific agencies and were well below the limits. Temperature effects photosynthetic activity and dissolved oxygen. It also has an important influence on the chemical reactions that occur in water bodies by effecting biological activities and therefore, governs the kind of organisms that live in water bodies (Kale, 2016).

For Mualkawi rivulet, a positive and significant correlation was observed with turbidity at 0.916 (Appendix VIII). For Tiau river, a negative correlation was observed with TDS (-0.557) and total alkalinity (-0.831) (Appendix IX). Seasonal variation of temperature at Mualkawi rivulet and Tiau river are shown in Figure 4.6.

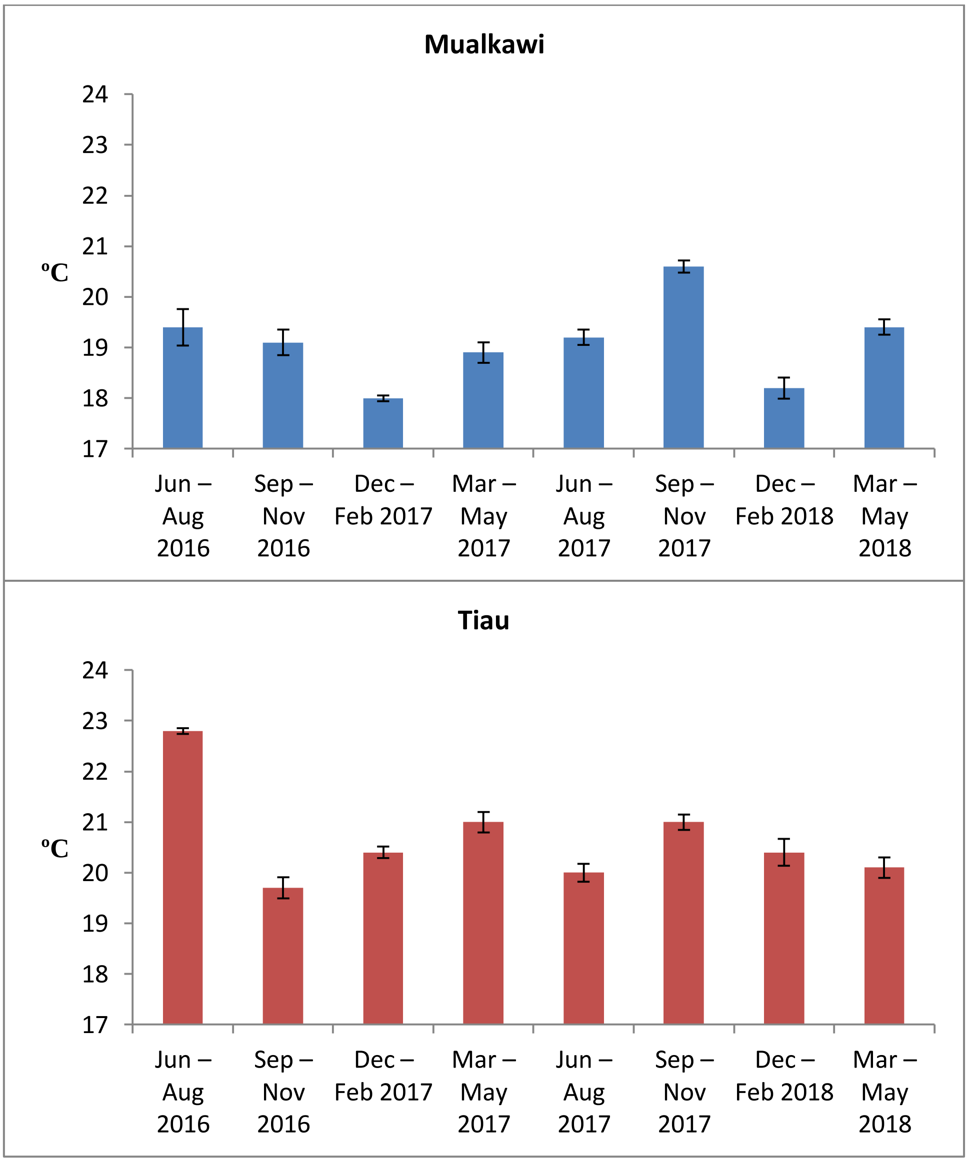

Figure 4.6. Seasonal variation of temperature (°C) at Mualkawi rivulet and Tiau river during June 2016 - May 2018.

4.2.2 pH (Potential of Hydrogen)

During the assessment period from June 2016 to May 2018, the average pH level of Mualkawi rivulet ranges from 6.1 to 8.3 with a total mean value of 7.2. From the results, the lowest ph level recorded was in monsoon season (June - August, 2016) and the highest ph level recorded was in winter season (December - February 2018). For Tiau river, the average pH level ranges from 6.2 to 7.9 a total mean value of 7.3. The lowest ph level recorded was in monsoon season (June - August, 2016) and the highest ph level recorded was in winter season (December – February, 2017) and (December – February, 2018).

The samples were compared with the permissible limits for Drinking Water Quality Standards (Appendix VI) and Inland Surface Water Quality Standards (Appendix VII) set by different scientific agencies and were well below the limits. pH is important in determining the corrosivity of water – lower the pH, higher is its corrosive nature. In humans, exposure to extreme pH values results in irritation to the eyes, skin, and mucous membranes; and since pH can affect the degree of corrosion of metals as well as disinfection efficiency, it may have an indirect effect on health as well (World Health Organization, 1996).

For Mualkawi rivulet, a positive and significant correlation was observed with total iron (0.723) (Appendix VIII). For Tiau river, a positive and significant correlation was observed with electrical conductivity (0.554), TDS (0.549) and total alkalinity (0.725); and a negative correlation was observed with temperature (-0.565) (Appendix IX). Seasonal variation of pH level at Mualkawi rivulet and Tiau river are shown in Figure 4.7.

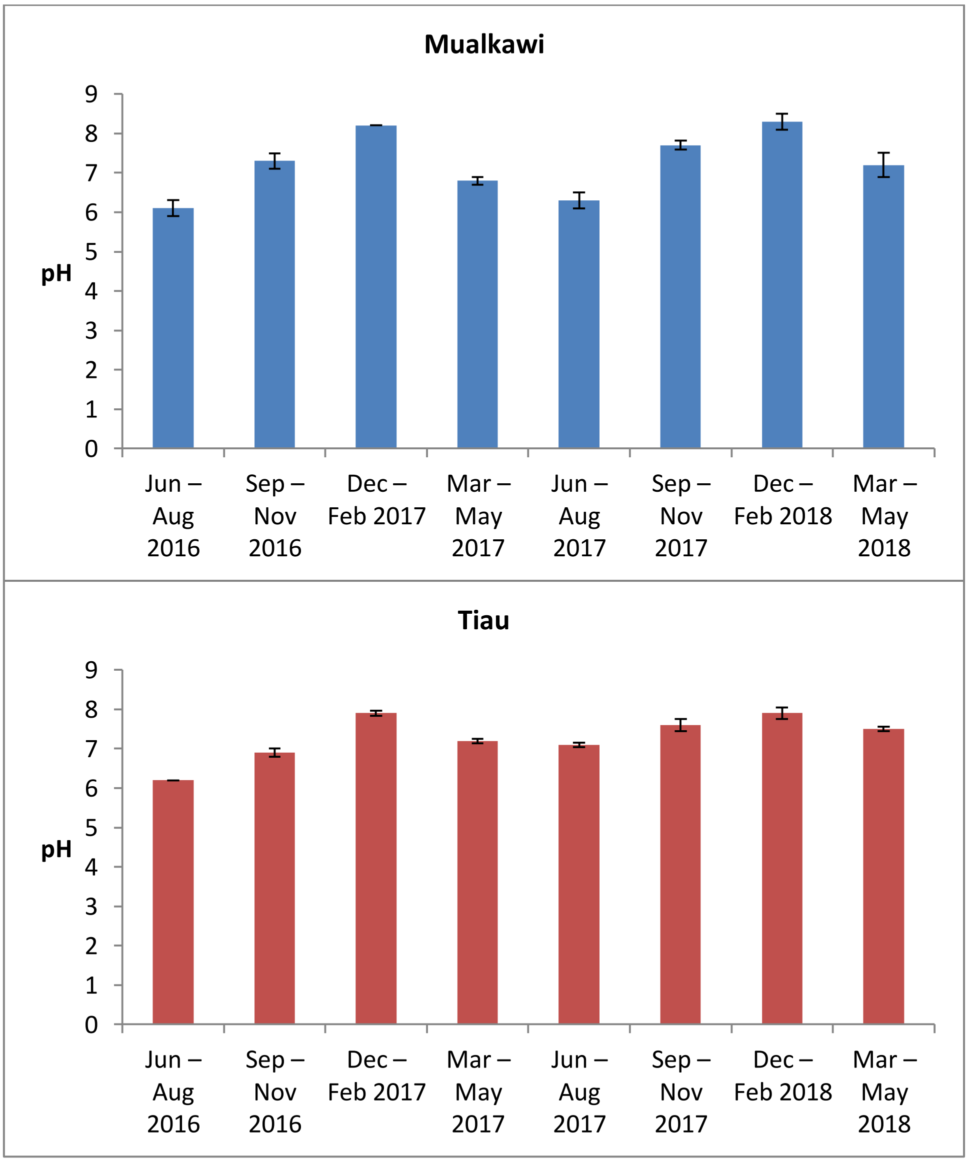

Figure 4.7. Seasonal variation of pH level at Mualkawi rivulet and Tiau river during June 2016 - May 2018.

4.2.3 Electrical conductivity

During the assessment period from June 2016 to May 2018, the average electrical conductivity level of Mualkawi rivulet ranges from 30.2 to 72.2 mS/cm with a total mean value of 45 mS/cm. From the results, the lowest electrical conductivity level recorded was in monsoon season (June - August, 2016) and the highest electrical conductivity level recorded was in summer season (March – May, 2017). For Tiau river, the average electrical conductivity level ranges from 96.5 to 160 mS/cm a total mean value of 130.5 mS/cm. The lowest electrical conductivity level recorded was in monsoon season (June - August), 2016 and the highest electrical conductivity level recorded was in summer season (March – May, 2017).

The samples were compared with the permissible limits for Drinking Water Quality Standards (Appendix VI) and Inland Surface Water Quality Standards (Appendix VII) set by different scientific agencies and were well below the limits. The presence of free ions in water affects the electrical conductivity of water. Therefore the amount of dissolved solids present in water determines the electrical conductivity. Activities including dumping of sewage, agriculture run off, etc. may enhance electrical conductivity (Meride and Ayenew, 2016).

For Mualkawi rivulet, a positive and significant correlation was observed with TDS (0.945), total hardness (0.931) and total alkalinity (0.916) (Appendix VIII). For Tiau river a positive and significant correlation was observed with pH (0.554), TDS (0.984), total hardness (0.857), total alkalinity (0.688), total chloride (0.683) and total iron (0.505) (Appendix IX). Seasonal variation of electrical conductivity level at Mualkawi rivulet and Tiau river are shown in Figure 4.8.

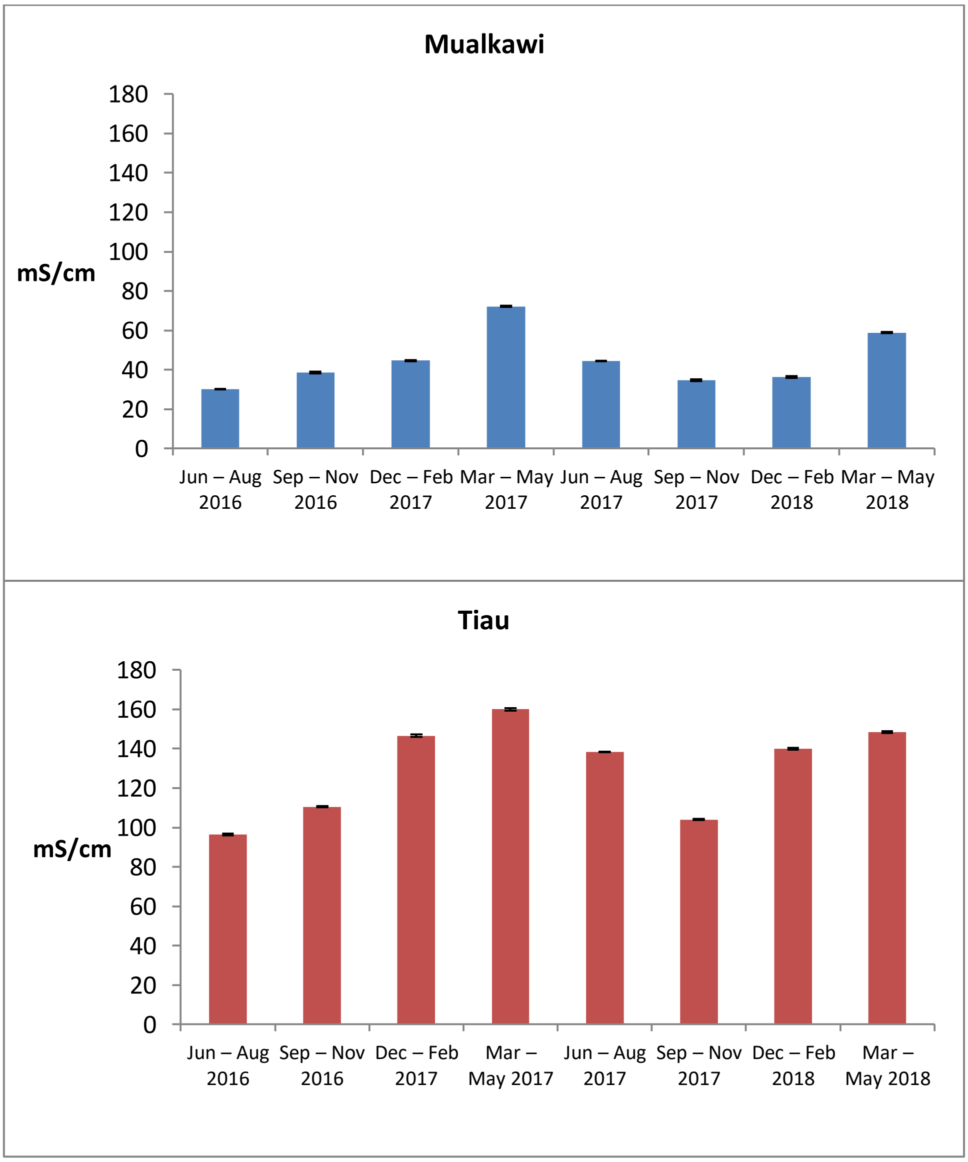

Figure 4.8. Seasonal variation of electrical conductivity level (mS/cm) at Mualkawi rivulet and Tiau river during June 2016 - May 2018.

4.2.4 Turbidity

During the assessment period from June 2016 to May 2018, the average turbidity level of Mualkawi rivulet ranges from 9.5 to 26.3 NTU with a total mean value of 15.9 NTU. From the results, the lowest turbidity level recorded was in winter season (December - February), 2017 and the highest turbidity level recorded was in autumn season (September - November) 2017. For Tiau river, the average turbidity level ranges from 1 to 15.2 NTU a total mean value of 10.3 NTU. The lowest turbidity level recorded was in winter season (December - February, 2017) and the highest turbidity level recorded was in autumn season (September – November, 2017).

The samples were compared with the permissible limits for Drinking Water Quality Standards (Appendix VI) and Inland Surface Water Quality Standards (Appendix VII) set by different scientific agencies and was revealed that the turbidity levels in both Mualkawi rivulet and Tiau river exceeded the permissible limits in most seasons. The highest turbidity level recorded for the present study was in Mualkawi rivulet during autumn season (Sept – Nov), 2017 at 26.3 NTU. Mualkawi rivulet exceeded the permissible limits in all seasons and Tiau river also exceeded the permissible limits in all seasons except for winter season of Dec – Feb, 2017. Turbidity levels in water sources may increase mainly due to suspended materials in water sources that cause water to turn cloudy or turbid (Grobbelaar, 2009). Natural sources of suspended material include sediment from the weathering of rocks, dead plant material and phytoplankton. Human-caused sources include substances in stormwater from urban area, industrial activities, construction and land clearing activities. Therefore, it is evident that the road construction project will lead to increase in turbidity levels in the water bodies present along the road project.

A positive and significant correlation was observed with temperature (0.916) and total chloride (0.670) in Mualkawi rivulet (Appendix VIII). Seasonal variation of turbidity level at Mualkawi rivulet and Tiau river are shown in Figure 4.9.

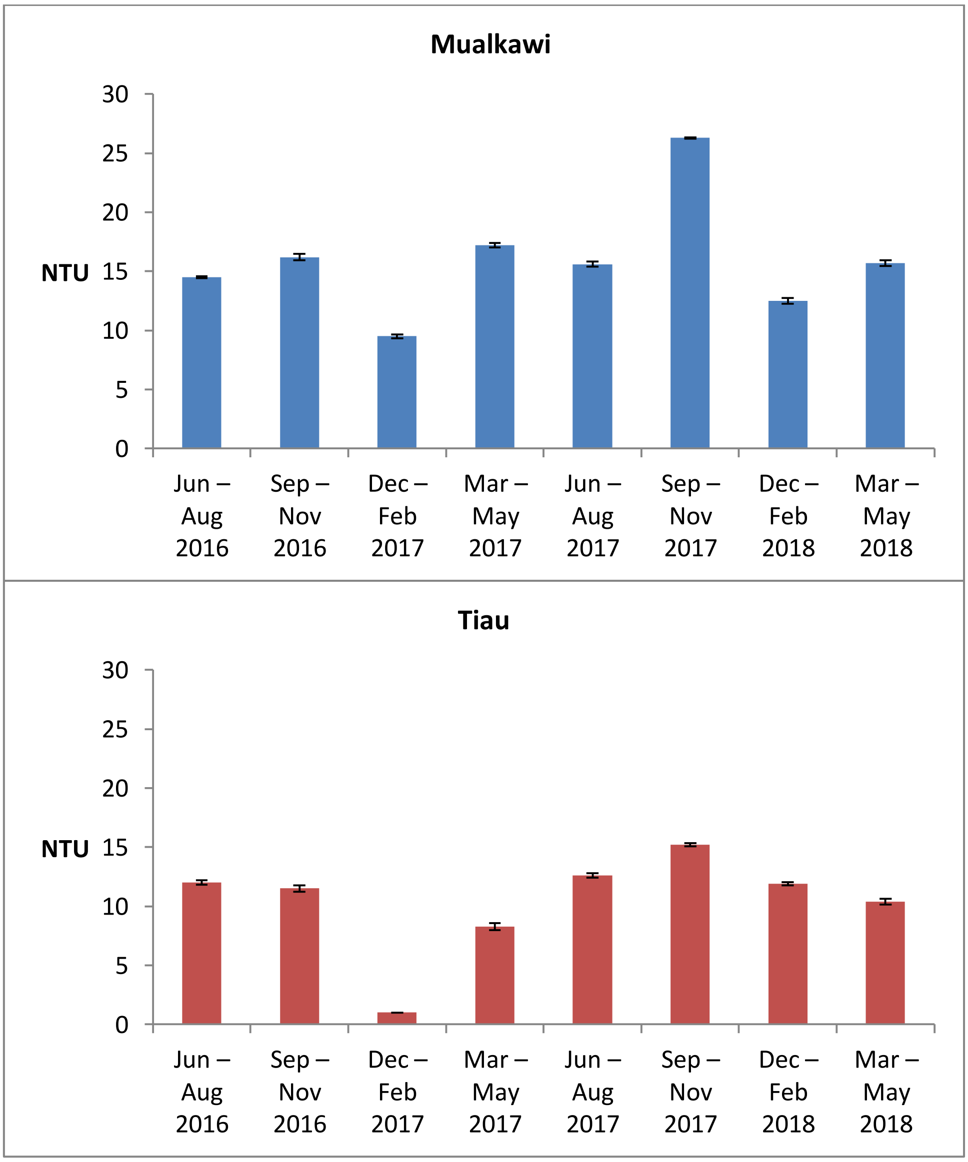

Figure 4.9. Seasonal variation of turbidity level (NTU) at Mualkawi rivulet and Tiau river during June 2016 - May 2018.

4.2.5 Total Dissolved Solids (TDS)

During the assessment period from June 2016 to May 2018, the average TDS level of Mualkawi rivulet ranges from 16.4 to 36.7 mg/L with a total mean value of 23.8 mg/L. From the results, the lowest TDS level recorded was in monsoon season (June - August, 2016) and the highest TDS level recorded was in summer season

(March – May, 2018). For Tiau river, the average TDS level ranges from 48.2 to 80.1 mg/L a total mean value of 66 mg/L. The lowest TDS level recorded was in monsoon season (June - August, 2016) and the highest TDS level recorded was in summer season (March – May, 2017).

The samples were compared with the permissible limits for Drinking Water Quality Standards (Appendix VI) and Inland Surface Water Quality Standards (Appendix VII) set by different scientific agencies and were well below the limits. TDS is the sum total of cation and anion concentration in water and elevated TDS level can cause harm to aquatic life. Natural sources of TDS include sewage, urban and agricultural run-off and also industrial wastewater. Elevated TDS level can increase salinity have shown shifts in biotic communities, limit biodiversity and cause complications at specific life stages of aquatic flora and fauna (Scannell and Duffy, 2007).

For Mualkawi rivulet, a positive and significant correlation was observed with electrical conductivity (0.945), total hardness (0.948) and total alkalinity (0.952) (Appendix VIII). For Tiau river, a positive and significant correlation was observed with electrical conductivity (0.984), total hardness (0.851), total alkalinity (0.740) and total chloride (0.621) (Appendix IX). Seasonal variation of TDS level at Mualkawi rivulet and Tiau river are shown in Figure 4.10.

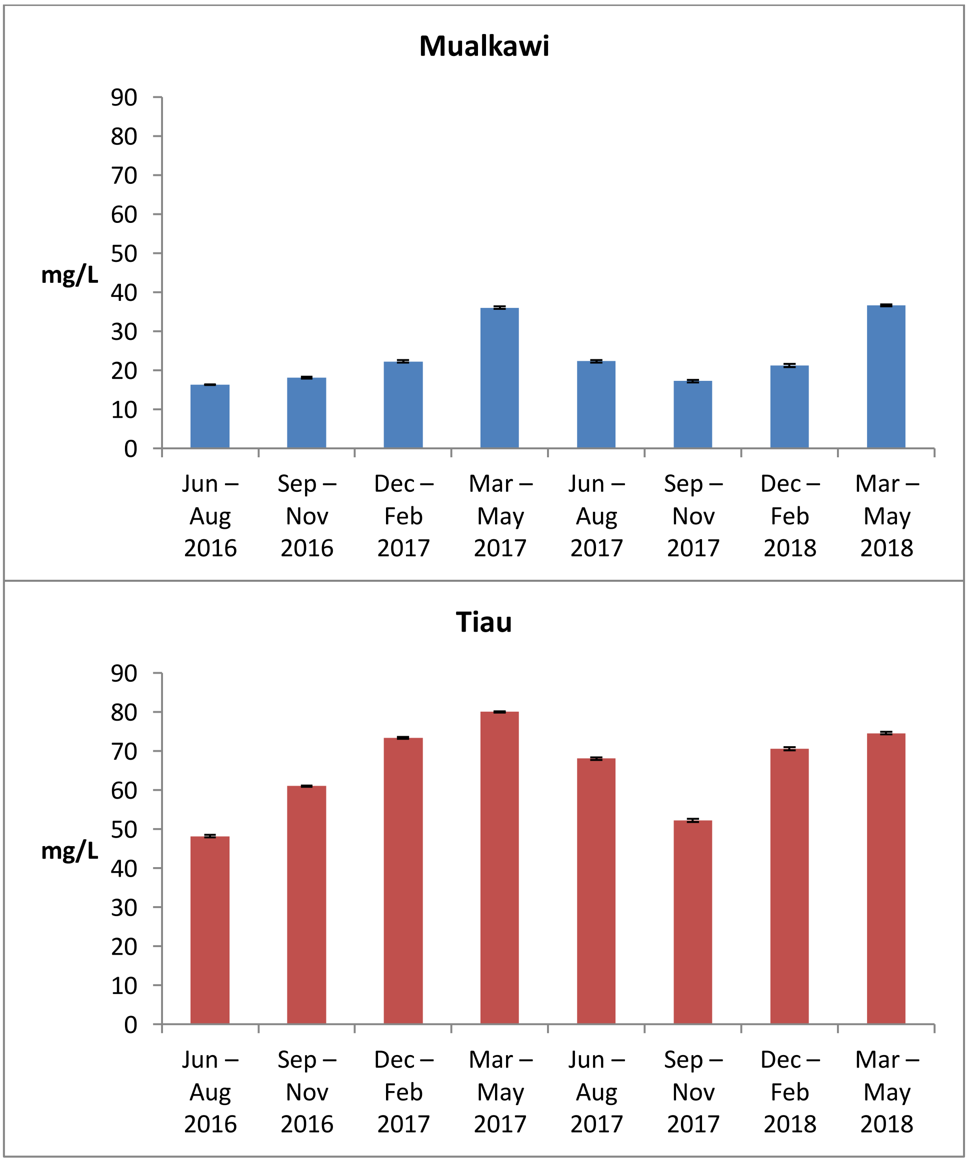

Figure 4.10. Seasonal variation of TDS level (mg/L) at Mualkawi rivulet and Tiau river during June 2016 - May 2018.

4.2.6 Alkalinity

During the assessment period from June 2016 to May 2018, the average alkalinity level of Mualkawi rivulet ranges from 30 to 70 mg/L with a total mean value of 46.7 mg/L. From the results, the lowest alkalinity level recorded was in monsoon season (June - August, 2016) and the highest alkalinity level recorded was in summer season (March – May, 2017) and (March – May, 2018). For Tiau river, the average alkalinity level ranges from 50 to 110 mg/La total mean value of 96.25 mg/L. The lowest alkalinity level recorded was in monsoon season (June - August, 2016) and the highest alkalinity level recorded was in summer season (March – May, 2017) and (March – May, 2018).

The samples were compared with the permissible limits for Drinking Water Quality Standards (Appendix VI) and Inland Surface Water Quality Standards (Appendix VII) set by different scientific agencies and were well below the limits. Alkalinity is the capability of water to neutralize acid and therefore is an important factor in protecting water from rapid pH changes which can be harmful to aquatic life.

For Mualkawi rivulet, a positive and significant correlation was observed with electrical conductivity (0.916), TDS (0.952) and total hardness (0.892) (Appendix VIII). For Tiau river, a positive and significant correlation was observed with pH (0.725) electrical conductivity (0.688), TDS (0.740) and total hardness (0.558) (Appendix IX). Seasonal variation of alkalinity level at Mualkawi rivulet and Tiau river are shown in Figure 4.11.

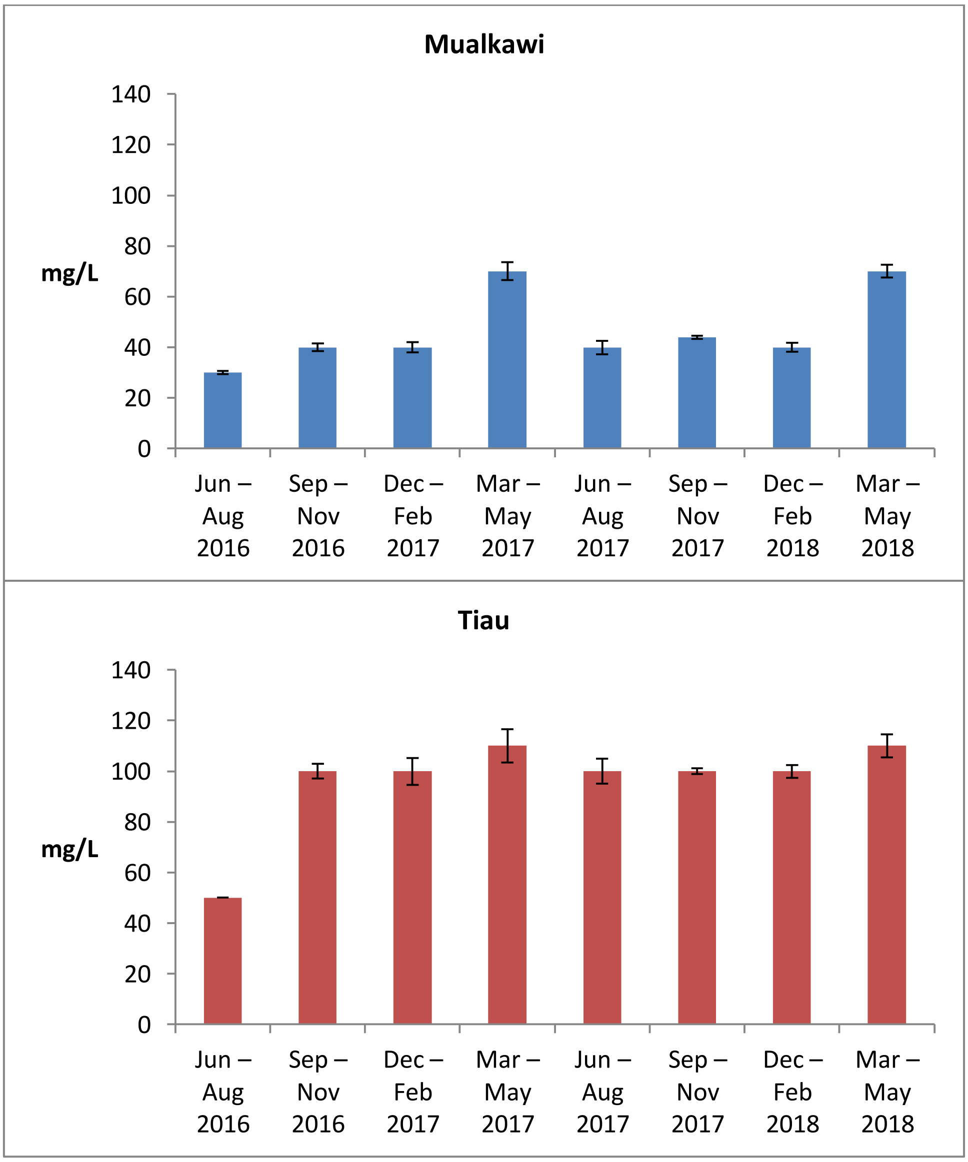

Figure 4.11. Seasonal variation of alkalinity level (mg/L) at Mualkawi rivulet and Tiau river during June 2016 - May 2018.

4.2.7 Total hardness

During the assessment period from June 2016 to May 2018, the average hardness level of Mualkawi rivulet ranges from 8 to 50 mg/L with a total mean value of 21.5 mg/L. From the results, the lowest hardness level recorded was in autumn season (September – November, 2017) and the highest hardness level recorded was in summer season (March – May, 2017). For Tiau river, the average hardness level ranges from 60 to 140 mg/La total mean value of 87.25 mg/L. The lowest hardness level recorded was in monsoon season (June – August, 2016) and autumn season (September – November, 2017). The highest alkalinity level recorded was in summer season (March – May, 2017).

The samples were compared with the permissible limits for Drinking Water Quality Standards (Appendix VI) and Inland Surface Water Quality Standards (Appendix VII) set by different scientific agencies and were well below the limits. Hardness is an important measure in determining the quality and usability of water. The principal sources of water hardness are sedimentary rocks, seepage/run-off from soils and leaching of calcium and magnesium salts. Although both calcium and magnesium are essential minerals and beneficial to human health, lack or excess intake can result in adverse health consequences (World Health Organization, 1996).

For Mualkawi rivulet, a positive and significant correlation was observed with electrical conductivity (0.931), TDS (0.948) and total alkalinity (0.892) (Appendix VIII). For Tiau river, a positive and significant correlation was observed with electrical conductivity (0.857), TDS (0.851), total alkalinity (0.558) and total chloride (0.771) (Appendix IX). Seasonal variation of alkalinity level at Mualkawi rivulet and Tiau river are shown in Figure 4.12.

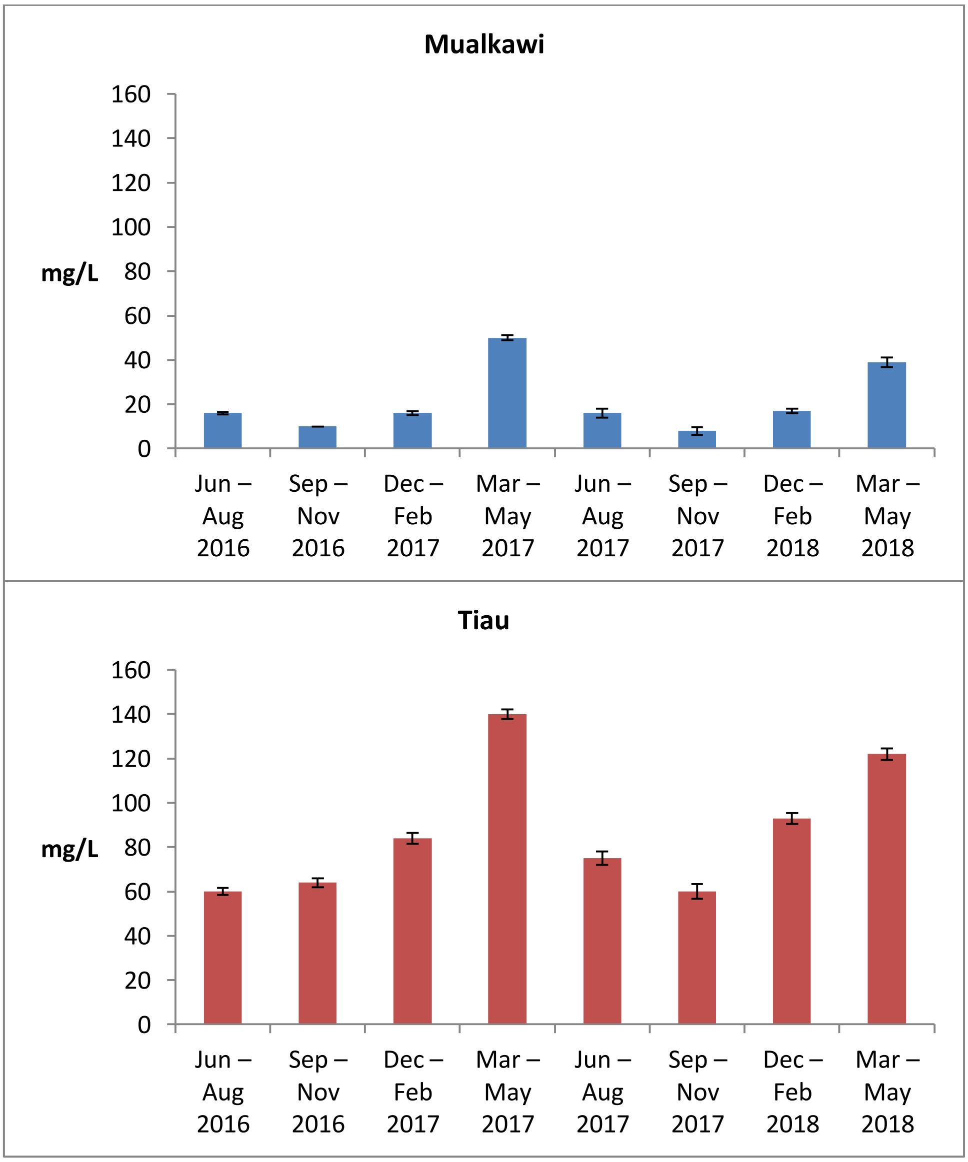

Figure 4.12. Seasonal variation of total hardness level (mg/L) at Mualkawi rivulet and Tiau river during June 2016 - May 2018.

4.2.8 Chloride

During the assessment period from June 2016 to May 2018, the average chloride level of Mualkawi rivulet ranges from 5.4 to 7.2 mg/L with a total mean value of 6.2 mg/L. From the results, the lowest chloride level recorded was in winter season (December - February, 2017) and the highest chloride level recorded was in autumn season (September – November, 2017). For Tiau river, the average chloride level ranges from 5.3 to 10 mg/L with a total mean value of 6.9 mg/L. The lowest chloride level recorded was in autumn season (September – November, 2016) and the highest chloride level recorded was in summer season (March – May, 2017).

The samples were compared with the permissible limits for Drinking Water Quality Standards (Appendix VI) and Inland Surface Water Quality Standards (Appendix VII) set by different scientific agencies and were well below the limits. Chloride is a widely distributed element among the halogens in water. They are found in all types of rocks and are highly mobile and transported to closed basins or oceans. Chlorides increase the electrical conductivity of water which in turn increases its corrosivity, therefore increasing the levels of metals in drinking water. In humans, chloride toxicity can cause complications in the heart (*Ibid.*,1996).

For Mualkawi rivulet, a positive and significant correlation was observed with turbidity (0.670) (Appendix VIII). For Tiau river, a positive and significant correlation was observed with electrical conductivity (0.683), TDS (0.621) and total hardness (0.771) (Appendix IX). Seasonal variation of total hardness level at Mualkawi rivulet and Tiau river are shown in Figure 4.13.

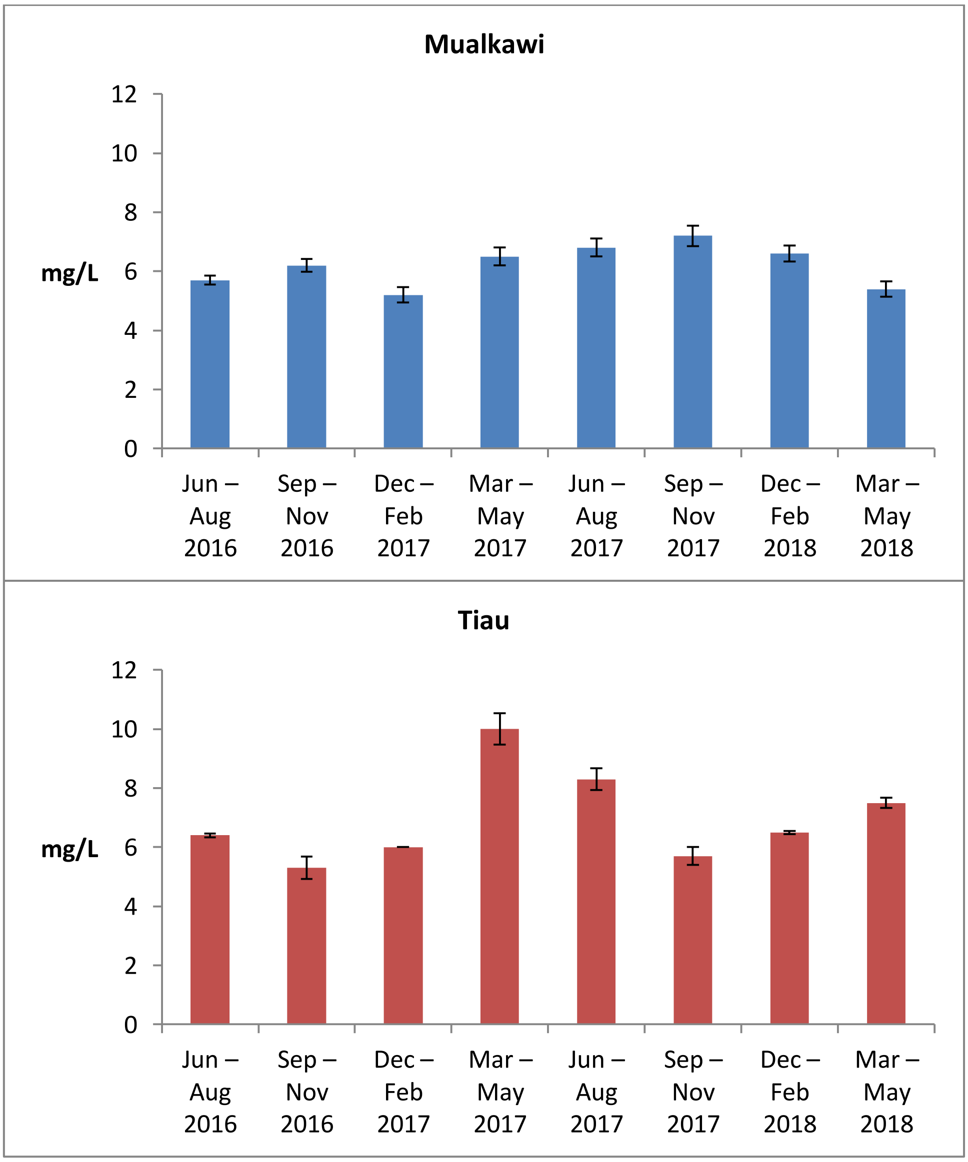

Figure 4.13. Seasonal variation of total chloride level (mg/L) at Mualkawi rivulet and Tiau river during June 2016 - May 2018.

4.2.9 Total iron

During the assessment period from June 2016 to May 2018, the average iron level of Mualkawi rivulet ranges from 0.1 to 0.31 mg/L with a total mean value of 0.16 mg/L. From the results, the lowest iron level recorded was in summer season (March – May, 2017) and the highest iron level recorded was in autumn season

(September – November, 2017). For Tiau river, the average iron level ranges from 0.17 to 0.53 mg/L a total mean value of 0.34 mg/L. The lowest iron level recorded was in summer season (March – May, 2018) and the highest iron level recorded was in monsoon season (June – August, 2017).

The samples were compared with the permissible limits for Drinking Water Quality Standards (Appendix VI) and Inland Surface Water Quality Standards (Appendix VII) set by different scientific agencies and were well below the limits. Iron is an essential element in human nutrition however high iron level can cause complications in the heart and liver. Iron can also affect taste and color of water - turbidity and color may develop in piped systems at levels above 0.05–0.1 mg/litre (*Ibid.,* 1996).

For Mualkawi rivulet, a positive and significant correlation was observed with pH (0.723) (Appendix VIII). For Tiau river, a positive and significant correlation was observed with electrical conductivity (0.505)(Appendix IX). Seasonal variation of total hardness level at Mualkawi rivulet and Tiau river are shown in Figure 4.14.

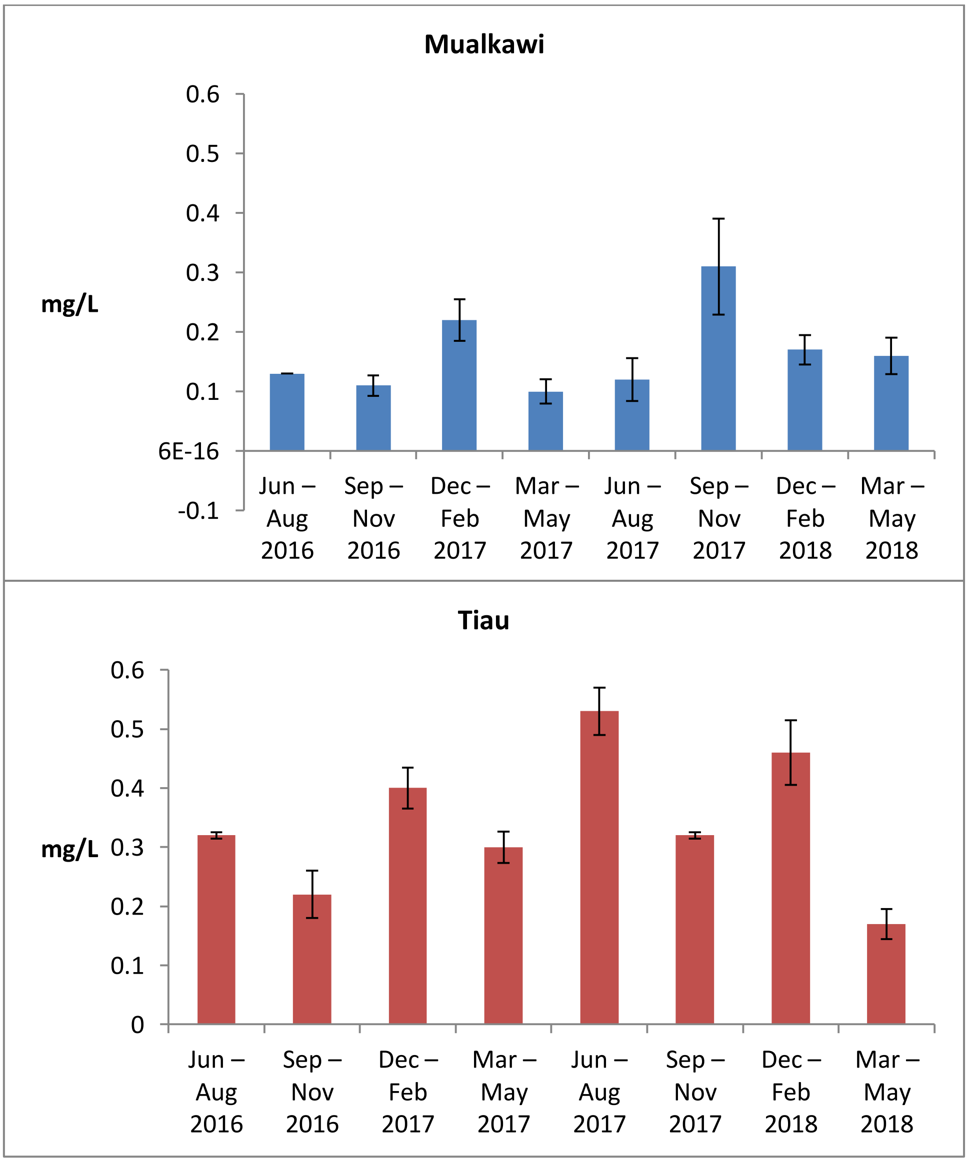

Figure 4.14. Seasonal variation of total iron level (mg/L) at Mualkawi rivulet and Tiau river during June 2016 - May 2018.

4.3 Noise quality

The noise intensity were measured at three sites viz. Zotlang, Melbuk and Zokhawthar along the road project on seasonal basis – Winter season (December, January, February); Summer season (March, April, May); Monsoon season (June, July, August) and Autumn season (September, October, November). The sampling sites – Zotlang is located at latitude N 23°26'53.9" and longitude E 93°20'09.6" with an elevation of 1294 m, Melbuk is located at latitude N 23°23'58.9" and longitude E 93°21'30.9" with an elevation of 1233 m, Zokhawthar is located at latitude N 23°22'22.9" and longitude E 93°23'06.6" with an elevation of 782 m. The meteorological data of sampling sites is shown in Table 4.6. As per the Noise Pollution (Regulation and Control Rules) 2000, the permissible limits of noise pollution for residential area during daytime is given at 55 dB (A).

Table 4.6. Meteorological data of sampling sites.

	Zotlang (Champhai)			**Melbuk (Zokhawthar)**			**Zokhawthar**		
Sampling period	**Temper- -ature (°C)**	**Humidity (%)**	**Wind Velocity (m/s)**	**Temper- -ature (°C)**	**Humidity (%)**	**Wind Velocity (m/s)**	**Temper- -ature (°C)**	**Humidity (%)**	**Wind Velocity (m/s)**
Jun–Aug 2016	20.5	38	2.0	18.5	31.0	1.0	22.1	30	2.1
Sep–Nov 2016	21.0	40	1.2	19.5	35	0.8	21.0	40	1.1
Dec–Feb 2017	15.1	34.5	1.9	16.3	37.5	0.3	15.6	32	0.7
Mar-May 2017	24.5	34	1.1	22.9	33.5	0.7	22.2	37	2.1
Jun–Aug 2017	19.4	34.5	2.1	18.8	31.5	1.6	21.0	32	2.5
Sep–Nov 2017	20.6	40	0.9	21.9	37.5	0.3	22.0	50	1.2
Dec–Feb 2018	19.8	31	2.4	21.0	32.5	1.1	19.2	35	2.0
Mar-May 2018	23.4	30	1.5	22.5	37.5	0.8	21.0	35	2.0
Overall mean	**20.5**	**35.2**	**1.6**	**20.2**	**34.5**	**0.8**	**20.5**	**36.4**	**1.7**

Statistical Analysis

ANOVA was employed to assess seasonal variation in all three sites during daytime and it was revealed that there was no significant variation between the seasons during the assessment period (June 2016 to May 2018) – 0.956 (at 5%) (Appendix X). Noise quality assessment at Zotlang, Melbuk and Zokhawthar is shown in Table 4.7.

Table 4.7. Noise quality assessment at Zotlang, Melbuk and Zokhawthar *(The symbol '±' indicates the standard deviation or the amount of variation from the mean value).*

Season	Parameters	Zotlang	Melbuk	Zokhawthar
Jun – Aug 2016	*Leq (with SD values)*	75.3 (±10.05)	57.8 (±5.41)	58.3 (±4.02)
	Lmax	78.3	60.4	59.8
	Lmin	45.4	42.7	46.1
Sep – Nov 2016	*Leq (with SD values)*	57.9 (±5.04)	79.4 (±9.96)	78.5 (±7.44)
	Lmax	60.6	81.1	78.2
	Lmin	43.8	50.4	54.5
Dec – Feb 2016-2017	*Leq (with SD values)*	64.5 (±3.83)	70.9 (±6.02)	74.1 (±8.42)
	Lmax	66.6	71.9	76.6
	Lmin	54.3	55.2	49.6
Mar – May 2017	*Leq (with SD values)*	75.6 (±4.08)	77.1 (±3.25)	50.7 (±2.22)
	Lmax	76.5	80.5	49
	Lmin	64.8	66.9	42.1
Jun – Aug 2017	*Leq (with SD values)*	74.1 (±4.60)	59.7 (±3.60)	52.8 (±3.11)
	Lmax	76.3	60.7	54
	Lmin	60.7	48.8	42.1
Sep – Nov 2017	*Leq (with SD values)*	69.7 (±5.09)	77.6 (±4.75)	57.8 (±4.42)
	Lmax	70.7	78	58.9
	Lmin	57	63.7	45
Dec – Feb 2017-2018	*Leq (with SD values)*	69.6 (±4.39)	76.9 (±4.91)	65.1 (±7.27)
	Lmax	69.5	76.3	66.5
	Lmin	56.3	63	44.8
Mar – May 2018	*Leq (with SD values)*	72.4 (±4.08)	78.5 (±3.25)	52.7 (±2.22)
	Lmax	73.1	79.2	51.4
	Lmin	60.1	66.3	44.4

4.3.1 Seasonal noise level in different sites

Zotlang

During the assessment period from June 2016 to May 2018, the average noise level ranged from 57.9 to 75.6 dB (A) with a mean value of 70.28 dB (A). The lowest average noise level was recorded in winter season (December - February, 2017) and the highest average noise level was recorded in summer season (March – May, 2017).

The noise levels computed exceeds the permissible limits as per the Noise Pollution (Regulation and Control) Rules 2000 (Appendix XI) in all seasons in the study site, as Zotlang area is identified as a residential area. Seasonal average noise levels in Zotlang are shown in Figure 4.15.

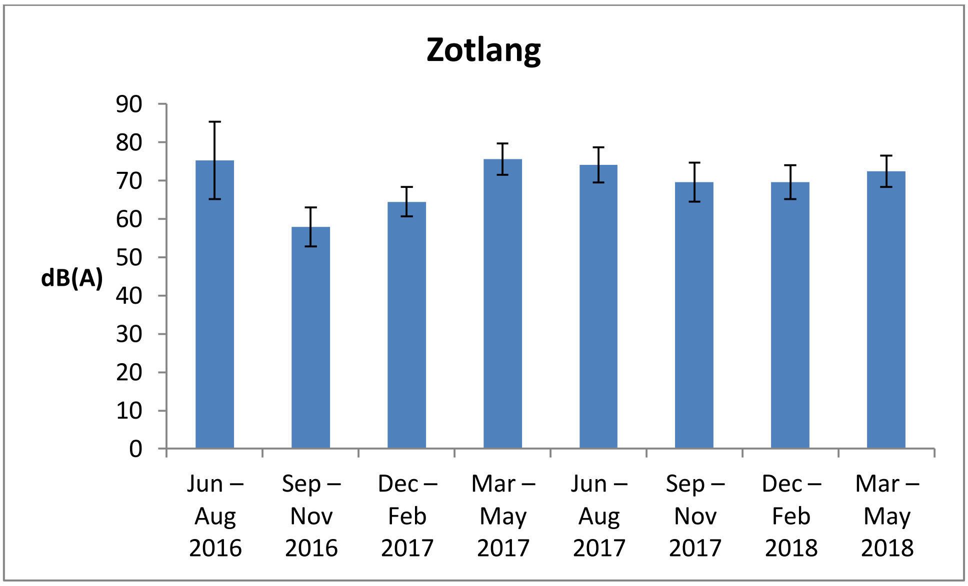

Figure 4.15. Seasonal average noise levels in Zotlang from June 2016 to May 2018.

Melbuk

During the assessment period from June 2016 to May 2018, the average noise level ranged from 57.8 to 79.4 dB (A) with a mean value of 72.06 dB (A). The lowest average noise level was recorded in monsoon season (June - August, 2016) and the highest average noise level was recorded in autumn season (September – November, 2016).

The noise levels computed exceeds the permissible limits as per the Noise Pollution (Regulation and Control) Rules 2000 (Appendix XI) in all seasons in the study site, as Melbuk area is identified as a residential area. Seasonal average noise levels in Melbuk are shown in Figure 4.16.

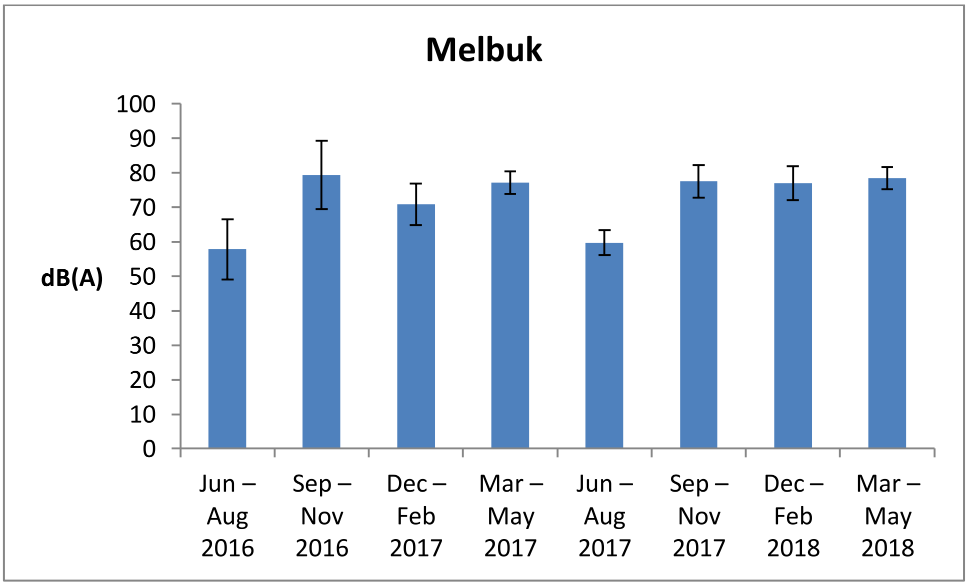

Figure 4.16. Seasonal average noise levels in Melbuk from June 2016 to May 2018.

Zokhawthar

During the assessment period from June 2016 to May 2018, the average noise level ranged from 50.6 to 78.5 dB (A) with a mean value of 60.98 dB (A). The lowest average noise level was recorded in summer season (March – May, 2018) and the highest average noise level was recorded in autumn season (September – November, 2016).

The noise levels in Zokhawthar site, the area identified as a residential area, exceeded the permissible limits as per the Noise Pollution (Regulation and Control) Rules 2000 (Appendix XI) in most seasons except in summer seasons (March – May,

2018) and in monsoon season (June – August, 2017). Seasonal average noise levels in Zokhawthar are shown in Figure 4.17.

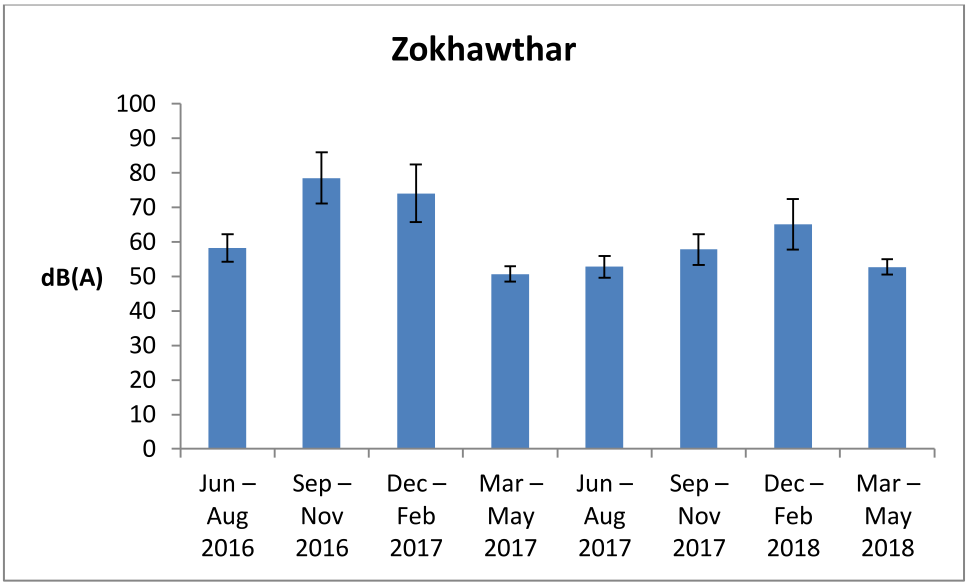

Figure 4.17. Seasonal average noise levels in Zokhawthar from June 2016 to May 2018.

4.3.2 Comparison of noise quality with baseline data from pre-construction phase 2014

The results generated from the present study are statistically compared with the baseline data of Pre-Construction Phase – Environmental Impact Assessment Report of Widening To 2-Lane, Re-Alignment And Geometric Improvement Of Champhai-Zokhawthar Road (00.000 Km To 27.247 Km) within Mizoram State Roads Project II dated 16 February 2014 STUP Consultants Pvt.

Statistical Analysis

ANOVA was employed to assess the overall average noise levels of the present study with its baseline data from Pre-Construction Phase 2014 and it was revealed that there was no significant variation between the two phases – 0.159 (at 5%) (Appendix XII). Comparison of noise quality between pre-construction and construction phases is depicted in Figure 4.18.

Zotlang

The overall average noise levels during the study period i.e. 70.28 dB (A) is much higher in comparison to noise levels during pre-construction phase i.e. 61.56 dB (A). The overall average noise levels in both phases exceed the permissible limits as per the Noise Pollution (Regulation and Control) Rules 2000 (Appendix XI).

Melbuk

The overall average noise levels during the study period i.e. 72.06 dB (A) is much higher in comparison to noise levels during pre-construction phase i.e. 62.71 dB (A). The overall average noise levels in both phases exceed the permissible limits as per the Noise Pollution (Regulation and Control) Rules 2000 (Appendix XI).

Zokhawthar

The overall average noise levels during the study period i.e. 60.98 dB (A) is lower in comparison to noise levels during pre-construction phase i.e. 61.11 dB (A). The overall average noise levels in both phases exceed the permissible limits as per the Noise Pollution (Regulation and Control) Rules 2000 (Appendix XI).

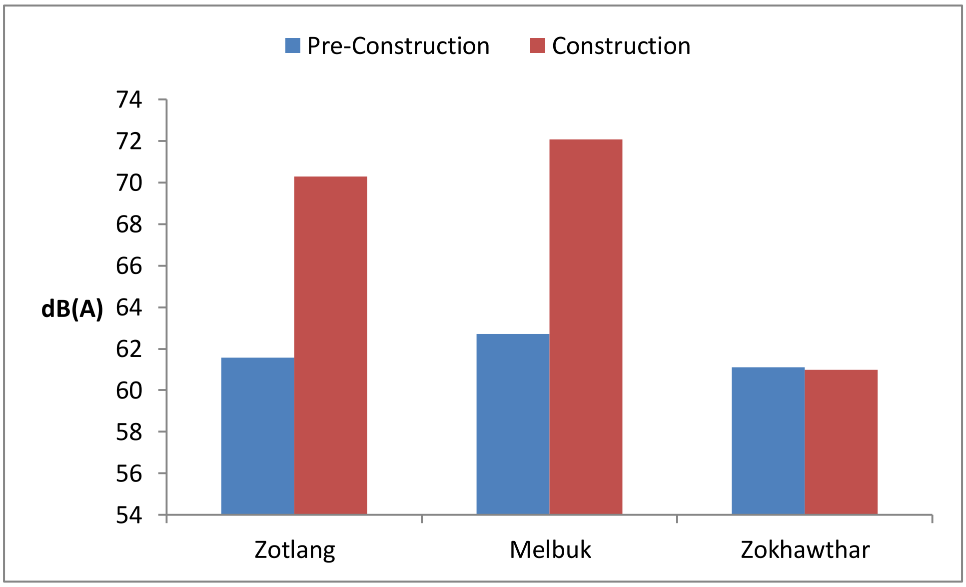

Figure 4.18. Comparison of noise quality between pre-construction and construction phases.

4.4 Biodiversity

Background information on nature of land along road project

The Champhai-Zokhawthar road project passes through 0.28 ha of forest land, 47.5 ha of agricultural land and 0.45 ha of habited area. The nature of the land is mainly Government land and jhum land. Since there is 0.28 ha of forest land to be diverted by the road project, Forest Clearance was applied for and ultimately granted under Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 by the State Government.

As per record and related documents from State PWD and Forest Departments, the total number of trees to be felled along the entire road project is 693 Nos. However, the details of the tree species were not put on record. Tree inventory survey data as per EIA report indicates that out of the total 693 population of trees to be felled, 407 Nos. are trees having 30-60 cm girth size, 178 Nos. are 60-90 cm girth size, 78 Nos. are 90-180 cm girth size and girth size having more than 180 cm are 30. Besides the 693 Nos. of trees to be felled, 300 bamboo clumps will also be felled due to earth cutting along the hillside of the road.

Furthermore, as per record, the road construction will cause displacement of 183 households. The land use along the road project are mainly few settlements and cultivated jhum land. It has also been estimated that the road project will provide direct and indirect effects to more than 15,000 people.

4.4.1 Floral composition

Family

A total of 38 families were recorded in the study area. Out of these, 37 families (97.36%) were angiosperms and 1 family (2.63%) belonged to pteridophytes. Gymnosperm plants were not observed in the study area. The dicotyledons comprised of 31 families and the monocotyledons comprised of 6 families. Out of the 37 families of dicots and monocots, dicots represent 83.78% and monocots represent 16.21%. The ratio of monocots to dicots is 1:5.1 for families. The most dominant and species rich families include Fabaceae (8 species), Poaceae (7 species), Asteraceae (7 species), Fagaceae (7 species), Euphorbiaceae (4 species), Rubiaceae (4 species) and Verbenaceae (3 species). 24 families are represented by only one species and 6 families are represented by two species each.

Genera

A total of 66 genera were recorded in the study area. Out of these, 65 genera (98.46%) were angiosperms and 1 genus (1.53%) belonged to pteridophytes. Gymnosperm plants were not observed in the study area. The dicotyledons comprised of 54 genera and the monocotyledons comprised of 11 genera. Out of the 65 genera of dicots and monocots, dicots represent 83.07% and monocots represent 16.92%. The ratio of monocots to dicots is 1:4.9 for genera.

Species

A total of 78 species were recorded in the study area. Out of these, 77 species (98.71%) were angiosperms and 1 species (1.28%) belonged to pteridophytes. Gymnosperm plants were not observed in the study area. The dicotyledons comprised of 65 species and the monocotyledons comprised of 12 species. Out of the 77 species of dicots and monocots, dicots represent 84.41% and monocots represent 15.58%. The ratio of monocots to dicots is 1:5.4 for species. Among the 78 species, 37 (47.43%) trees, 19 (24.35%) shrubs and 22 (28.20%) herbs are represented.

The distribution of dicots and monocots in the study area are shown in Table 4.8 and Figure 4.19.

Table 4.8. Distribution of dicots and monocots.

Category	**Dicots**		**Monocots**		**Total No.**
	No.	**%**	**No.**	**%**	
Family	31	83.78	6	16.21	37
Genera	54	83.07	11	16.92	65
Species	65	84.41	12	15.58	77

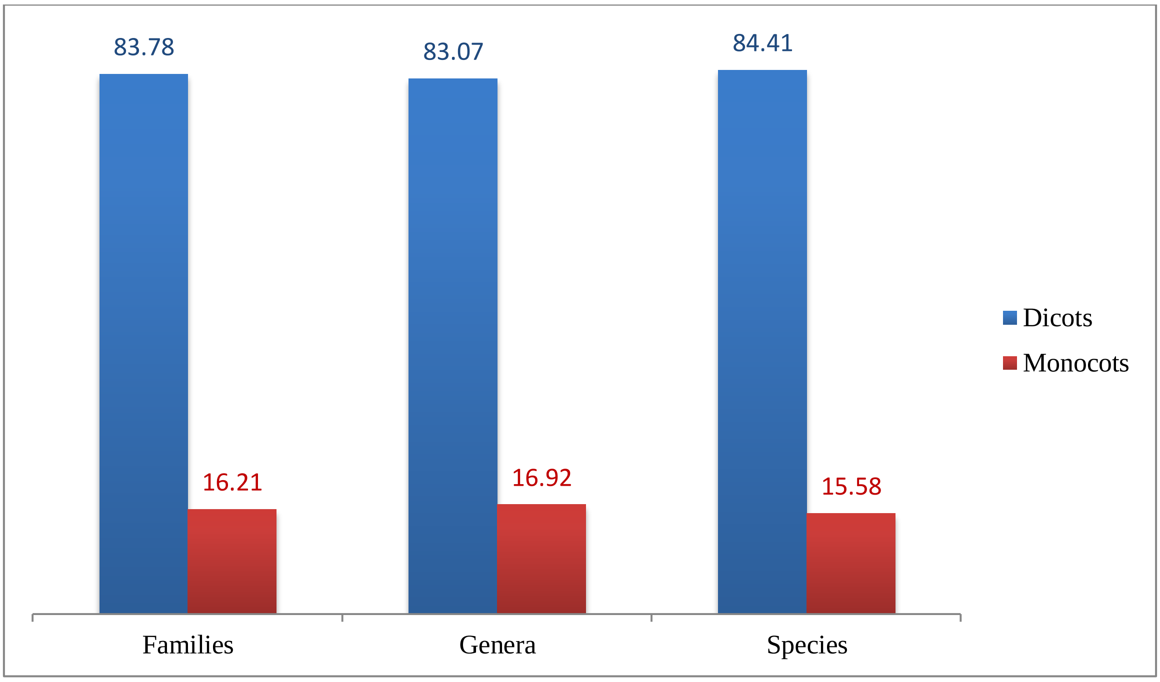

Figure 4.19. Distribution of families, genera and species under dicots and monocots.

The data shown at Table 4.8 and Figure 4.19 indicates that the species of dicots is more and outnumber the species of monocots for families, genera and species.

Statistical analysis

A statistical analysis was done for trees, shrubs and herbs observed along the road project and IVI calculations revealed variety in number and occurrence of different species of flora. IVI calculations of tree species showed the occurrence of 37 tree species. The top ten dominant tree species in respect of species composition along the road project are *Castanopsis tribuloides* (Thingsia), *Callicarpa arborea* (Hnahkiah), *Albizzia chinensis* (Vang), *Ficus bengalensis* (Hmawng), *Wendlandia grandis* (Batling), *Quercus leucotrichophora* (Then), *Quercus serrata* (Sasua), *Schima wallichii* (Khiang), *Azadirachta indica* (Neem) and *Lithocarpus dealbata* (Fah). Among the tree species identified, *Schima wallichii* (Khiang), *Ficus semicordata* (Theipui kung), *Macaranga indica* (Hnahkhar), *Azadirachta indica*

(Neem), *Quercus griffithii* (Khawthli), *Callicarpa arborea* (Hnahkiah), *Quercus helferiana* (Hlai), *Phoebe lanceolata* (Bulfek), *Bischofia javanica (*Khuangthli), *Bauhinia purpurea* (Vaube), *Trema orientalis* (Belphuar) and *Duabanga grandiflora* (Zuang) are least concern (LC) under the IUCN Red List.

IVI calculations of shrub species showed the occurrence of 19 shrub species. Among shrubs, the top ten dominant species in respect of species composition include *Saccharum longisetosum* (Luang), *Mussaenda macrophylla* (Vakep), *Dendrocalamus longispathus* (Raw-nal), *Mikania micrantha* (Japan hlo), *Thysanolaena maxima* (Hmunphiah), *Solanum torvum* (Tawkpui), *Conyza bonariensis* (Buarzen), *Morinda angustifolia* (Lum), *Musa sylvestris* (Changel) and *Rubus ellipticus* (Hmutau). Among the shrub species identified, *Embelia vestita* (Tling) and *Colocasia esculenta* (Dawl) are least concern (LC) under the IUCN Red List.

IVI calculations of herb species showed the occurrence of 22 herb species. The most dominant species of herbs found along the road project include *Ageratum conyzoides* (Vailenhlo), *Imperata cylindrical* (Di), *Desmodium sequax* (Cha-bet-ban), *Bidens pilosa* (Vawkpuithal), *Adenostemma lavenia* (Vailenhlosuak), *Urena lobata* (Se-hnap), *Cynodon dactylon* (Phaitualhnim), *Centella asistica* (Lambak), *Begonia roxburghii* (Sekhupthur) and *Mimosa pudica* (Hlonuar). Among the herb species identified *Amomum dealbatum* (Aidu), *Urena lobata* (Sehnap) and *Mimosa pudica* (Hlonuar) are least concern (LC) under the IUCN Red List.

Biodiversity indices

The biodiversity indices – species richness (Whitaker, 1975), species diversity (Shannon and Wiener, 1963), evenness index (Pielou, 1975) and index of dominance (Simpson, 1949) were calculated for trees, shrubs and herbs.

Species richness of flora was highest in trees (14.91) followed by herbs (8.31) and lowest in shrubs (7.39). Species diversity also exhibited highest value in trees (2.96) followed by herbs (2.82) and lowest in shrubs (2.55). The individual number of species was most evenly distributed in trees (0.82) followed by herbs (0.46) and lowest in shrubs (0.43). The dominance index was highest in herbs (0.93) followed by trees (0.92) and lowest in shrubs (0.91).

The IVI and values of biodiversity indices of trees, shrubs and herbs are shown in Table 4.9, Table 4.10, Table 4.11 and Table 4.12 respectively. Figure 4.20 depicts the floral species under the IUCN Red List Category.

Table 4.9. Importance Value Index of tree species.

Sl. No.	Scientific Name	Local name	Fre	RF	Den-sity	RD	Dom	R dom	IVI	Rank
1	*Quercus serrate*	Sasua	30	5.22	125	8.25	0.03	2.88	16.35	7
2	*Schima wallichii*	Khiang	45	7.83	70	4.62	0.02	2.09	14.54	8
3	*Rhus semialata*	Khawm-hma	5	0.87	5	0.33	0.01	0.84	2.04	37
4	*Lithocarpus dealbata*	Fah	15	2.61	50	3.30	0.03	3.27	9.18	10
5	*Prunus cerasoides*	Tlai-zawng	10	1.74	15	0.99	0.04	4.01	6.74	14
6	*Castanopsis tribuloides*	Thingsia	55	9.57	255	16.83	0.07	6.98	33.38	1
7	*Ficus semicordata*	Theipui kung	5	0.87	5	0.33	0.01	0.95	2.15	36
8	*Quercus leucotrichophora*	Then	40	6.96	115	7.59	0.02	2.26	16.80	6
9	*Macaranga indica*	Hnah-khar	15	2.61	20	1.32	0.03	2.60	6.53	15
10	*Azadirachta indica*	Neem	5	0.87	5	0.33	0.11	11.14	12.34	9
11	*Albizzia chinensis*	Vang	55	9.57	145	9.57	0.01	1.12	20.25	3
12	*Quercus griffithii*	Khawthli	15	2.61	25	1.65	0.01	0.70	4.95	19
13	*Wendlandia grandis*	Batling	45	7.83	115	7.59	0.02	1.64	17.05	5

14	*Callicarpa arborea*	Hnah-kiah	45	7.83	165	10.89	0.02	2.34	21.06	2
15	*Anogeissus acuminata*	Zairum	10	1.74	15	0.99	0.03	2.51	5.24	16
16	*Quercus helferiana*	Hlai	20	3.48	50	3.30	0.01	1.30	8.08	11
17	*Phoebe lanceolata*	Bulfek	10	1.74	15	0.99	0.01	1.12	3.85	27
18	*Bischofia javanica*	Khuang-thli	5	0.87	5	0.33	0.03	2.60	3.80	28
19	*Betula cylindrostachys*	Hriang	5	0.87	5	0.33	0.01	1.43	2.63	35
20	*Rhus succedanea*	Chhim-hruk	10	1.74	10	0.66	0.01	1.18	3.58	32
21	*Emblica officinallis*	Sunhlu	20	3.48	30	1.98	0.01	1.24	6.70	13
22	*Bauhinia purpurea*	Vaube	5	0.87	15	0.99	0.02	1.93	3.79	30
23	*Gmelinia arborea*	Thlan-vawng	10	1.74	15	0.99	0.02	2.34	5.07	17
24	*Albizzia odoratissima*	Thingri	5	0.87	5	0.33	0.03	2.78	3.98	24
25	*Michelia champaca*	Ngiau	5	0.87	5	0.33	0.03	3.17	4.37	22
26	*Trema orientalis*	Belphuar	5	0.87	5	0.33	0.02	2.01	3.21	33
27	*Dendrocalamus longispathus*	Rawnal	5	0.87	40	2.64	0.00	0.37	3.88	26
28	*Quercus polystachya*	Thil	10	1.74	15	0.99	0.02	2.17	4.90	20
29	*Dinochloa compaetiflora*	Sairil	5	0.87	40	2.64	0.01	0.52	4.03	23
30	*Macropanax undulatus*	Phuan-berh	5	0.87	10	0.66	0.02	2.09	3.62	31
31	*Ligustrum robustum*	Chawm-zil	10	1.74	20	1.32	0.02	1.50	4.56	21
32	*Ficus bengalensis*	Hmawng	5	0.87	5	0.33	0.18	17.40	18.60	4

33	*Erythrina indica*	Fartuah	15	2.61	15	0.99	0.04	3.58	7.18	12
34	*Bombax insigne*	Pang	10	1.74	15	0.99	0.02	2.26	4.98	18
35	*Duabanga grandiflora*	Zuang	5	0.87	15	0.99	0.02	2.09	3.95	25
36	*Xeromphis spinosa*	Sazupui-thei	5	0.87	30	1.98	0.01	0.95	3.80	29
37	*Vaccinum sprengelii*	Sirkam	5	0.87	20	1.32	0.01	0.65	2.84	34

Table 4.10. Importance Value Index of shrub species.

SL. No.	Scientific Name	Local name	Fre	RF	Den-sity	RD	Dom	R dom	IVI	Rank
1	*Conyza bonariensis*	Buarzen	20	6.56	125	6.72	625.0	5.91	19.19	7
2	*Dendrocalamus longispathus*	Rawnal	25	8.20	240	12.9	960.0	9.08	30.18	3
3	*Saccharum longisetosum*	Luang	30	9.84	280	15.05	933.3	8.82	33.71	1
4	*Musa sylvestris*	Changel	15	4.92	60	3.23	400.0	3.78	11.93	9
5	*Acasia pinnata*	Khanghu	10	3.28	25	1.34	250.0	2.36	6.99	16
6	*Mikania micrantha*	Japan hlo	20	6.56	190	10.22	950.0	8.98	25.75	4
7	*Bobitis sinensis*	Katchat	5	1.64	35	1.88	700.0	6.62	10.14	13
8	*Clerodendrum viscosum*	Phuihna mchhia	10	3.28	50	2.69	500.0	4.73	10.69	11
9	*Eurya japonica*	Sihneh	10	3.28	35	1.88	350.0	3.31	8.47	15
10	*Thysanolaena maxima*	Hmun-phiah	20	6.56	185	9.95	925.0	8.75	25.25	5
11	*Elaeagnus caudate*	Sarzuk-pui	5	1.64	10	0.54	200.0	1.89	4.07	19
12	*Embelia vestita*	Tling	5	1.64	15	0.81	300.0	2.84	5.28	18
13	*Rubu sellipticus Sm.*	Hmuțau	5	1.64	40	2.15	800.0	7.56	11.35	10
14	*Solanum torvum*	Tawkpui	30	9.84	180	9.68	600.0	5.67	25.19	6
15	*Morinda*	Lum	30	9.84	55	2.96	183.3	1.73	14.53	8

	angustifolia									
16	*Ricinus communis*	Mutih	15	4.92	45	2.42	300.0	2.84	10.17	12
17	*Colocasia esculenta*	Dawl	5	1.64	30	1.61	600.0	5.67	8.93	14
18	*Mussaenda macrophylla*	Vakep	40	13.11	240	12.90	600.0	5.67	31.69	2
19	*Acacia concina*	Khang-thur	5	1.64	20	1.08	400.0	3.78	6.50	17

Table 4.11. Importance Value Index of herb species.

SL. No.	Scientific Name	Local name	Fre	RF	Den-sity	RD	Dom	R dom	IVI	Rank
1	*Achiranthus bidentata*	Vangvat-hlo	15	4.55	80	3.63	533.33	3.55	11.73	12
2	*Centella asistica*	Lambak	25	7.58	110	4.99	440.00	2.93	15.50	8
3	*Chromolaena odorata*	Tlang-sam	10	3.03	55	2.49	550.00	3.66	9.19	17
4	*Imperata cylindrica*	Di	30	9.09	245	11.11	816.67	5.44	25.64	2
5	*Lobelia pyramidalis*	Be-raw-chal	20	6.06	60	2.72	300.00	2.00	10.78	14
6	*Desmodium heterocarpon*	Berbek	15	4.55	65	2.95	433.33	2.89	10.38	15
7	*Amomum dealbatum*	Aidu	10	3.03	25	1.13	250.00	1.67	5.83	20
8	*Lobelia nummularia*	Choakthi	5	1.52	55	2.49	1100.0	7.33	11.34	13
9	*Cynodon dactylon*	Phaitual-hnim	10	3.03	115	5.22	1150.0	7.66	15.91	7
10	*Polygonum barbata*	An-bawng	5	1.52	45	2.04	900.00	6.00	9.55	16
11	*Bidens pilosa*	Vawkpui-thal	35	10.61	195	8.84	557.14	3.71	23.16	4
12	*Spilanthes*	Ankasate	5	1.52	35	1.59	700.00	4.66	7.77	19

	acmella									
13	*Ageratum conyzoides*	Vailen-hlo	35	10.61	285	12.93	814.29	5.42	28.96	1
14	*Begonia roxburghii*	Sekhup-thur	5	1.52	70	3.17	1400.0	9.33	14.02	9
15	*Adenostemma lavenia*	Vailen-hlosuak	20	6.06	165	7.48	825.00	5.50	19.04	5
16	*Desmodium sequax*	Cha-bet-ban	20	6.06	220	9.98	1100.0	7.33	23.37	3
17	*Urena lobata*	Se-hnap	15	4.55	130	5.90	866.67	5.77	16.21	6
18	*Amaranthus viridis*	Zamzo	5	1.52	10	0.45	200.00	1.33	3.30	22
19	*Mimosa pudica*	Hlonuar	20	6.06	95	4.31	475.00	3.16	13.53	10
20	*Scleria levis*	Thip	10	3.03	80	3.63	800.00	5.33	11.99	11
21	*Smilax perfolia*	Kai-ha	5	1.52	15	0.68	300.00	2.00	4.19	21
22	*Polygonum chinensis*	Ta-ham	10	3.03	50	2.27	500.00	3.33	8.63	18

Table 4.12. Biodiversity indices of trees, shrubs and herbs.

Sl. No	**Biodiversity Indices**	**Trees**	**Shrubs**	**Herbs**
1	Species Richness, D	14.91	7.39	8.31
2	Species Diversity, H′	2.96	2.55	2.82
3	Evenness Index, E	0.82	0.43	0.46
4	Index of Dominance, 1-D	0.92	0.91	0.93

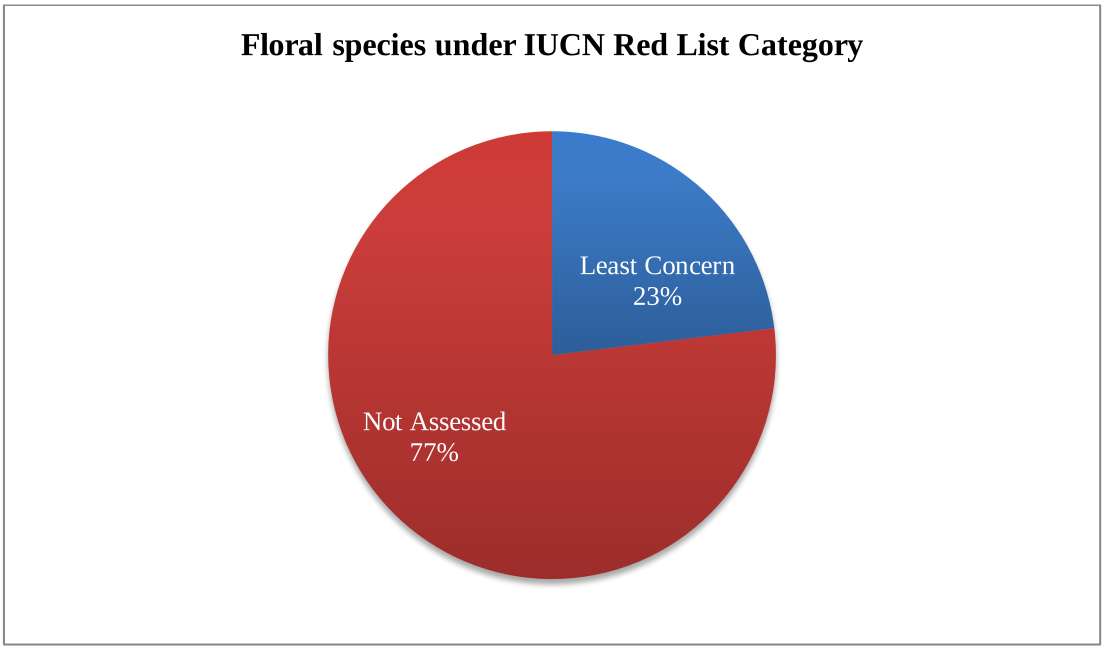

Figure 4.20. Floral species under IUCN red list category.

4.4.2 Faunal composition

A total of 21 species of birds, 7 species of reptiles and 11 species of mammals were identified through field observation as wells as recent sightings by local residents. The 21 species of avian fauna belonged to 14 families under 9 orders. The most dominant avian fauna families include Columbidae (4 species), Phasianidae (2 species), Pycnonotidae (2 species) and Strigidae (2 species). 10 families are represented by one species only. The most dominant avian fauna orders include Passeriformes (7 species), Columbiformes (4 species), Galliformes (2 species), Strigiformes (2 species) and Picciformes (2 species). 4 orders are represented by one species only.

The 7 species of reptilian fauna belonged to 5 families under 1 order. The most dominant reptilian fauna families include Agamidae (2 species) and Varanidae (2 species). 3 families are represented by one species only. All species of reptiles belonged under Squamata order.

The 11 species of mammalian fauna belonged to 10 families under 5 orders. The most dominant mammalian fauna family is Canidae (2 species) and the remaining 9 families are represented by one species only. The most dominant mammalian fauna orders include Carnivora (5 species), Rodentia (2 species) and Artiodactyla (2 species). 2 orders are represented by one species only.

Although many species of fauna were observed (spotted) and identified through field observation, the majority of the species were identified by local residents from recent sightings (reported). Among the reptilian species identified, *Ophiophagus hannah* (Rulngan) and *Python bivittatus* (Saphai) are vulnerable under the IUCN Red List. Among the mammalian species, *Nemorhaedus goral* (Sathar) and *Macaca assamensis* (Zawng) are nearly threatened, *Ursus thibetanus* (Savawm) is vulnerable and *Cuon alpines* (Chinghnia) is endangered under the IUCN Red List. Table 4.13 shows details including the scientific name, local name, family, order, IUCN red list category and field observation of the faunal species observed and identified in the study area. Figure 4.21 depicts the different faunal species under the IUCN Red List Category.

Table 4.13. Faunal composition of the study area.

Sl. No	Scientific Name	Local Name	Family	Order	IUCN Category	Field observation
(a) Birds						
1	*Pitta sordida*	Buarchawm	Pittidae	Passeriformes	Least Concern	Spotted
2	*Emberiza pusilla*	Ram Chawng-zawng	Emberizidae	Passeriformes	Least Concern	Spotted
3	*Chalcophaps indica*	Ramparva	Columbidae	Columbiformes	Least Concern	Reported
4	*Gallus gallus*	Ram ar	Phasianidae	Galliformes	Least Concern	Reported
5	*Pycnonotus cafer*	Tlaiberh	Pycnonotidae	Passeriformes	Least Concern	Spotted

6	*Strix leptogramnica*	Chingpirinu	Strigidae	Strigiformes	Least Concern	Reported
7	*Clamentor coromandus*	Lalruanga-sehnawt	Cuculidae	Cuculiformes	Least Concern	Reported
8	*Chloropsis cochinchinensis*	Chhawlhring	Irenidae	Passeriformes	Least Concern	Spotted
9	*Psittacula finschii*	Vaki	Psittacidae	Passeriformes	Least Concern	Reported
10	*Falco tinnunculus*	Mute	Falconidae	Falconiformes	Least Concern	Spotted in Mualkawi area
11	*Macropygia unchall*	Mimsirikut	Columbidae	Columbiformes	Least Concern	Reported
12	*Lophura leucomelanos*	Vahrit	Phasianidae	Galliformes	Least Concern	Reported
13	*Streptopelia chinensis*	Thuro	Columbidae	Columbiformes	Least Concern	Reported
14	*Megalaima virens*	Tawllawt	Megalaimidae	Piciformes	Least Concern	Reported
15	*Pycnonotus melanicterus*	Tukhumvilik	Pycnonotidae	Passeriformes	Least Concern	Spotted
16	*Lonchura striata*	Pit te	Estrildidae	Passeriformes	Least Concern	Reported
17	*Duculabadia*	Bullut	Columbidae	Columbiformes	Least Concern	Reported
18	*Megalaimaasiatica*	Tuklo	Capitonidae	Piciformes	Least Concern	Reported
19	*Spizaetus Cirrhatus*	Muarla	Accipitridae	Accipitriformes	Least Concern	Spotted in Mualkawi area
20	*Turnix spp.*	Vahmim	Turnicidae	Charadriiformes	Least Concern	Reported
21	*Glaucidium cuculoides*	Chhimbuk te	Strigidae	Strigiformes	Least Concern	Reported
(b) Reptiles						
1	*Calotes versicolor*	Laikingawr-sen	Agamidae	Squamata	Not assessed	Spotted

2	*Calotes emma*	Laikingkinei	Agamidae	Squamata	Not assessed	Spotted
3	*Varanus spp.*	Tangkeu	Varanidae	Squamata	Least Concern	Reported
4	*Trimeresurus medoensis*	Rultuha	Viperidae	Squamata	Data deficient	Reported
5	*Ophiophagus Hannah*	Rulngan	Elapidae	Squamata	Vulnerable	Reported
6	*Python bivittatus*	Saphai	Pythonidae	Squamata	Vulnerable	Reported
7	*Varanus bengalensis*	Tangkawng	Varanidae	Squamata	Least Concern	Reported
(c) Mammals						
1	*Muntiacus vaginalis*	Sakhi	Cervidae	Artiodactyla	Least Concern	Reported
2	*Hystrix hodgsoni*	Sakuh	Hystricidae	Rodentia	Least Concern	Reported
3	*Prionailurus bengalensis*	Sanghar	Felidae	Carnivora	Least Concern	Reported
4	*Paradoxurus hermaphroditus*	Sazaw	Viverridae	Carnivora	Least Concern	Reported
5	*Canis aureus*	Sihal	Canidae	Carnivora	Least Concern	Reported
6	*Dremomys lokriah*	Thehlei	Sciuridae	Rodentia	Least Concern	Spotted
7	*Sus scrofa*	Sanghal	Suidae	Artiodactyla	Least Concern	Reported
8	*Nemorhaedus evansi*	Sathar	Bovidae	Cetartiodactyla	Nearly Threatened	Reported
9	*Macaca assamensis*	Zawng	Cercopithe-cidae	Primates	Nearly Threatened	Reported
10	*Ursus thibetanus*	Savawm	Ursidae	Carnivora	Vulnerable	Reported
11	*Cuon alpinus*	Chinghnia	Canidae	Carnivora	Endangered	Reported

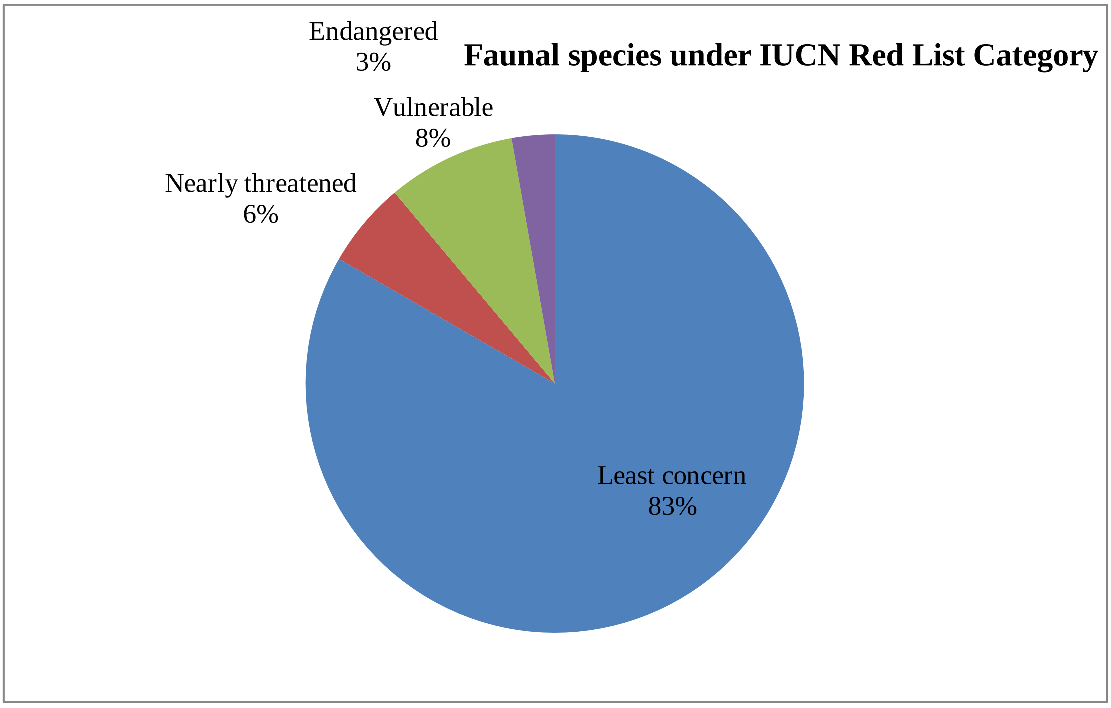

Figure 4.21. Faunal species under IUCN red list category.

4.4.3 Comparison of biodiversity with baseline data from pre-construction phase 2014

The results generated from the present study are compared with the baseline data of Pre-Construction Phase – "Environmental Impact Assessment Report of Widening to 2-Lane, Re-Alignment and Geometric Improvement of Champhai-Zokhawthar Road (00.000 km To 27.247 km) within Mizoram State Roads Project II dated 16 February 2014 STUP Consultants Pvt."

Floral diversity

The floral diversity comparison between pre-construction phase and construction phase are shown in Table 4.14.

Table 4.14. Comparison of floral diversity between pre-construction and construction phases.

Parameters	**Pre-construction phase**	**Construction phase**
(a) Tree Species		
Number of species identified	20	37
Number of family identified	15	23
IVI value range	7.78 – 26.15	2.04 – 33.38
Most dominant species	*Duabanga grandiflora*(Zuang)	*Castanopsis tribuloides* (Thingsia)
Most dominant family	Euphorbiaceae	Fagaceae
(b) Shrub Species		
Number of species identified	17	19
Number of family identified	10	23
IVI value range	7.98 – 38.96	4.07 – 33.71
Most dominant species	*Saccharum longisetosum* (Luang)	*Saccharum longisetosum* (Luang)
Most dominant family	Poaceae	Poaceae
(c) Herb Species		
Number of species identified	29	22
Number of family identified	20	12
IVI value range	3.02 – 20.09	3.30 – 28.96
Most dominant species	*Mikania micrantha*(Japan hlo)	*Ageratum conyzoides* (Vailenhlo)
Most dominant family	Asteraceae	Asteraceae

Faunal diversity

The faunal diversity comparison between pre-construction phase and construction phase are shown in Table 4.15.

Table 4.15. Comparison of faunal diversity between pre-construction and construction phases.

Parameters	**Pre-construction phase**	**Construction phase**
(a) Birds		
Number of species identified	8	21
Number of family identified	8	14
Number of order identified	4	9
Most dominant family	Columbidae, Pycnonotidae, Psitticulidae, Falconidae, Megalaimidae, Capitonidae, Dicruridae,Phylloscopidae.	Columbidae
Most dominant order	Passeriformes	Passeriformes
(b) Reptiles		
Number of species identified	1	7
Number of family identified	1	5
Number of order identified	1	1
Most dominant family	Agamidae	Agamidae and Varanidae
Most dominant order	Squamata	Squamata
(c) Mammals		
Number of species identified	3	11
Number of family identified	3	10
Number of order identified	2	5
Most dominant family	Felidae, Viverridae, Sciuridae	Canidae
Most dominant order	Carnivora	Carnivora

4.5 Socio-economic status of major villages along Champhai - Zokhawthar road project

4.5.1 Overview

There are three major villages along the Champhai-Zokhawthar road project. Among these villages, Zokhawthar has the highest population with 2632 inhabitants, followed by Mualkawi with 664 inhabitants and Melbuk with 553 inhabitants. Each village is governed by Village council/Panchayat. More than 60% of families in these villages are farmers and dependent on jhum farming, the remaining families are engaged in Govt. services and small scale businesses. With regards to local institutional level, there are three Govt. Primary schools (one in each village), three Govt. Middle School (one in each village) and one Govt. Secondary school (Melbuk). There are no higher education institutions in these villages and setting up of at least a Higher Secondary School is in great need. However, all three villages have access to public libraries which provides great educational services for the villagers. Power supply (electricity) is available in all three villages. There are three welfare/Health Centres. Among these two are located in Melbuk and one in Zokhawthar village. Apart from district roads, national highways as well as state highways pass through the villages.

General information on major villages that the proposed road passes through is given in Table 4.16.

Table 4.16. Information on Zokhawthar, Mualkawi and Melbuk villages.

Village Name	**Zokhawthar**	**Mualkawi**	**Melbuk (Khawnuam)**
District Name	Champhai	Champhai	Champhai
Sub-District Name	Khawzawl	Khawzawl	Khawzawl
Total Households	501	128	123
Total Population of Village	2632	664	553
Total Male Population of Village	1299	335	268
Total Female Population of Village	1333	329	265

Power Supply For Domestic Use per year(in Hours)	44	40	40
All Weather Road	Available	nil	nil
National Highway	Nil	nil	available
State Highway	Available	available	nil
Major District Road	Nil	available	nil
Post Office	Available	nil	available
No. of schools (Pre-primary to Senior secondary)	8	2	5
Welfare & Health Centres	1	0	2

Source: District Census Handbook of Champhai (2011)

4.5.2 Agriculture and Livestock

Majority of the inhabitants in these villages depend on agriculture and related activities connected to land use. The vegetables are grown using seeds produced from previous season as well as seeds and seedlings supplied by concerned Govt. Departments. The cropping pattern in the region is characterized by predominance of rice and ginger. Many types of vegetables are also grown, which provides a major income source for many villagers and contributes to the economic development of the villages. However, these agricultural crops are not grown in large scale and are not traded extensively. These agricultural crops include *Allium hookeri, Colocasia esculenta, Cucumis sativas, Manihot esculenta, Trichosanthes anguina, Zea mays, Zingiber officinale, Lycopersicon lycopersicum, Vigna unguiculata, etc.*

The region is quite rich in diversity of different agricultural and horticulture crops although climatic conditions are quite extreme especially in winter season. These crops are usually readily available and cheap, and hold great potential for increase in productivity. Village councils as well as Government departments should take initiatives to help farmers increase their crop productivity rate, acquire land for farming and provide market access through networking and supply. To ensure and cater to better economic returns from these crops, installation of processing units would serve a great purpose in production as well as distribution.

Regarding livestock, animal rearing in these villages is dominated by piggery and poultry, however large scale animal husbandry is not carried out in these villages. Veterinary services are not available in the region and setting up of at least a veterinary dispensary is in great need.

4.5.3 Timber and fuelwood

The majority of houses in the region are wooden and tile based houses with either thatched or tin roofs. Concrete buildings are also available but are less in number. Construction of wooden houses and their regular maintenance consume timber. These timber species include *Bombax insigne, Duabanga grandiflora, Michelia champaca, Phoebe lanceolata, Gmelinia arborea, Albizzia chinensis, Schima wallichii, Castanopsis tribuloides, Macaranga indica, Quercus griffithii* etc.

Although a majority of the households have LPG connections, consumption of fuelwood for cooking purposes is still very common in the region. Large amount of fuelwood are also utilized for making charcoal which are then sold locally and also to nearby villages, and contributes to their income. These fuelwood species include *Lithocarpus dealbata, Gmelinia arborea, Anogeissus acuminate, Schima wallichii, Albizzia chinensis, Callicarpa arborea, Wendlandia grandis, Quercus leucotrichophora, Macaranga indica, Wendlandia grandis* etc.

CHAPTER – 5

DISCUSSION

The present study has revealed in a number of ways the consequences of road construction and its impact on the environment. Roads are an integral part of the transport system and play an important role in the socio-economic growth of a community, state or nation. Although they will yield positive impacts with respect to social and economic development, their negative impacts are neglected and underestimated in respect to its environmental strain. Alteration of landscapes and topography of the study area, degradation to air quality, water quality as well as noise quality are evident from the results obtained. Although environmental degradations are bound to occur during construction work, taking in to account the baseline environmental condition of the area, the level of degradation caused over a span of few years is notable. The Champhai – Zokhawthar road, in the near future will be an important gateway for trade and tourism for the country, therefore it is mandatory to uphold and conserve the environmental stability of the area.

The Champhai – Zokhawthar road after completion will provide a better and faster transport of vehicular traffic which will all be in favour of the residents of areas along the road and of the state of Mizoram in general. Banzal and Sal (2013) conducted a study on the EIA process of NH-200 which is 126.525 km linear road and stated the benefits of better roads including faster and safer connectivity; employment opportunity to people; development of tourism and pilgrimage; reduction in accidents; better approach to medical and educational services; improved quality of life for people etc. A study conducted by Bardecki (2009) on impact of road construction in Nepal has also mentioned the direct and indirect commercial benefits which will immensely contribute to the commercial sector of the country. For a backward and poor North-Eastern state such as Mizoram, the people as well as the government yearn for such benefits and opportunities. Meanwhile such studies conducted by Walia *et al.*, (2017) which highlights the widespread impact of highway construction on the environment, expresses the negative view of such construction projects and forces the people to re-think or re-consider our decisions to conduct such detrimental projects. The issue of developmental activities and environmental conservation remains paradoxical; and although environmental concerns are viewed as a socio-economic barrier, the multiple impacts of developmental activities on environment determine otherwise. This heeds the importance of environmental assessment models and sustainable projects as project related pollutions are perceived as the most disturbing adverse impacts of construction activities (Celik and Budayan, 2016). Therefore roads affect both the biotic and the abiotic components of landscapes as it causes change in dynamics of populations of plants and animals, altering landscape, introducing exotic and alien elements, and changing levels of available resources, such as water, light and nutrients (Coffin, 2007).

The air quality parameters measured for the present study were below the permissible limits set by NAAQS 1994 and 2009 (Appendix II); however comparing the before and after scenario of air quality, the concentrations increased a considerable amount therefore will likely cause more damage to human health, society and the overall environment. According to the study conducted by Mao *et al.*, (2017), damage to environment and society is attributable to:

(i) Damage to air quality - increase in particulate concentration (PM2.5 and PM10) and decrease in atmospheric visibility.

(ii) Damage to climate - the higher the PM10 concentration, the greater UV radiation reduction.

(iii) Damage to ecology – high dust concentration leads to masking, blocking, heating of vegetation.

(iv) Damage to nearby architecture and vehicles- dust retention effects causes the damage physical and chemical damage to architecture and vehicles as well as economic loss.

(v) Damage to the health of construction workers - death, chronic pulmonary diseases, cardiovascular diseases, cerebro-vascular disease and acute infection.

(vi) Damage to the health of nearby residents – Particulates smaller than 10μm is direct cause of damage to health of nearby residents entering human system through the skin, the digestive tract or respiratory tract.

Dust generation is probably the most common effect of construction activities mainly due to extensive earthworks involved. The present study also involves these activities which lead to excessive increase in SPM and RSPM concentrations in the area. Similarly, Font *et al.,* (2014) conducted a study on re-development of Thames Road in London and quantified the impact of air pollutants – PM 10, PM 2.5, NO_x and NO_2. The study compared the before (2004 - 2005) and after (2007 - 2008) scenario of the road project in order to calculate the pollution concentration increment of the road construction works. The PM10 concentration increased up to ~15 µg/m^3, however PM 2.5, NO_x and NO_2 concentration increase was found to be negligible. Also, Reid *et al.,* (2010) conducted a study on the particulate emissions from State Road -92 widening project in Southern Arizona between 2009 and 2010. The results revealed that PM10, PM 2.5, CO and NO_2 concentrations did not exceed the NAAQ Standards however 24 hr case study carried out in April and May 2009 showed high PM 10 concentration (29 - 72 µg/m^3) although PM 2.5 and NO_2 concentrations remained relatively consistent. Air pollutant concentrations were highest during excavation works and PM10/PM2.5 emissions were attributable to trucks, tractors, excavators and other heavy machinery. A study conducted by Amin *et al.,* (2017) on Highway 25 in Montreal concluded that air pollution increased with additional traffic congestion during and after road construction; which ultimately cements the requirement of effective environmental impact assessment before and during the road construction. In addition, roads also affect patterns of wind direction and speed, temperature, relative humidity and insolation (Coffin, 2007). Roadsides tend to get windier and more turbulent, dryer and sunnier.

Water sources along roads or road construction sites are susceptible to pollution mainly through sedimentation. Forests are often the originating sources of water for rural as well as urban areas and damage to forests is likely to have an effect on the water availability of the area (Boston, 2016). Excess soil dumping and debris slides are the main sources of water pollution observed during the present study. Also, the impact of road on environment is also largely related to its use – density of the road network, the volume of traffic on a road, the road's location and topography play major roles in the intensity of associated environmental effects of roads (Anon., 2005b). Moreover, after the Champhai - Zokhawthar road construction is completed, it will provide smoother and faster transport which will lead to increase in spills and wastes generated during vehicle use, littering etc. Roads being impervious, runoff containing pollutants from the road and the vehicles on it enters nearby water sources. Water flora and fauna are then affected causing various toxicological impacts.

The water quality assessment carried out at two water sources during the present study showed that concentrations of all 9 parameters studied were below permissible limits for Drinking Water Quality Standards (Appendix VI) and Inland Surface Water Quality Standards (Appendix VII) set by various institutions/organizations, except for turbidity. The high concentration of turbidity is attributable to sedimentation, soil dumping and soil debris on water sources. Chen *et al.,* (2009) conducted a study on the effects of highway construction on stream water quality and tested the before and after effects of such highway construction. The study revealed that the highway construction had impacts on turbidity and TSS at the downstream sites during construction. High total iron content was also observed at the downstream sites during construction. A similar study by Extence (1978) also found high values of total iron at the downstream site of a motorway construction in the Great Britain. High concentrations of chloride were most attributed to construction activities. The total chloride and iron content concentrations during the present study were 6.2 mg/l and 0.16 mg/l respectively. Shyu *et al.,* (2012) in their study on the effect of constructing a tunnel on the water quality of reservoir watershed in Taiwan concluded that the construction activities caused prolonged degradation in water quality in such a way that the reservoir will require at least 10 years recovering period. A study conducted by Chen *et al.*, (2009) on the effects of highway construction on water quality observed impacts on turbidity, total suspended solids, and total iron during construction as well as statistically significant impacts on macro-invertebrates.

Impacts of noise from road traffic and vehicle movement on humans and wildlife is well documented, however research on impact of noise on humans and wildlife from road construction activities is quite rare. However their effects on humans and wildlife is generally similar, if not more in construction activities as there is more heavy machinery involved. Since noise pollution usually do not cause direct impacts or losses, but rather indirect impacts causing problems and complications in humans and wildlife over a period of time, it is difficult to express its health effects as well as economic loss in a short period of time (Jacyna *et al.*, 2017). Still, exposure to high noise levels causes humans and animals to experience a wide range of problems as a result of this exposure which demands better and improved ways to prevent, mitigate, or compensate for its effects. With improved construction mechanism adopted by project proponents through EIA, noise pollution in highway constructions is unavoidable and affects the work and life of labour as well as nearby residents (Jiao *et. al.*, 2015).

The noise assessment conducted at the three sites in the present study revealed that noise levels are extremely high during the construction period and exceeded the permissible limits set by Noise Pollution (Regulation and Control) Rules 2000 (Appendix XI). Such high levels are attributable to traffic as well as operations of heavy machineries. Tsunokawa and Hoban (1997) listed the main noise sources from road as vehicle noise and its construction and maintenance works - vehicle noise comes from the engine, transmission, exhaust, and suspension; poor vehicle maintenance and use of old vehicles is a contributing factor to this noise source. Xiao *et al.*, (2016) conducted a health noise assessment of construction noises in Beijing using a quantitative model which assesses noise-induced health impairments - cardiovascular disease, cognitive impairment, sleep disturbance, and annoyance using disability-adjusted life years (DALYs) as an indicator of damage.

Their results indicate that construction noise could bring significant health risks to the neighbouring resident community, with an estimated 34.51 DALYs of health damage and 20.47 million yuan (2.89 million dollars approx.) in social costs. In particular, people aged 45–54 are most vulnerable to construction noise, with the greatest health risks being caused by sleep disturbance.

The most significantly impacted by road noise are birds as they are the species that incorporate sound into their basic behavior. They are affected by high noise levels and different species of birds are found in the Champhai – Zokhawthar area. A study conducted by Reijnen and Foppen (1994) found that out of 43 species of deciduous and coniferous woodland breeding birds, 26 species (60%) showed reduced densities near highways. Similarly, Bottalico *et al.*, (2015) studied the effects of noise generated by construction activities on birds and concluded that masking of communication signals of birds occurs a few distance from the construction site which has physiological and behavioural effects on birds. Birds also tend to leave areas where noise levels are high due to masking of their communication signals which leads to decline in bird population and density. In addition, Coffin (2007) noted that the patterns of noise produced by traffic fluctuate in time which may have varying effect of road noise on animals as determined by time of day or season of the year, depending on the daily and life cycle patterns of that particular animal.

Road construction affects biodiversity in general. Alterations in landscape and topography lead to variations in faunal and floral composition and pattern which affects the overall stability of the area. Royal Town Planning Institute/RTPI (1999) quotes *'A crucial test of the health of a local environment is whether the wildlife community that is present fully reflects the animal and plant communities normally associated with the habitat in that area. In this way, biodiversity is one of the most important indicators of the state of our environment'.* This implies that conservation of biodiversity is an essential element of sustainable development and therefore should be considered explicitly in EIA's. However, Byron (2000) stated that impacts on biodiversity in road EIAs are covered minimally and prove to be insignificant in representing the road construction impacts. The weaknesses of EIAs in covering impacts on biodiversity include overall consideration of different species of flora and fauna, consideration of all levels of biodiversity, consideration of structural/functional relationships, etc. Roads lead to the loss of biological diversity however its effects are not analysed in a wider context. There are many materials and literatures available on roadkill and habitat fragmentation; however materials and literatures on the long term effects on the population dynamics of the concerned species are less and many research may have not been done. Road construction as well as traffic generates dust which affects vegetation by covering surfaces and affecting photosynthesis, respiration and transpiration thereby resulting in injury and decreased productivity (Farmer, 1993). Dust also provides adsorption surfaces for volatile contaminants that are subsequently deposited on plant surfaces causing phytotoxic pollutants to enter plant tissues, and causing respiratory ailments in animals and humans.

Spellerberg and Morission (1998) listed effects of road construction which are relevant and observed during the present study.

Effects during construction

- During road construction there is loss of habitat and biota.
- Additional effects result from the supporting activities for construction.
- There are impacts which occur beyond the immediate vicinity of the road such as changes in hydrology.

Short term effects

- The mortality of plants has direct and secondary effects on other organisms.
- Some fauna will move from the area of the road as a result of habitat loss and physical disturbance.
- Animals may be killed on the road.

Long term effects

- There is a change in the biological communities which extends for varying distances from the road edge.
- There is fragmentation of habitat and this in turn has implications for habitat damage and loss, for dispersal and mobility of organisms, and for isolation of populations.
- Run-off from the roads may affect aquatic communities.
- Emissions, litter, noise and other physical disturbances may extend into the roadside vegetation for varying distances and results in changes in species composition.
- Roads may act as barriers limiting dispersal and mobility.

During the present study, the floral diversity and faunal diversity were found to be more widespread and increased in the construction phase than the pre-construction phase. The reasons for the difference in floral and faunal diversity between pre-construction and construction phase maybe attributable to minimal assessment during pre-construction phase. Tarvirdizadeh *et al.,* (2014) assessed a forest road impact on the diversity and the composition of herbaceous plant communities in the forest road margins and found that the average cover of herbaceous species on the cut and fill slopes was significantly higher than that inside the forest and that of the roadsides. There were also more invasive species which altered the composition of the herbaceous cover and increased the richness of species on cut and fill slopes. Similarly, Li *et al.,* (2014) studied the ecological effects of plant diversity on asphalt road and earth road in coastal wetland in the Yellow River Delta during plant bloom phase of July and August 2012 and found that the plant diversities and alien plants were high in the range of 0–20m to the road verge. More alien or exotic species were spotted on asphalt roadside that earth roadside. There were more common species in the asphalt roadsides than that in the earth roadsides. Their results thus indicated that the construction and maintenance of roads could increase the plant species diversities of communities and risk of alien species invasion. In their study on plant invasive species of Central India, Sharma and Raghubanshi (2009) stated that roadsides provide suitable conditions for the establishment and growth of non-native species due to rapid anthropogenic developments. A total of 55 non-native plant species were identified out of total 71 species recorded during their study. Zeng *et al.*, (2010) also studied the effects of road disturbance on plant diversity by examining the spatio-temporal distribution pattern of plant species richness, diversity and composition along roadside and found that roads act as dispersal conduits and led to increase in occurrence probability of new settlers to a new area. Alien species, non- halophyte and halophyte species, threatened and cosmopolitic species, were found prosperous at roadside.

CHAPTER – 6

SUMMARY AND CONCLUSIONS

The increase in human population has caused limitations and constraints on basic human needs and amenities which ultimately halts developmental advancements in a number of ways. However, with the 7.8 billion humans on Earth, immediate resolution to resolve the increasing poverty rate requires attention. Road construction and upgradation of existing roads enhances mobility, causes exposure from isolation and therefore reduces poverty. The Champhai-Zokhawthar road construction is a pivotal project which is expected to increase access to social services, economic opportunity and accessibility of trade with countries neighboring India in the East and states neighboring Mizoram. Mizoram being a state which solely depends on roads for transportation will greatly benefit from this road improvement plan, however road construction and its related activities tend to generate many environmental impacts - raw materials consumption, air pollution, water pollution, soil pollution and noise pollution (Seiler, 2001) and the present study of Champhai – Zokhawthar road construction is no different.

The effects of road construction projects are widespread and detrimental to the environment. Large forest areas are destroyed which not only results in economic losses, but changes the conditions of the environment (Caliskan, 2013). Road construction activities require careful execution by considering economical, environmental and social requirements (Ozturk *et al.*, 2009). Therefore, awareness on these negative impacts needs to be focused on with proper and effective mitigation measures before decision-making is done in any road construction project. As a means to check the level of environment degradation and depletion of natural resources, Environmental Impact Assessment (EIA) provides a systematic evaluation of the environmental effects caused by developmental projects including road constructions. EIA as a mandatory regulatory procedure originated in the early 1970s, with the implementation of the National Environment Policy Act (NEPA) in the United States of America (Singh, 2007). The foundation of EIA in India was laid in 1976-77 and formalized when Government of India enacted the Environment (Protection) Act on 23rd May 1986 (Mukherjee, 2012). In this present study, the environmental impacts of road construction on air quality, water quality, noise quality and vegetation are assessed to highlight the extent of its impact on the environmental condition of areas situated along the road project.

The present study was conducted during April 2016 to May 2018. Ambient air quality was monitored at Zokhawthar village from September 2016 to August 2018 taken quarterly at 3 months interval by setting up a High Volume Air Sampler, Envirotech Model APM 460 BL. 'Handbook of Methods in Environmental Studies: Air, Noise, Soil and Overburden Analysis' (Maiti, 2003) and 'Manual on Environmental Analysis' (Aery, 2010) were mainly used for analysis of air quality parameters. Water samples were collected from two sampling sites i.e. Mualkawi rivulet and Tiau River from June 2016 to May 2018 quarterly for water quality analysis. 'Handbook of Methods in Environmental Studies, Water and Wastewater Analysis' (Maiti, 2004) and Standard Methods for the Examination of Water and Wastewater (APHA, 2005) were used for analysis of various physico-chemical parameters. Noise sampling was carried out at three sites i.e. Zotlang (Residential), Tarmat Base Camp (Residential area) and Zokhawthar (Residential area) from June 2016 to May 2018. The instrument used for sampling was Lutron SL-4001. Biodiversity assessment was conducted by assessing floral diversity and faunal diversity along the road project.

Validation and significance of the results was checked by performing statistical data analysis using MS Excel and SPSS software. To highlight the extent of the environmental impact of the road construction, the results generated from the analysis of air, water, noise and biodiversity during Construction Phase are statistically compared with the baseline data of Pre-Construction Phase provided through available literature/secondary information – Environmental Impact Assessment Report of Widening To 2-Lane, Re-Alignment And Geometric Improvement Of Champhai-Zokhawthar Road (00.000 Km To 27.247 Km) within Mizoram State Roads Project II dated 16 February 2014 STUP Consultants Pvt.

The results and observations of the study can be summarized as:

1. The analysis of variance (ANOVA) for air quality showed that there was no significant variation in air quality between the seasons during the study period – 0.960 (at 5%). The parameters measured and their overall mean concentrations were suspended particulate matter (SPM) - 118.32 $\mu g/m^3$, respirable suspended particulate matter (RSPM) - 50.17$\mu g/m^3$, nitrogen dioxide (NO_2) - 18.58 $\mu g/m^3$ and sulphur dioxide (SO_2) - 5.76 $\mu g/m^3$. The concentrations of parameters measured in all seasons were compared with the permissible limits set by Central Pollution Control Board - (NAAQS, 1994 and 2009) and were well below the prescribed limits.

2. The concentration of SPM, RSPM, NO_2 and SO_2 peaked during the dry seasons and showed lesser concentration during monsoon period. The study site is dry during autumn and winter seasons, and due to un-metalled roads, there were heavy dust movements. Road construction activities of slope cutting and dumping of soil in nearby areas contributed immensely to the increase in concentration during the dry period. The concentration of parameters measured was relatively lesser during monsoon period due to rains and irregularity in road construction activities.
3. Comparing the results of air quality between the pre-construction phase and construction phase, analysis of variance (ANOVA) shows the significant difference of means as 0.758 (at 5%). Although there were no significant changes, the overall mean values indicate that concentration of the parameters have increased. From the study, it was observed that due to heavy dust movements in and around the village, residents wear masks and sprinkle water around the premises of their homes as a precautionary measure. There were also reports of increase in respiratory problems during dry seasons. Comparing the overall mean NO_2 and SO_2 concentration during the pre-construction phase and construction phase, the increase in concentration is negligible and the values recorded are all below National Ambient Air Quality Standards prescribed limit.

4. For Mualkawi Rivulet, ANOVA showed that there was no significant variation between the seasons during the study period – 0.512 (at 5%) and for Tiau river, ANOVA also revealed that there was no significant variation between the seasons during the study period – 0.969 (at 5%). The parameters measured for both Mualkawi Rivulet and Tiau River are pH, temperature, turbidity, electrical conductivity, total dissolved solids, total hardness, total alkalinity, total chloride and total iron. Results reveal that all values recorded are below the permissible limits except for turbidity. Turbidity values exceeded the permissible limits for almost every season which indicates that road construction activities especially slope cutting and soil dumping has led to a peak rise in turbidity value of water bodies.
5. Since there were no records of water sampling done at Mualkawi rivulet and Tiau river for pre-construction phase, the present study, therefore forms a baseline data for water quality at Mualkawi Rivulet and Tiau River. The Environmental Impact Assessment Report of Champhai – Zokhawthar Road Construction dated 16th February 2014 has identified ponds, streams, nallahs and rivulets along the project corridor, however there were no sampling done for these water bodies. However, groundwater sources were identified at Zotlang, Melbuk and Zokhawthar for which water quality assessment was carried out.
6. ANOVA for noise quality showed that there was no significant variation in noise quality between the seasons during the study period – 0.956 (at 5%). The mean noise level at Zotlang, Melbuk and Zokhawthar were 70.28 dB (A), 72.06 dB (A) and 60.98 dB (A) respectively. The mean noise levels at the three study sites exceeded the permissible limits as per the Noise Pollution (Regulation and Control) Rules 2000 except for Zokhawthar site during summer seasons (March - May) 2017 - 2018 and in monsoon season (June - Aug) 2017.

7. Comparing the noise levels between the pre-construction phase and construction phase, analysis of variance (ANOVA) shows the significant difference of means as 0.159 (at 5%). However, the overall mean noise level

at Zotlang and Melbuk areas during construction phase is much higher in comparison to noise level during pre-construction phase. Zotlang is a residential area wherein the diversion road cuts through the locality and noise is mainly detected from vehicles passing through the area as well heavy machinery operating in the area. The Contractor's base camp is located at Melbuk area and heavy machinery were continuously in operation during study period. However, the mean noise level at Zokhawthar during construction phase is lower compared to the noise level during pre-construction phase which may be due to the fact that construction work/activities were inconsistent during study period and there was a halt in construction during rainy seasons.

8. Biodiversity assessment was conducted along the road project and the elevation of the study area ranges from 1140msl – 1322msl. In floral diversity assessment, a total of 37 families, 65 genera and 77 species were identified. IVI calculations showed the occurrence of 37 tree species, 19 shrub species and 22 herb species. The most dominant tree, shrub and herb are *Castanopsis tribuloides* (Thingsia), *Saccharum longisetosum* (Luang) and *Ageratum conyzoides* (Vailenhlo) respectively. Biodiversity indices were also calculated and revealed that species richness of flora was highest in trees (14.91), species diversity also exhibited highest value in trees (2.96), individual number of species was most evenly distributed in trees (0.82) whereas the dominance index was highest in herbs. In faunal diversity assessment, a total of 21 species of birds, 7 species of reptiles and 11 species of mammals were identified. Faunal species such as *Ophiophagus hannah* (Rulngan), *Python bivittatus* (Saphai) *and Ursus thibetanus* (Savawm) were identified which belonged to vulnerable category under the IUCN Red List. *Nemorhaedus goral* (Sathar) and *Macaca assamensis* (Zawng) are nearly threatened category and *Cuon alpines* (Chinghnia) is endangered under the IUCN Red List.
9. Comparing the biodiversity assessment done in the pre-construction phase and construction phase, it is evident that there has been change in landscape as well as floral and faunal composition.

The study of the impact assessment of Champhai-Zokhawthar road has revealed that alterations in the quality of the environment occurs both seasonally and phase-wise. Ambient air quality parameters have shown increase in air pollution over the course of three years; mean noise levels have also increased during the construction phase; there has also been a considerable change in the tree species composition and habitat. Although there were no baseline data for water quality at Mualkawi Rivulet and Tiau River for comparison, the levels of turbidity at both water sources show that road construction activities are detrimental to quality of the water bodies. Changes in environmental quality of an area is evident and bound to occur with such construction activities as it involves alteration of the landscape, topography and use of heavy machineries; however execution and monitoring of construction work can be improved. There might be cases wherein pollution caused are inevitable however with better planning and proper execution of the work carried out, such pollution can be curbed. Water bodies located along the road project provide an important source of water usage for the community, however there were no measures taken for its conservation; excess soil dumping directly and indirectly from slope cutting and other activities were observed during the study period. Any form of noise cancelling earplugs should have been worn by workers as they were exposed to high noise levels for long durations from operating heavy machines. There should also have been a number of dumping sites for excess soil situated along the road project so that unnecessary sedimentation of soil does not occur. Therefore, the present study indicates the range of effects of road construction activities but the extent or magnitude of such effects still require more research till post construction phase and commission of the project work itself. Still, the study can provide guidance for better design of environmental impact assessments for new road projects.

Furthermore, suitable alternatives have been developed and adopted in various countries that can considerably lower the environmental impacts of road constructions. Indian Roads Congress (IRC) and Central Road Research Institute (CRRI) have developed guidelines and technologies that are well-adapted to all regions of India and are at the same time eco-friendly. Central Road Research Institute (CSIR-CRRI) which is a leading national research organization in road and transport planning, has formulated a new road construction technology termed as

CRRI-Bitchem cold mix which assumes zero pollution as it does not require heating as the name suggest. CRRI-Bitchem cold mix is an energy efficient and eco-friendly method of road construction which helps in mitigating carbon footprint and prevents adverse effects on health of workers. This new technology is a 100% mainstream technology and can be adopted in all types of projects; it has a 50% higher surface life than the conventional hot mix technology as it contains anti-stripping agents and provides 200% faster progress per day; it is also 90% energy efficient saving 1500 L of fuel per km of construction which is equivalent to 4000 kg of CO_2 emission per km. A sample study conducted by CSIR-NEIST observed that the cold mix technology can be executed throughout the year permitting all weather construction whether rainy season and/or cold winters, except during times of inclement weather. This is an ideal solution to solve the problems of road connectivity in India especially so in hilly areas where factors like heavy rain and rough terrain often delay the construction and maintenance process of roads. AppaRoa et al. (2013) stated that as hot mix technology involves the use of fossil fuels, one tone of hot mix asphalt will produce about 5.25 kg of carbon. Their study concluded that the environmental footprint of cold mix technology or microsurfacing is considerably less and recycling of pavements is an efficient solution for construction and maintenance of roads as it offers enormous benefits like cost savings, preservation of materials and preservation of environment.

In Mizoram, initiatives have been taken by State PWD to encourage and implement the use of cold mix technology. Sensitization workshops have also been jointly organized by CSIR-CRRI and Mizoram PWD to highlight the advantages of cold mix technology especially for regions such as Mizoram where monsoon seasons are usually long. Currently as per State PWD records, cold mix technology has been executed in three PMGSY road construction viz., Khawlailung - Piler road (4.16 km), Chekkawn - Sialsir road (6.24 km) and Thentlang – Sialhau road (19.54 km) under Serchhip district of Mizoram. The road projects are under progress and expected to be completed within 24 months.

Relating to eco-friendly approach to road constructions, the Save Chite Lui Coordination Committee (committee/body constituted under Chite Lui Act, 2018 for prevention and control of water pollution in Chite river) and Mizoram Public Works

Department, Govt. of Mizoram in 2018 collaborated in constructing the first known ”Green Road” in Mizoram. The road construction was carried out as per guidelines made by Indian Roads Congress in 2013 termed as “Guidelines for the Use of Waste Plastic in Hot Bituminous Mixes (dry process) in Wearing Courses”. Plastic wastes collected and salvaged from the Chite River which is located in the heart of Aizawl City were recycled (cleaning and shredding). These recycled plastic wastes were then mixed with hot aggregates and bitumen in the mixing plant.

According to laboratory as well as field studies and investigations, these green roads have higher resistance to deformation and water induced damages; improved road stability and strength. Primarily and most importantly, these roads provide a safe and efficient method of waste plastic disposal. The Green road is located at Reiek village just on the outskirts of Aizawl City. It measures 0.800 km in length and 5.50 m in width. The road is under the maintenance of PWD - Aizawl Road South Division, Govt. of Mizoram. This Green Road being a first in Mizoram is an important stepping stone for a much larger and more advanced construction of green highways in Mizoram. Although the road stretch is less than one kilometer, it has paved an important milestone for Mizoram in implementing eco-friendly and green roads/highways.

Furthermore, with the launch of Green Highways (Plantation, Transplantation, Beautification and Maintenance) Policy in 2015 by Government of India, concerned departments of the State Government have taken initiatives in line with the policy’s vision to develop and promote eco-friendly highways. Roadside plantations and avenue plantations have been carried out along various road projects in Mizoram. These plantation schemes are aimed to reduce impact of air pollution and dust by planting trees and shrubs along highways as they are natural silk for air pollutants and carbon sequencing. A key feature of the policy is that one percent of total project cost of all highway projects (about Rs.1000 crores per year) will be kept for the plantations and its maintenance, which if properly managed and administered will go a long way in environment conservation and protection.

Therefore, in conclusion, development in transport connectivity projects can boost the economy of a nation/state/community and for a state like Mizoram, the

Champhai-Zokhawthar road will pave an important gateway for formal international trade with neighboring countries. However if there is negligence of the effects of road construction on the environment with lack of effective conservation and monitoring plans, development attained would be impractical and contradict sustainable development. EIA should be conducted in all categories of any project work and monitoring must be strictly carried out during the construction phase till completion of the project work so as to ensure sustainability. Implementation of eco-friendly programmes and technologies in all levels of EIA process should be encouraged. An effective road construction project can be a catalyst for socio-economic and regional development by integrating social well-being, economic viability and environmental integrity.

APPENDICES

APPENDIX I

ANOVA results for air quality between the seasons during the assessment period (September 2016 to August 2018).

ANOVA					
Score					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5065.938	7	723.705	.269	.960
Within Groups	64590.882	24	2691.287		
Total	69656.821	31			

APPENDIX II

National Ambient Air Quality Standards vide Notification dated 11th April 1994 and National Ambient Air Quality Standards vide Notification 18th November 2009.

Sl.No	**POLLUTANTS**	**Time Weighted Average**	**CONCENTRATION in Ambient Air**	
			Industrial area	**Residential, Rural and other areas**
1	**Sulphur dioxide (SO_2)**	Annual average (AA) 24 hour	50 µg/m^3 80 µg/ m^3	50 µg/ m^3 80 µg/ m^3
2	**Nitrogen dioxide (NO_2)**	Annual average (AA) 24 h	40 µg/ m^3 80 µg/ m^3	40 µg/ m^3 80 µg/ m^3
3	**Suspended Particulate Matter (SPM)**	Annual average (AA) 24 h	360µg/ m^3 500µg/ m^3	140µg/ m^3 200µg/ m^3
4	**Respirable Particulate Matter (RPM)**	Annual average (AA) 24 h	60 µg/ m^3 100 µg/ m^3	60 µg/ m^3 100 µg/ m^3

APPENDIX III

ANOVA results for air quality assessment between pre-construction and construction phases.

ANOVA					
Score					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	216.840	1	216.840	.104	.758
Within Groups	12507.626	6	2084.604		
Total	12724.467	7			

APPENDIX IV

ANOVA results for water quality between seasons at Mualkawi rivulet during assessment period (June 2016 to May 2018).

ANOVA					
Score					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1975.794	7	282.256	.900	.512
Within Groups	20077.883	64	313.717		
Total	22053.676	71			

APPENDIX V

ANOVA results for water quality between seasons at Tiau river during assessment period (June 2016 to May 2018).

ANOVA					
Score					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4417.331	7	631.047	.253	.969
Within Groups	159528.341	64	2492.630		
Total	163945.671	71			

APPENDIX VI

Drinking Water Quality Standards as per World Health Organization (1971), U.S. Public Health Service (1962), Indian Council of Medical Research (1975) and Bureau of Indian Standards (2012).

Parameters	WHO	USPH	ICMR	BIS
pH (mg/L)	6.5-9.2	-	-	-
Temperature (°C)	-	-	-	-
Turbidity (NTU)	5	5	10	5
Electrical conductivity (mS/cm)	-	-	-	-
TDS (mg/L)	1000	500	1500	2000
Total hardness (mg/L)	500	-	600	600
Total Iron (mg/L)	1.0	0.3	1.0	-
Total Chloride (mg/L)	600	250	1000	1000
Total alkalinity (mg/L)	-	-	-	600

APPENDIX VII

Surface water quality criteria for different uses specified by Bureau of Indian Standards (IS: 2296), 1982.

Parameters	A	B	C	D	E
pH (mg/L)	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.0-8.5
Temperature (°C)	-	-	-	-	-
Turbidity (NTU)	-	-	-	-	-
Electrical conductivity (mS/cm)	-	-	-	1000	2500
TDS (mg/L)	500	-	1500	-	2100
Total hardness (mg/L)	300	-	-	-	-
Total Iron (mg/L)	0.3	-	-	0.5	-
Total Chloride (mg/L)	250	-	600	-	600
Total alkalinity (mg/L)	-	-	-	-	-

Note: *** Classes of water use:**

A: Drinking water source without conventional treatment but after disinfection

B: Outdoor bathing (organized)

C: Drinking water source with conventional treatment followed by disinfection.

D: Propagation of wild life, fisheries.

E: Irrigation, industrial cooling, controlled waste disposal.

APPENDIX VIII

Correlation results between water quality parameters for Mualkawi rivulet.

	pH	*Temp.*	*Turbidity*	*EC*	*TDS*	*Total hardness*	*Total Alkalinity*	*Total Chloride*	*Total iron*
pH									
Temp.	-0.355								
Turbidity	-0.121	0.916*							
EC	-0.113	-0.168	-0.053						
TDS	-0.074	-0.150	-0.098	0.945*					
Total hardness	-0.221	-0.153	-0.100	0.931*	0.948*				
Total Alkalinity	-0.004	0.071	0.171	0.916*	0.952*	0.892*			
Total Chloride	-0.004	0.433	0.670*	-0.144	-0.266	-0.242	-0.105		
Total iron	0.723*	0.162	0.307	-0.411	-0.333	-0.428	-0.212	0.305	

APPENDIX IX

Correlation results between water quality parameters for Tiau river.

	pH	*Temp.*	*Turbidity*	*EC*	*TDS*	*Total hardness*	*Total Alkalinity*	*Total Chloride*	*Total iron*
pH									
Temp.	-0.565*								
Turbidity	-0.279	0.066							
EC	0.554*	-0.465	-0.381						
TDS	0.549*	-0.557*	-0.378	0.984*					
Total hardness	0.309	-0.194	-0.213	0.857*	0.851*				
Total Alkalinity	0.725*	-0.831*	-0.178	0.688*	0.740*	0.558*			
Total Chloride	-0.066	0.017	-0.026	0.683*	0.621*	0.771*	0.303		
Total iron	0.379	-0.312	0.086	0.505*	0.423	0.341	0.281	0.279	

APPENDIX X

ANOVA results for noise quality between the seasons during the assessment period (June 2016 to May 2018).

ANOVA					
Score					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	229.106	7	32.729	.271	.956
Within Groups	1930.833	16	120.677		
Total	2159.940	23			

APPENDIX XI

Ambient Air Quality Standards in respect of Noise as per Noise Pollution (Regulation and Control) Rules, 2000

Area Code	**Category of Area/Zone**	**Limits in dB(A) Leq ***	
		Day Time	**Night Time**
(A)	**Industrial area**	75	70
(B)	**Commercial area**	65	55
(C)	**Residential area**	55	45
(D)	**Silence Zone**	50	40

APPENDIX XII

ANOVA results for noise quality assessment between pre-construction and construction phases.

ANOVA					
Score					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	53.760	1	53.760	2.983	.159
Within Groups	72.084	4	18.021		
Total	125.845	5			

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BIO-DATA OF THE CANDIDATE

NAME	:	Lalventluanga
FATHER'S NAME	:	Lalsangluaia
DATE OF BIRTH	:	29th May, 1991
MARITAL STATUS	:	Unmarried
PERMANENT ADDRESS	:	H/No. – YD-20, Chaltlang Dawrkawn, Aizawl, Mizoram
EMAIL ADDRESS	:	venalushai@gmail.com
PHONE NO.	:	9862369205
BRIEF RESUME	:	Lalventluanga completed B.Sc (Environmental Science) from St.Edmund's College, Shillong and M.Sc (Environmental Science) from NEHU, Shillong. He is currently pursuing further studies as a Research Scholar in the Department of Environmental Science in Mizoram University.

EDUCATIONAL QUALIFICATION

COURSE	YEAR OF PASSING	BOARD/UNIVERSITY	PERCENTAGE	DIVISION
HSLC	2007	MBSE	83.8	Distinction
HSSLC	2009	MBSE	60.4	First
B.Sc	2012	NEHU	67.88	First
M.Sc	2014	NEHU	68.88	First
Ph.D (Course Work)	2015	Mizoram University	"O" Grade	Distinction

PARTICULARS OF THE CANDIDATE

NAME OF CANDIDATE	**:**	Lalventluanga
DEGREE	**:**	Doctor of Philosophy
DEPARTMENT	**:**	Environmental Science
TITLE OF THESIS	**:**	

Environmental Impact Assessment of Champhai – Zokhawthar Road Construction in Mizoram.

DATE OF ADMISSION	**:**	11.08.2015

APPROVAL OF RESEARCH PROPOSAL

1. DRC	**:**	31. 03. 2016
2. BOS	**:**	07. 04. 2016
3. SCHOOL BOARD	**:**	13. 04. 2016
MZU REGISTRATION NO.	**:**	1506785 of 05-Apr-16
PH.D REGISTRATION NO. & DATE	**:**	MZU/Ph.D/905 of 13.04.2016

Head
Department of Environmental Science

PHOTO PLATE - I

Photo 1: Champhai-Zokhawthar road project starting point at Champhai Police Check Gate.

Photo 2: Champhai-Zokhawthar road project end point at Zokhawthar village.

PHOTO PLATE - II

Photo 3: Noise assessment at study area using Lutron SL-4001.

Photo 4: Air quality assessment at Zokhawthar village using High Volume Air Sampler.

PHOTO PLATE - III

Photo 5: Water assessment at Mualkawi rivulet and Tiau river.

Photo 6: Biodiversity assessment at the study area.

PHOTO PLATE - IV

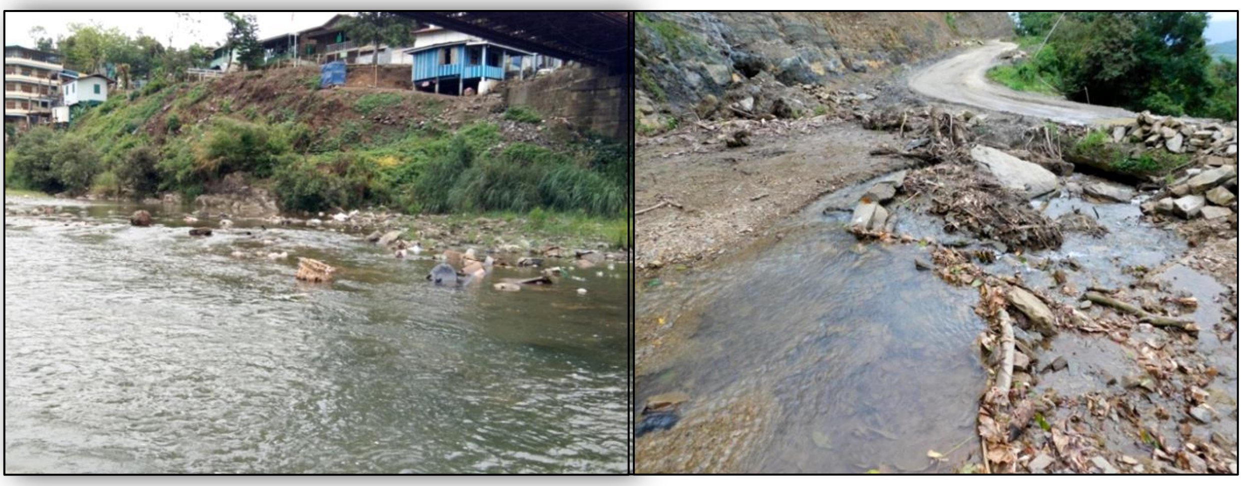

Photo 7: Dust and wastes deposited on Tiau river and Mualkawi rivulet.

Photo 8: Excess soil from slope cutting deposited in the Tiau river.

Photo 9: Excess soil and waste dumped on nearby ditches.

PHOTO PLATE - V

Photo 10: Excess soil is carried by trucks and deposited on Tiau river.

Photo 11: Alteration in landscape and vegetation along the project road.

Photo 12: Tarmat base camp near Melbuk village.

ABSTRACT

ENVIRONMENTAL IMPACT ASSESSMENT OF CHAMPHAI – ZOKHAWTHAR ROAD CONSTRUCTION IN MIZORAM

LALVENTLUANGA

MZU REGN No. 1506785

PH.D REGN No. MZU/Ph.D/905 of 13.04.2016

DEPARTMENT OF ENVIRONMENTAL SCIENCE

SCHOOL OF EARTH SCIENCES AND NATURAL RESOURCES MANAGEMENT

MAY, 2020

ABSTRACT

Road construction plays a pivotal role in the contribution of economic growth of a community, state or nation. In recent years, Mizoram has made immense progress in various sectors and initiated developmental programmes for its economic growth. The enhancement and improvement of the road sector provides better access to social services, economic opportunity and accessibility of trade with neighbouring countries and states.

From an environment point of view, road construction poses a threat to the physical environment and the health conditions of people living and working in the areas. Therefore, road construction activities must be carefully executed by considering economical, environmental, and social requirements.

As a means to check the level of environment degradation and depletion of natural resources, Environmental Impact Assessment (EIA) provides a systematic evaluation of the environmental effects caused by developmental projects including road constructions. In this present study, the environmental impacts of road construction on air quality, water quality, noise quality and biodiversity are assessed to highlight the extent of its impact on the environmental condition of areas situated along the road project.

The objectives of the study are as follows:

1. To determine the air quality in areas between Champhai and Zokhawthar.
2. To analyze the water quality of water bodies in and around the Champhai – Zokhawthar area.
3. To measure and record the level of noise pollution at different sites along the construction area.
4. To assess the biodiversity effected by the Champhai – Zokhawthar Road Construction.

The present study was conducted during April 2016 to May 2018. Ambient air quality was monitored at Zokhawthar village quarterly at 3 months interval by setting up a High Volume Air Sampler, Envirotech Model APM 460 BL. Water samples were collected from two sampling sites i.e. Mualkawi rivulet and Tiau River

quarterly for water quality analysis. Noise sampling was carried out at three sites i.e. Zotlang, Tarmat Base Camp/Melbuk and Zokhawthar using Lutron SL-4001 for sampling. Biodiversity assessment was conducted by assessing floral diversity and faunal diversity along the road project. The results generated from the analysis of air, water, noise and biodiversity during Construction Phase are statistically compared with the baseline data of Pre-Construction Phase to highlight the extent of the environmental impact of the road construction.

The results and observations of the study can be summarized as:

1. The concentrations of parameters measured in all seasons were compared with the permissible limits set by Central Pollution Control Board - (NAAQS, 1994 and 2009) and were well below the prescribed limits. Road construction activities of slope cutting and dumping of soil in nearby areas contributed immensely to the increase in concentration during the dry period. Comparing the results of air quality between the pre-construction phase and construction phase there were no significant changes, however the overall mean values indicate that concentration of the parameters have increased.

2. The parameters measured for both Mualkawi Rivulet and Tiau River are pH, temperature, turbidity, electrical conductivity, total dissolved solids, total hardness, total alkalinity, total chloride and total iron. Results reveal that all values recorded are below the permissible limits except for turbidity. Turbidity values exceeded the permissible limits for almost every season which indicates that road construction activities especially slope cutting and soil dumping has led to a peak rise in turbidity value of water bodies.

3. The mean noise levels at the three study sites exceeded the permissible limits as per the Noise Pollution (Regulation and Control) Rules 2000 except for Zokhawthar site. Comparing the noise levels between the pre-construction phase and construction phase, there were no significant difference, however the overall mean noise level at Zotlang and Melbuk areas during construction phase is much higher in comparison to noise level during pre-construction phase.

4. Biodiversity assessment was conducted along the road project across an elevation of 1140 msl – 1322 msl. In floral diversity assessment, a total of 37 families, 65 genera and 77 species were identified. IVI calculations showed the occurrence of 37 tree species, 19 shrub species and 22 herb species. In faunal diversity assessment, a total of 21 species of birds, 7 species of reptiles and 11 species of mammals were identified. Some faunal species identified belonged to vulnerable and endangered categories under the IUCN Red List. Comparing the biodiversity assessment done in the pre-construction phase and construction phase, it is evident that there has been change in landscape as well as floral and faunal composition.

The study of the impact assessment of Champhai - Zokhawthar road construction revealed that alterations in the quality of the environment occurs both seasonally and phase-wise. Changes in environmental quality of an area is evident and bound to occur with such construction activities as it involves alteration of the landscape, topography and use of heavy machineries; however execution and monitoring of construction work can be improved. There might be cases wherein pollution caused are inevitable however with better planning and proper execution of the work carried out, such pollution can be curbed.

Therefore, it is concluded that EIA should be conducted in all categories of any project work and monitoring must be strictly carried out during the construction phase till completion of the project work so as to ensure sustainability.